HISTORY OF THE SECOND WORLD WAR

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Editor-in-Chief

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GENERAL PREFACE

By Sir ARTHUR SALUSBURY MacNALTY
K.C.B., M.D., F.R.C.P., F.R.C.S.
Editor-in-Chief

Medical histories of wars meet more than one necessity. Primarily they are of value to the medical profession and medical administrators because they record discoveries and progress in medicine and surgery made under the stimulus of warfare, relate how problems of medical administration in theatres of war were met and solved, and detail mistakes and errors for the profit of those who come after. Apart from their technical features these histories should be of interest to the statesman, the lay administrator, the general historian, the student of economics and the general reader. For they show that war is not restricted to strategy and tactics, that epidemic disease and the measures taken to combat it may also mean victory or defeat, while efficient hospital treatment may reduce the wastage of man-power from wounds or disease.

The value of medical history is accentuated if it is official, for it then possesses many sources of information which are inaccessible to the unofficial medical historian.

The first official medical history of a war was British. This concerned the Crimean War, was produced through the initiative of Sir Andrew Smith, Director-General of the British Army Medical Department, and was published in two volumes in 1858. The first volume deals with the medico-military matters of individual corps; the second volume (two parts) treats of the history of diseases and those of wounds and injuries. Subsequent medical histories of war have appeared in this and other countries (see list of references on page XV). 'The Medical History of the First World War, 1914–18', with Major General Sir W. G. Macpherson as Editor-in-Chief, was published in twelve volumes during the period 1921–31. It is mainly a history of the Royal Army Medical Corps in the last war. Its lessons and experience proved of great value to the Medical Department in connexion with administrative and other action in the Second World War.

SPECIAL FEATURES OF THE SECOND WORLD WAR IN RELATION TO MEDICAL HISTORY

Previous official medical histories have dealt mainly and sometimes exclusively with the organisation and advances in medical knowledge in an historical setting in relation to armies in the field. In other words they have quite properly been military medical histories.

The Second World War was unprecedented in that it affected the civil population much more than wars had done in the past in Great Britain. It was also remarkable in that a large standing army was maintained in this country for a considerable length of time, so that Service medical problems and those of the civilian population were closely intermingled. The war also produced a number of new features in medical, public health and social history, for example, movements of population from urban to rural areas through official or unofficial evacuation, and an entirely new Emergency Medical Service with, for the first time, administrative association of municipal and voluntary hospitals which received both civilian and Service cases. It experienced the effects of intensive air-raids presenting problems in medicine and surgery which, if not entirely new, had never before been seen on so extensive a scale, and there were many medical problems in connexion with industry, munition factories, nutrition and so forth.

It is obviously desirable that these great and unprecedented events should receive permanent record in official medical history in order to assist the growth of knowledge and to inform future generations.

It is important also to prepare material and to record events while they are fresh in the memory, for they will be forgotten if left entirely to the retrospective historian.

ORGANISATION OF THE MEDICAL HISTORY

There was a War Cabinet Committee for the Control of Official Histories of which the President of the Board of Education was Chairman. After the war this committee became the Cabinet Committee for the Control of Official Histories with the Secretary of State for the Home Department, the Right Hon. J. Chuter Ede, M.P., as Chairman. It was early determined that an official medical history should be part of the organised plan set up by this committee. The War Cabinet, with the considerations in mind which have already been detailed here, laid it down that this history must be on a co-ordinated basis, including not only the medical side of the three fighting Services, Navy, Army and Air Force, but also the medical civilian services.

On March 10, 1941, an interdepartmental conference recommended that an Editorial Board, composed of representatives of the medical departments of the Fighting Services and of other Government Departments concerned, should be appointed to direct the work, and that Sir Arthur S. MacNalty, formerly Chief Medical Officer of the Ministry of Health and Board of Education, should be the Editor-in-Chief.

The President of the Board of Education, the Right Hon. R. A. Butler, M.P., became the first Chairman of the Editorial Board and guided its initial deliberations. He was succeeded in February, 1942, by Sir Cyril Flower, C.B., V.P.S.A., then Deputy Keeper of the Public

Records Sir Cyril Flower is a member of the Advisory Historical Committee on Official Histories, so that he keeps the Medical History in close association with all the histories of the war.

The Editorial Board had in its initial membership the Directors-General of the Medical Services of the Navy, Army, Air Force, and the Emergency Medical Services of the Ministry of Health; the Deputy Chief Medical Officer of the Ministry of Health; the Chief Medical Officer of the Department of Health for Scotland; Professor J. M. Mackintosh, Glasgow University; the Secretary of the Medical Research Council and Dr. Janet Vaughan; Brigadier General Sir James E. Edmonds, Secretary of the Historical Section of the Offices of the War Cabinet; Colonel J. S. Yule, Offices of the War Cabinet; Major General L. T. Poole, War Office; and the Editor-in-Chief. W. Franklin Mellor, formerly a member of the League of Nations Health Organisation, is Secretary of the Board.

The Directors-General concerned appointed medical representatives to collect material for the History; these gentlemen, with the approval of the Editorial Board, were subsequently designated as Service Editors of the History. The Directors-General may be regarded as Supervising Editors of the Official Medical History for their respective Services.

The Editorial Board meets about twice a year. At their first meeting they appointed an Editorial Committee constituted as follows:—

The Editor-in-Chief (*Chairman*).
Surgeon Commander J. J. Keevil (*Admiralty*).
Colonel S. Lyle Cummins (*War Office*).
Wing Commander R. Oddie (*Air Ministry*).
Dr. J. Alison Glover (*Board of Education*).
Dr. A. Sandison (*Ministry of Pensions*).
Professor J. M. Mackintosh (*Department of Health for Scotland*).
Dr. F. H. K. Green (*Medical Research Council*).
W. Franklin Mellor (*Secretary*).

Subsequently, Colonel S. Lyle Cummins resigned and was succeeded by Brigadier F. A. E. Crew, F.R.S., and Major R. N. Hunter. Dr. Charles Newman and Lieutenant Colonel C. L. Dunn of the Ministry of Health, who were Assistant Editors at headquarters, joined the Committee later.

In the course of time, although the original constitution and representation on the Editorial Board and Editorial Committee remained as before, certain alterations and additions were made. For instance, Dr. James Boyd, Chief Medical Officer of the Ministry of Health and Local Government Board, joined the Editorial Board when the Government of Northern Ireland associated itself with the work in 1942.

The present membership of the Editorial Board and of the Editorial Committee is given on pages xvii and xviii.

THE WORK AT HEADQUARTERS

The central organisation of the Official Medical History, which was at first accommodated in the Ministry of Health in Whitehall, gradually expanded as its work, responsibilities, records and indispensable staff increased. New offices of the History were first situated in Caxton House, Westminster; then at 25 Victoria Street, S.W.1; later in Universal House, Buckingham Palace Road, S.W.1; and lastly at 14 Berkeley Street, W.1.

From 1942 to 1947 Charles Newman, M.D., F.R.C.P. acted as Editor of the Clinical volumes, but resigned on being appointed Dean of the British Postgraduate School, Hammersmith.

The headquarters staff at 14 Berkeley Street comprised the Editor-in-Chief, the Secretary, three Editors, Lt. Colonel C. L. Dunn, C.I.E., I.M.S. (ret.)—E.M.S. volumes; N. G. Horner, M.D., F.R.C.P., F.R.C.S., formerly Editor of the *British Medical Journal*, and V. Zachary Cope, B.A., M.D., M.S., F.R.C.S.—Clinical volumes; two research assistants (Mrs. Kathleen Webster and Mr. A. W. Cubbage), a secretary shorthand typist (Miss N. Jensen), a shorthand typist and one copyist. The function of the central office was to exercise general supervision of the production of the History by the Editor-in-Chief; to assist in co-ordinating the historical research work of all the Government medical services and to be responsible for the actual preparation of the volumes relating to the Civilian Medical Services, with the exception of that on medical research for which the Medical Research Council accepted responsibility. In each of the Fighting Services an editorial staff, working under the direction of the Director-General of Medical Services, was set up in 1941 and has undertaken the important task of preparing the naval, military and air force medical histories.

It will readily be appreciated that much of the work of the Medical History was done through personal visits, interviews and outside inspections and conferences, and the Editorial Committee when it met had to consider the results of this spade work.

At the central office of the History conferences and interviews were held and all those writing on medical problems of the war were welcome. In this office a centre of documentation dealing with the whole field of war-time medical work was assembled, but all the material on war-time medical problems was not housed in this department. Much was filed throughout the various Government Departments and elsewhere, but the liaison effected with the various Services and bodies assured that all the material collected would be available for the Official Medical History.

Close attention was paid to medical literature. Much has already been written on medical problems during the war. Articles and papers of interest were collated and indexed. Advantage was taken of the very complete organisation set up by the Medical Research Council whose publication *Bulletin of War Medicine* provided an invaluable synopsis of war-time medical literature. The first editor, Sir Harold Scott, enlisted authorities in every branch of medicine, surgery and kindred subjects as abstractors for this Bulletin and helped in countless ways. *War Medicine* issued by the American Medical Association and the *Bulletin of Hygiene* published by the Bureau of Hygiene and Tropical Diseases also provided valuable data. All available medical publications (English and foreign and those of friend and foe) were scanned for material. Without this detailed scrutiny the History could not achieve its full purpose.

THE SCOPE OF THE OFFICIAL MEDICAL HISTORY

The full list of subjects to be published in the Official Medical History of the Second World War is as follows:—

	Edited by
The Civilian Health and Medical Services	Sir Arthur S. MacNalty, K.C.B., M.D., F.R.C.P., F.R.C.S.
The Emergency Medical Services	Lt. Col. C. L. Dunn, C.I.E., I.M.S. (ret.)
Medicine and Pathology	V. Zachary Cope, M.D., M.S., F.R.C.S.
Surgery	V. Zachary Cope, M.D., M.S., F.R.C.S.
The Naval Medical Services: (1) Administration (2) The Campaigns	Surgeon Commander J. L. S. Coulter D.S.C., R.N. Barrister-at-Law
The Army Medical Services: (1) Administration (2) The Campaigns	Professor F. A. E. Crew, D.Sc., M.D., F.R.C.P. Ed., F.R.S.
The Royal Air Force Medical Services: (1) Administration (2) Commands (3) Campaigns	Squadron Leader S. C. Rexford-Welch, M.R.C.S., L.R.C.P.
Medical Research	F. H. K. Green, C.B.E., M.D., F.R.C.P., and Major General Sir Gordon Covell, C.I.E., M.D., I.M.S. (ret).
Medical Statistics	

In the assembly of material for official records of this kind many difficulties and delays were encountered; and the small editorial staffs at the central office and in the Fighting Services have accomplished no mean task in making considerable progress during the war years and afterwards, despite the many setbacks inseparable from an enterprise of this kind.

The Fighting Services. The Fighting Services will give an account of the organisation of the Services before the outbreak of hostilities and of their growth and functioning during the war. They will describe the medical aspects of the campaigns; those problems relating to combined operations or those common to two or all the Services in various fields of medicine being dealt with by all three Services in collaboration. Medical problems peculiar to the Services will be treated at length in these sections in order to bring out the lessons of the war and, in particular, to put war-time experience at the disposal of new entrants to the Services.

A great deal of material has been collected and classified in the Service Departments. Each Service drew up a synopsis of contents of its contribution, and experts in naval, military and aviation medicine were asked to contribute. Arrangements were made for experts working on subjects wholly or partly common to all the Services to consult together, in order to avoid overlapping as far as possible. Contributors were asked to submit progress reports, as of course final monographs could not be written until the war was over and its medical experiences gathered in. Progress reports or interim monographs ensured that changing experience was recorded while memory was fresh, and, at the same time, furnished a record of the evolution of ideas and of changing problems and technique. Editors and narrators in the Service Departments put this material into preliminary form for inclusion in the History.

The Civilian Aspect. The Medical History will describe the state of the national health at the beginning of the war and the expansion of the Health and Medical Services to meet war conditions and their functioning and development during the war. Material for this section has been contributed by the civil Ministries working in collaboration, each one describing its growth and the changes in organisation and administration. Some problems, such as evacuation, have been treated by more than one Ministry, and here co-ordination has been necessary to give a balanced account. Subjects dealt with include the Emergency Medical Services, their organisation and work during the war and the functioning of the medical and medico-social services throughout the country. Special attention is given to such problems as those arising out of the planning and working of the evacuation schemes, the Civil Defence Services, shelter life; to problems of war-time nutrition and to all those medical and medico-social changes and developments which the war forced upon the nation for good or ill. I should like here to acknowledge the great help we have received from Medical Officers of Health and their staffs in these subjects. The war-time movements and changes in type of disease, and the adjustment in public health measures and medical technique to deal with them will be detailed. The migrations of the civil population to meet war-time requirements and their consequences and lessons in the field of industrial medicine will be described. These are some of the problems and subjects dealt with in the civilian volumes of the History.

Technical Subjects. The technical volumes will cover the whole field of scientific and practical advances in every subject which has a bearing on disease and injuries as they occur in war-time. Other subjects, such as war-time medical education, the social aspects of the war in relation to disease, the rehabilitation of the sick and wounded, etc., will also find their appropriate places. There will be statistics in the text of the contributions and a special volume will be devoted to this important subject.

THE WORK OF THE EDITORIAL COMMITTEE

The duties of the Editorial Committee were many and various. It supervised the collection of material for the History, kept the various Government Departments in touch with one another, prevented overlapping and unnecessary waste of effort in the collection of material, advised on detailed planning and the scope of the History, and on the selection of contributors. It had power to co-opt experts from time to time on special subjects, consulted with special investigation committees set up by other bodies, especially those of the Medical Research Council, and initiated inquiries and research through and in collaboration with these bodies.

An important task of the Committee was the collection of material. With this end in view, Government Departments gave their active collaboration by furnishing reports, circulars, memoranda and other official documents relating to medical administration as well as to technical and clinical subjects. The chief Government Departments collaborating were, in addition to the Fighting Services, the Ministry of Health, the Ministry of Education, Ministry of Labour and National Service, Ministry of Supply, Ministry of War Transport, the Department of Health for Scotland, Ministry of Pensions, and the Ministry of Home Security. Close touch was also maintained with the many bodies and persons whose work had any bearing, directly or indirectly, on matters of interest for the Medical History. Among these may be mentioned the Medical Research Council, the British Medical Association, the Central War Emergency Committee, the General Medical Council, the Nuffield Provincial Hospitals Trust, Royal College of Physicians, Royal College of Surgeons, Royal College of Obstetricians and Gynaecologists, Royal Society of Medicine, the British Council, etc. The Colonial Office supplied information relating to the Colonial Forces and to Malta, Hong Kong, Malaya and other countries involved in the war. Certain of the Allied Governments set up in the United Kingdom during the war gave information to the Editorial Committee as regards the work of their Medical Services. For this information we are indebted to the Foreign Office and to the Chief Medical Officers of these Governments.

COLLABORATION WITH THE COMMONWEALTH COUNTRIES AND THE UNITED STATES OF AMERICA

In 1941 the Chief Medical Officers of the Commonwealth Governments were informed of the proposed official Medical History and they promised to co-operate by supplying data concerning their Medical Forces stationed in this country. Furthermore, at an early date, close liaison was established with the Editorial Committee on Historical Records of the National Research Council of the United States of America, which was then collecting data for the United States Medical History of the War. There was a mutual exchange of experience and information through the good offices of Professor John Fulton of Yale University, Surgeon-General Parran and Dr. K. B. Turner of the American Embassy. Owing to the many and pressing claims of the Campaigns upon the medical officers of these Governments, it was not until after the conclusion of the war that closer collaboration with all the respective medical historians was secured. By 1946, Official Medical Histories of the Second World War were also in preparation in the Commonwealth countries and in the United States.

In that year a permanent Official Medical Historians Liaison Committee of the Commonwealth Countries was set up with the approval of the Foreign Office, the Commonwealth Relations Office and the Governments concerned. This Committee acts as a central agency for the exchange of narratives and provides facilities for the historians to meet in order to review progress, consult together on technical questions and propose solutions of such problems as relate to the accuracy and correlation of data, avoidance of overlap as between one History and another and methods of presentation. Thus, for the first time, official Histories in the English-speaking world are being prepared in collaboration and in the light of free interchange of experience and opinion. The labours of this Committee will be reflected in all the Official Medical Histories. Thanks to its work, the various national Histories, when published, should be as accurate and complete as is reasonably possible, and the events in which several or all of the Allied Forces took part should be correlated and rightly interpreted.

The members of the Liaison Committee were :—

Alan S. Walker, M.D., F.R.A.C.P.	Australia
W. R. Feasby, B.A., M.D. Surgeon Captain A. McCallum, M.A., R.C.N.	Canada
Lt.-Col. J. G. Thomson, I.M.S., later succeeded by Lt.-Col. B. L. Raina, I.A.M.C. Lt.-Col. Muhammud Jafar, I.M.S.	India and Pakistan

OFFICIAL MEDICAL HISTORIANS LIAISON COMMITTEE OF THE COMMONWEALTH COUNTRIES AND THE U.S.A.

First Meeting: Ottawa, September 24th–26th, 1947

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Observers :— Colonel J. H. McNinch, M.C., U.S. Army Donald O. Wagner, M.D. Surgeon Captain Louis H. Roddis, U.S. Navy	United States of America

W. Franklin Mellor (Secretary)

The Committee held meetings in Ottawa (1947), Oxford (1948), Canberra (1949), and Delhi (1952). Its valuable work, and the part played by the Secretary in its initiation and in the carrying out of its technical work have been the subject of commendation in official Commonwealth communications to the British Government.

The clinical volumes, of which this is the first, deal with those problems of injury and disease which confronted medical officers in the various theatres of war; they record the many advances in our knowledge and the application of this knowledge to the prophylaxis and treatment of disease and in countering the results of injury.

It has been generally accepted, and statistics fully bear out the view, that in no previous war have the Medical Services been so efficient or the confidence of the fighting man in those Services so great or so fully justified. Excellent organisation and improved transport played a large part in the improvement but there is no doubt that notable advances in therapeutics and in methods of surgical treatment also contributed a great deal to this desirable result.

The story of how the problems arose, how the solutions of the problems were achieved and how the new knowledge was applied in the various branches of medicine and surgery will be found in the clinical volumes.

ACKNOWLEDGEMENT

It is only fitting that I should conclude my general introduction to the Official Medical History of the Second World War by acknowledging the services rendered by the editorial staff.

The preparation of the Official Medical History could not have been attempted, much less accomplished, without collaboration over a very wide field. To utilise the innumerable sources of historical material, to enlist the help of many experts and advisers on a vast range of medical problems and to distil wisdom from these sources of knowledge for future use is the task of the associate editors. I should therefore like to take this opportunity, on behalf of the Editorial Board, to record an appreciation of their loyal help and important contributions to medical history.

The organisation of this work at the centre and within the Fighting Services, despite many difficulties, has been of a high order. This organisation owes much to the personal qualities of the Secretary who, in addition to his work on behalf of the Editorial Board, actively widened the basis of collaboration in historical research to include the Commonwealth Countries and the United States of America, an innovation which was warmly approved and officially implemented in these countries and which has proved its worth by assuring the greater accuracy and value of all the Official Medical Histories of the Second World War.

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EDITORIAL COMMITTEE

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Surgeon Commander J. J. Keevil, D.S.O., M.D.; Surgeon Lieutenant L. D. de Launay, M.B., B.S.; Surgeon Lieutenant Commander N. M. McArthur, M.D.; Surgeon Commander A. D. Sinclair, M.B., Ch.B. (*Admiralty*); Colonel S. Lyle Cummins, C.B., C.M.G., LL.D., M.D. (*War Office*); Wing Commander R. Oddie, M.B., B.Ch.; Wing Commander E. B. Davies, M.B., B.Ch.; Squadron Leader R. Mortimer, M.B., B.S.; Squadron Leader H. N. H. Genese, M.R.C.S., L.R.C.P. (*Air Ministry*); Charles E. Newman, M.D., F.R.C.P.; N. G. Horner, M.D., F.R.C.P., F.R.C.S. (*Ministry of Health*).

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PREFACE

THIS, the first of two volumes of the Official Medical History of the Second World War relating to Clinical Medicine and Surgery, is made up of a number of separate chapters written by various authors most of whom are acknowledged in the headings. Many are the work of individual experts, but others are composite papers prepared after consultation between groups invited to take part by reason of their first-hand experience in the field under review. Some overlap here and there is inevitable, and a distinction cannot always be maintained between clinical and administrative or between clinical and pathological, though matters of pure organisation and administration are fully covered in the volumes devoted to medicine in the three Armed Services and to the history of the Emergency Medical Services. So far as may be, related subjects are put in proximity for the convenience of the reader; but a logical order of contents is impossible in such a miscellany, and the most that has been attempted is to include mainly surgical articles in one volume and to reserve clinical medicine and pathology for the other. This plan has at least the advantage of keeping together, or not far apart, things that have some affinity. The practical outcome of research in medical and allied science pervades nearly every part of the record of achievement in the clinical field during the war; but a history of the multifarious work in laboratories or elsewhere which underlay these advances will be found in the volume on Medical Research.

Gratitude is here expressed to all who have collaborated whether by writing (and in some cases re-writing) first drafts or by active help in correcting and amplifying chapters for final revision. They have been generous in submitting to editorial requirements and restrictions on space. Bibliographical references are placed at the end of each Chapter or Section. The editor would have liked to adopt the well-known Harvard system throughout the volume, but as some authors prefer the older numerical system and a number of articles did not fully lend themselves to the newer method, it was not possible to achieve uniformity in this respect.

Much of the early work associated with the preparation of the clinical volumes was undertaken by Dr. Charles Newman, Dean of the Post-Graduate Medical School, Hammersmith, and special thanks are due to him for his pioneer labours on behalf of the Official Medical History of the War.

V. Z. C.

INTRODUCTION

BY MAJOR GENERAL SIR HENRY TIDY

K.B.E., M.D., F.R.C.P.

DISEASE and epidemics have been inseparable from warfare throughout the ages. Until our own epoch little or nothing was known of their cause or mode of spread and no specific measures were available for prevention or treatment. Such surgical officers as existed in more recent times had some knowledge of the general principles of hygiene, but even these were constantly overridden by executive officers. Military operations brooked no interference from medical advisers. A warning that encampment in a malarious swamp might result in 100 per cent. of casualties would often be neglected even if it reached the ears of commanding officers. Often there would be no warning and indeed no recognition of the existence of the danger. When the catastrophe took place, there was no effective remedy.

In more stationary operations, epidemics frequently attacked both sides of the battle-line and casualties cancelled out, for then the angel of death spread his wings over friend and foe alike.

The traditional and essential function of military medical services is the maintenance of manpower in a state of fighting efficiency. Such function involves two separate factors, first the selection of the fit and suitable and elimination of the unfit, and secondly the prevention and treatment of disease. The standard of physical fitness required has been the strength to endure long route marches carrying heavy packs and the ability to wield or operate an offensive weapon in the field. Intelligence had to be no more than sufficient to obey automatically the words of command learnt on the barrack square. In our own services a man had to be fit to do anything and go anywhere. It was all or nothing.

These traditional requirements survived the first war almost intact. Almost but not quite, for the long trials in the trenches brought out the importance of personality and morale, even superseding the qualities of physical fitness and intelligence. A beginning was made of the work of psychiatrists both in selection and treatment, but it was hampered by the insufficient training and experience of the psychiatrists available. It was also curiously hampered by the decision that shell shock was due to traumatic encephalitis. The wheel later swung round entirely and all shell shock was attributed to psychoneurosis. Now it is recognised that both factors may be present.

The second war was in its infancy when the pressure for man-power and the rivalry of competing claims began to be felt.

Industry and science behind the lines demanded men who were physically fit and men of high and even the highest intellectual standard.

In the fighting services also men had to attain a standard far beyond that necessary for firing and cleaning a rifle.

As the pressure continued, men could no longer be rejected for a partial defect. Every man had to do what was in his power. It was the duty of selectors, balancing military and industrial needs, to find the employment best suited to the capabilities of each individual. The selectors had to learn their new duties by trial and experience and acquaint themselves with divisions and sub-divisions of fitness and efficiency which increased in complexity as the war unfolded, the demand for manpower became ever more insistent in competing directions and specialism developed further and further. Criteria once considered infallible were found to be faulty, standards laid down officially had to be changed, but gradually a high degree of efficiency was reached. Within the Forces, similar methods were evolved, varying with the requirements of the particular service.

The phrase 'the prevention and treatment of disease' presents many facets, and the modern interpretation is far more extensive than that of only a few years past.

The general principles of the hygiene of camps and barracks have long been established. A dirty or ill-sited camp invites a high incidence of disease. The essentials have been familiar both to medical and executive officers. Treatment, however, amounted to little more than alleviating the symptoms of a sick man.

Prevention and treatment have now acquired a wider significance. They no longer apply to individuals and groups of individuals but the horizon embraces entire diseases and epidemics.

The basis of the conquest of a disease must be an intimate knowledge of its clinical features, sifted and recorded initially by the clinician at the bedside. The spadework of such observations of most diseases was largely completed by the end of the nineteenth and the early years of the twentieth centuries. Before prevention and treatment could be effectively applied to the symptomatology, progress had to be awaited in ancillary sciences, in various branches of physiology, in the diagnostic applications of bacteriology and pathology, and, latest and most dramatic of all, it had to await the rise of modern pharmacology and therapeutics.

A few discoveries, a very few but of major importance, preceded the recent advances in the medical sciences. Jenner's discovery that cowpox protects against smallpox is the earliest light. The introduction of diphtheritic antiserum was an invaluable boon to humanity. Almroth Wright's development of typhoid vaccine completes this triad to the dawn of the twentieth century. The first war gave us TAB vaccine, an obvious advance, and the prophylactic injection of antitetanic serum in wounded men.

There is little more to be found from searching history for advances of value to modern military medicine. The keys to many locks were being forged, but nevertheless the sterility of medical science in the decades before 1920 as compared with surgery is somewhat of a reproach to that age.

Between the wars there were several unrelated changes in practice of some importance to military medicine. In cerebro-spinal fever the whole-sale 'swabbing' and isolation of contacts was abandoned. During the first war this system grew under official orders to such an absurd extent as seriously to affect man-power. Heat exhaustion is now prevented by replacing salt depletion and by acclimatisation, a simplification of the elaborate regulations of the first war.

Protective inoculation with tetanus toxoid has been fully justified and there have been few cases of tetanus. It is disappointing to find that the case-mortality is the same as in 1914–18. There is still no convincing evidence that antitetanic serum possesses curative value. Much knowledge of yellow fever was accumulated between the wars under the stimulus of the Rockefeller Foundation. No epidemic occurred in this war and it has been claimed that this is testimony to the efficacy of the preventive methods in force. It is unfortunately true that when preventive methods are highly successful, a doubt arises in the mind of the public whether anything would have happened in their absence. The fate of smallpox vaccination in the British Isles is a calamitous example of this tendency. Nevertheless, one must be careful about yellow fever. Egypt and parts of India seem to have all the conditions required for an epidemic and infection must have been introduced repeatedly into both areas. Yet no epidemics occur. There may be some factor which is still obscure which is essential for its spread.

The great advance in therapeutics which has distinguished the period since the first war probably owed its stimulus to the discovery of insulin, the demand for liver extracts, and the isolation of complex hormones. Large industrial concerns with ample resources found that it was financially profitable to undertake their production, and expensive plants were installed for the complicated processes involved. A high standard of scientific and technical skill was called for, and staffs were encouraged to explore new avenues of research. During the last thirty years the world has welcomed a series of great therapeutic discoveries.

Contemporary with the production of carefully authenticated preparations there has been a reduction in the appearance of those ephemeral drugs of which the only recommendation is a publicity campaign suggestive of a Hollywood film, and whose life is scarcely longer. This reduction is perhaps most marked among the inhabitants of the United Kingdom and other northerly races who do not demand a multiplicity of remedies and have a rooted objection to frequent *piqûres*.

The war provided a further and immediate stimulus to therapeutic discoveries, urging on activities already in existence, and insistently calling for help in new directions. Problems soon arose requiring solution by the scientists before production could be demanded from the industrialists. How to treat malaria without quinine had to be solved if military operations were to continue in many fields. New problems followed, problems for which there was no parallel in our military medical history. Such was the problem of the maintenance of health under the conditions existing in South-East Asia.

If war presented new problems, it also provided special facilities for their solution. The famous malarial research establishment at Cairns was supplied with funds on which no direct financial return was expected, but, of far greater importance, it had at its disposal unprecedented numbers of men available to undergo therapeutic tests and a staff of the highest scientific attainments. Such an institution would be impossible under peace conditions, and it was compelled to close on the cessation of hostilities with its work uncompleted. Nevertheless, the results already achieved could only have been obtained otherwise by the collation of piecemeal researches of numerous investigators over many years. Although the complete therapeutic conquest of malaria still remains for the future, the advances in the cure and suppression of malaria were the most important contributions to medicine during and as the outcome of the war.

The urgency of the struggle against malaria led to the introduction of a new principle in military preventive medicine involving an important precedent, executive officers and unit commanders being made responsible for anti-malarial discipline and officers being directly appointed from the Adjutant-General's branch with a supervising authority.

The problem of malaria in South-East Asia, had it been unsolved, might well have influenced the whole course of the campaign or of the entire war. The epidemic of typhus in Italy also might have immobilised or frittered away whole armies. Not all the new problems could be solved. The complex symptomatology and the serious late sequelae of infective hepatitis were unsuspected before the war. The clinician and pathologist are still at the stage of collecting facts. Prevention and treatment cannot be immediately expected.

Nevertheless, the advances in clinical medicine and pathology in this war were unequalled in the past in number and importance. They played a major part in the conduct of hostilities.

What lessons can be learnt from the study of this History? There are many clear lessons, but they apply essentially to the military and medical conditions and demands and to the circumstances of the war to which it relates.

It is well to remember, though not to be entirely bound by, the dictum that the only lesson to be learnt from the study of history is that there is no lesson to be learnt from it. It is wise to be careful in applying to preparations for the future lessons so painfully learnt in the past.

This volume records the medical history of the war of 1939–45 and gives an account of the many successful applications of new diagnostic, hygienic and therapeutic procedures. To that extent they may act as a guide in future campaigns but one must realise that any future conflict will be sure to bring forward new medical problems and demand a new orientation to disease as it affects armies in the field.

CHAPTER I

GENERAL MEDICINE

(i)

Medicine in the Royal Navy

Mainly based on a contribution

By Sir J. W. McNEE
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A FIGHTING ship is a complicated mass of machinery in a confined space, in the efficient working of which long apprenticeship is necessary and experience counts for much. During the war many naval ratings, of varying rank, well on in middle life and already retired or in other occupations, were recalled or reinstated on account of their special knowledge, and some very senior and distinguished admirals even when over the age of seventy returned as Commodores of Convoys. Thus the general medicine of the Navy was very like that of a sample of the civil population: there were diseases of youth (zymotic diseases), diseases of early and middle adult life (peptic ulcer) and diseases of older age (cancer and cardio-vascular degenerations).

Pulmonary tuberculosis has always been, as might be expected, a problem of the Navy. When one man with active but unrecognised pulmonary tuberculosis gets into a ship's company there is a danger of secondary cases (pleurisy or active pulmonary lesions) occurring in the ship. This was well recognised, but could not be avoided at the outset when reserves were being called up. The Medical Director-General, however, made the earliest use of mass miniature radiography, not only in the case of new recruits but also for naval ratings temporarily stationed ashore while ships were re-fitting or under repair. So important, however, was the problem of tuberculosis in the Navy that a consulting physician was appointed to deal solely with chest diseases and particularly pulmonary tuberculosis. The record of this work appears elsewhere in the present volume (Chapter XIII).

Skin diseases of many kinds were common in ships. Some of these, such as scabies and ringworm of the feet, were furthered by the crowding. The latter ('foot-rot') which occasionally also affected the nails of the hands, was so frequent as to be scarcely considered a disease and on the whole caused little disability. Oil dermatitis in the oil-burning ships was a special hazard.

The problems of exposure and the concomitant hazards after shipwreck gave rise to much thought and research. (See Chapter XI.)

The sinking of a ship—Royal Navy or Merchant Navy—at once raised for the survivors' sake questions of the best life-jackets, floats and rafts, lifeboats provisioned with the best food and water in the light of modern physiological knowledge, and last, but by no means least, the earliest possible rescue of the men from the sea. The development of Convoy Rescue Ships was an early advance in rescue work. The rescue ships were gradually much improved in efficiency by the enthusiasm of their crews and naval medical officers; they were small converted merchant ships, each equipped with operating theatre, a small hospital for severe injuries and cases of exposure, and many bunks for survivors. These ships saved thousands of lives, and in the event of another war would again be required.

THE CLINICAL WORK IN RESCUE SHIPS

A word or two about the work of the medical officer in such a ship may be of interest. The duties of rescue ships were to pick up survivors and to act as hospital ships for a convoy. As Wilkins (1944) mentioned, the accommodation for survivors and patients was often limited and many makeshifts were necessary in providing treatment. Survivors, who were often injured or suffering from exposure, were given morphine if necessary and any who had been in the water or had wet clothing were stripped, put under hot showers to wash off the fuel oil, and then warmed up between blankets with the aid of hot water bottles. Hot drinks (usually cocoa) were given. Not unnaturally many survivors were apprehensive and many disliked going down below or even refused to do so. In one case (described by Wilkins) forty or fifty survivors never used their bunks at all but even on the coldest nights were to be found huddled together on the boat deck. Those who showed obvious signs of hysteria were given potassium bromide and in some cases morphine ; morale was kept up by issuing cigarettes and games.

The commonest injuries were compound fractures, head injuries and burns and scalds. In treating shock, plasma transfusions were given when necessary but it was sometimes difficult when the ship might be rolling through 20 to 30 degrees.

When operation was necessary, it might be difficult to sterilise everything, but the galley steam-boiler was sometimes brought into use and served to sterilise basins, towels, etc. For short operations pentothal was excellent and for larger operations open ether or the Oxford vaporiser served well. Thomas's splints were sometimes used, but for compound fractures the closed plaster treatment (Winnett Orr, Trueta) was employed. Burns and scalds were treated by cleaning up thoroughly with soap and water, after which second degree burns were treated with triofax jelly, while for those of third degree sulphanilamide powder and tulle gras dressings were applied. To show the endurance of some of those who were injured the following case will serve :—

A stoker petty officer, who was sleeping over the engine room in one of H.M. ships that was torpedoed in the engine room, had second degree scalds of his face, trunk and arms, and third degree scalds of his hands. He was blown into the sea which was at a temperature of 29° F. and swam nearly a mile to one of H.M. trawlers. Three or four hours later he was transferred to the Convoy Rescue Ship, treated for shock by plasma transfusion and other means, and dressings were applied as described above. He made a good recovery and in due course was able to return to duty.

With regard to abdominal emergencies, owing to the lack of facilities it was usually necessary to adopt conservative treatment but (according to Wilkins) the results were not satisfactory.

DIETETIC PROBLEMS

The old Navy, in the days of sail and long voyages away from port, had a bad record of deficiency disease, especially scurvy. It may be recalled with pride that knowledge of how to prevent scurvy originated in the Navy (Lind, 1753) when scientific knowledge of human nutrition was primitive to a degree.

As the study of physiology developed, the energy requirements of the body and the part played by proteins, carbohydrates, fats, salts and water in human diet gradually became known. The discovery of accessory food factors (or vitamins) at once opened up a vast new chapter in nutrition and showed that a diet ample in quantity and ordinary quality might still be defective and lead to a 'deficiency disease'. All the new knowledge gained from the recent studies of nutrition was applied to feeding the Navy, and the naval diet was constantly under observation and review. One simple change arose from the developments both of modern ships-of-war and of modern warfare itself. The sailor is no longer ordinarily called on for great feats of muscular energy, much of his physical work being done for him by machines. He is called on, however, to be always on the alert and 'at the ready' physically and mentally, and accordingly the naval diet was improved in quality.

With modern knowledge of dietetics, rapid passages and wireless communication, old hazards such as scurvy were in ordinary circumstances a thing of the past. Nevertheless, problems of diet arose, in which the medical branch of the Navy gave its advice.

The problems of possible food deficiencies which attracted attention among naval medical officers during the war were as follows:—

The problem of night-blindness (defective dark adaptation) in relation to vitamin A. Defective dark adaptation is of equal importance to the Navy (in watch-keeping and flying) and to the R.A.F. (in night flying), and was the subject of full, but unpublished, joint investigation. The results showed that night vision and dark adaptation are uninfluenced by additional supplies of natural or medicinal vitamin A in the normal individual on an adequate diet, and the causes of the trouble must be sought elsewhere in all ordinary circumstances of service. In the Navy it was found that age was of greatest importance, and older men whose powers of dark adaptation declined simply had to be relieved from important watches. This problem was solved, in fact, by well-accredited tests, easily applied, whereby ratings with defective dark-adaptation were quickly recognised.

The problem of the possibility of some degree of vitamin C deficiency (so-called sub-clinical scurvy) especially in relation to ulceration of the gums (gingivitis), but also in relation to recurrent boils, sores and slow healing of wounds. The loss of our imported fruits (oranges, lemons, bananas, etc.) was a major factor in the dietetic difficulties of the war, and the Navy had to depend largely on the products of our own country —jams and jellies, potatoes and green vegetables—for its supply of vitamin C. The cooking of potatoes and green vegetables was notoriously defective, so that the vitamin content was often largely lost. Moreover, tests for the recognition of vitamin C and its deficiency were fairly simple to carry out in the smallest laboratory, and such tests attracted the attention of many naval medical officers. Infective gingivitis (known as trench mouth in the War of 1914–18) may occur as a contagious disease both in soldiers and sailors, and when it appeared in the present war, especially in small ships in which cooking arrangements were difficult, the question inevitably arose whether the gingivitis was due to a vitamin C deficiency. This assumption or possibility was naturally suggested by the absence of fresh fruit in the diet. Many reports from medical officers, especially in small ships, raised the question of sub-clinical scurvy, and finally a full scientific inquiry was made by direction of the Medical Director-General. Perhaps the most important result emerging from this inquiry came from a comparison between the so-called vitamin C saturation in naval ratings and in the civilian employees of a large engineering works engaged on heavy vehicle production. It was found that, although there were the expected seasonal variations in both classes, the sailors were rather better than their civilian friends in their state of vitamin C nutrition (McNee and Reid, 1942). Moreover, careful observations in a large naval hospital showed that in most cases the gingivitis was due to infection with Vincent's fusiform bacilli and spirochaetes, and that cure was uninfluenced and unhastened by the addition of any vitamin (including ascorbic acid) to the diet. The inquiry did bring out the difficulties and defects of cooking in small ships, and more information and suggestions for improvements would be welcomed on this matter in medical officers' reports. Many medical officers, especially in the earlier part of the war, reported deterioration of health in the crews of ships operating for periods of months in sunless Arctic waters. In such ships the supply of fresh vegetables was naturally defective, and mental depression, pains in the limbs, recurrent boils and sepsis were frequently put down to vitamin C deficiency. Some of these ships used ultra-violet lamps for treatment and good results were claimed. It was impossible to assess the importance of the various adverse factors to which these ships were subjected (defective or monotonous diet, lack of sunlight, etc.), and more information was clearly desirable.

The question of riboflavine (vitamin B2 complex) deficiency in the Services, and particularly the Navy, attracted attention especially from our North American colleagues, and the eye changes found in this deficiency were sought for by slit-lamp investigations in our ratings at various ports. No evidence of deficiency was found.

The conclusion was reached that no deficiency diseases really occurred in the Navy round Britain.

SALT DEFICIENCY

K. S. MacLean (1943) in reporting twenty-one cases of men suffering from the effects of heat on a cruiser in the Tropics called attention to the accompanying deficiency of sodium chloride. It had long been recognized by firemen in coal-burning ships that the cramp-like pains they experienced on duty could be cured by drinking water to which a generous allowance of common salt had been added. MacLean concluded 'that the so-called condition of "heat exhaustion" in which a rating on coming up from a watch below complains of headache, nausea and dizziness, is but the forerunner of the cramping muscular pains described as "fireman's cramp" and that both the conditions have a common cause . . . a deficiency of sodium chloride'. It was noteworthy that the ship on which the observations were made had been two months in tropical waters before any serious effects of heat were experienced; they followed the onset of very hot weather in the third week of June. Salt treatment caused a rapid clearing up of symptoms in most cases, and the introduction of measures to increase the salt intake of those exposed to excessive heat caused dramatic and satisfactory results.

A fuller investigation into conditions resulting from salt deficiency was undertaken by Surg. Lt. Commander M. J. L. Stening (1945) who made his observations during a period of 2½ years while at sea in tropical climates. During this time he diagnosed and treated 120 patients with clinical symptoms resulting from salt deficiency. An indication of the concentration of NaCl in the plasma was provided by the qualitative and quantitative assessment of the concentration of chloride in the urine.

The urinary chloride was shown to be low in all cases of salt deficiency. When estimations of the volume of daily urinary output was not practicable, importance was attached to readings less than 0·5 g. per cent. of NaCl in a urinary specimen. Stening pointed out that the sodium chloride content of an ordinary mixed diet for one day is about 3 g. but with the salt added to suit the palate probably 10 g. are taken daily. In hot weather the salt loss was higher than normal, not only because of the large volume of sweat produced, but because the sweat is unusually high in salt content. He found that an extra ration of 1 drachm (4 g.) daily was required in equable tropical climates when the man was performing mild exercises, but when much sweating occurred 8 g. ought to be taken. Some men voluntarily took as much as 30 g. daily. It was found that a daily urinary output of 5 g. or less indicated urgent salt replacement therapy and when only 3 g. were excreted daily in the urine the condition was dangerous.

Stening classified the conditions resulting from salt deficiency into subclinical and clinical states. The subclinical states were of importance because they were indications which, if neglected, might be followed by more serious states. They comprised one or more of the following—faintness, dizziness, headache, lack of concentration, mental apathy, impairment of appetite, undue tiredness, sleeplessness, nocturnal mild cramps and frequency of micturition without polyuria; if symptoms such as the above were due to salt deficiency they were accompanied by a diminution of sodium chloride in the urine and were relieved promptly on increasing the salt ration. The clinical states due to salt deficiency included:—(1) heat exhaustion, (2) cramps, (3) gastric and intestinal derangement, (4) heat stroke proper and hyperpyrexia. Though there was no true case of heat stroke included in the series of cases Stening held the view that heat hyperpyrexia supervened upon undisguised or incorrectly treated salt deficiency states; this view was not confirmed by the data in those cases of heat stroke in which the chlorides in the urine were estimated.

HEAT EXHAUSTION OR HEAT SHOCK

In these cases the picture was that of clinical shock, but it was associated with a demonstrable diminution of sodium chloride secretion in the urine and, as a rule, was remedied by correction of the deficiency of sodium chloride in the body fluids. Sometimes heat exhaustion was accompanied by severe abdominal pain so that the picture might simulate an abdominal catastrophe. In one case the general condition of collapse and abdominal pain was accompanied by board-like rigidity and tenderness of the abdominal wall so that a provisional diagnosis of perforated peptic ulcer was made; at operation, however, no intra-abdominal lesion was found and the symptoms rapidly subsided as the salt deficiency was made good.

Heat cramps were due to painful muscular spasm which might affect any striated muscle in the body. The severity of the cramps appeared to depend on the degree of hypochloraemia rather than on the rate of loss of salt. The best prophylactic against heat cramps was the taking of a daily ration of salt, increasing the dose according to the amount of activity or working conditions. In the ship all stokers were required to consume 1 drachm of salt powder when starting their watch and so take a minimum 2 drachms of salt daily apart from their meals. After adequate salt treatment the rapid relief from the severe and often excruciating pain of heat cramp was said to be dramatic.

Many people in the Tropics, who under conditions of limited activity do not require an additional supply of salt, find that extra muscular effort may lead to symptoms indicative of salt deficiency. (In this connexion it should be noted that when similar tropical conditions are produced experimentally great variations occur in the chloride concentration in different subjects and in the same subject at different times.) Other clinical symptoms sometimes attributable to salt deficiency included dyspepsia (pain, nausea or vomiting) and diarrhoea with or without fever.

Stening insisted that clinical states of salt deficiency should not be diagnosed unless confirmed by an estimation of the chloride excretion—a test which can be done with the minimum of equipment; he concluded that a prophylactic salt ration should be taken in the Tropics especially by those who have to work below deck and sweat profusely.

Many other dietetic questions, involving modern physiology and therefore the medical branch, were constantly under review, and formed the subject of Fleet Orders by the Medical Director-General. These concerned diets more suitable for fighting efficiency rather than for the days when heavy ship's gear was man-handled (before electric power developed), methods of keeping food warm for small isolated messes in gun turrets, question of feeding a ship's company on the cafeteria system (as in American and Canadian ships), diet in submarines, and many others. In all of these developments the medical branch played its part, and actively promoted research and experiment. It may be noted that central messing in the most modern large ships-of-war has replaced the older system of scattered small messes, although the latter had its points in building up the mutual trust and comradeship of a team.

COMMON DISEASES IN THE NAVY DURING THE WAR

Peptic ulcer and functional gastric disorders (Wade *et al.*, Allison) were as common in the Navy as in the other Services, and formed roughly about 10 per cent. of medical admissions to the large naval hospitals.

The problem of peptic ulcer in the Navy engaged the attention of several investigators. Surg. Lt. Commander H. J. Wade (1942) made a study of 1,003 consecutive cases of dyspepsia seen at a large naval auxiliary hospital. He found that 9 per cent. of all admissions were dyspeptics and of these 56 per cent. had clinical ulcers, 47 per cent.

were proved radiologically to have ulcers, 15 per cent. had duodenal dyspepsia and in 24 per cent. the dyspepsia was of uncertain origin. Of those proved radiologically there were six times as many duodenal as gastric ulcers. Nervous dyspepsia was responsible for 7·5 per cent. of cases and these were more numerous among the new entrants to the Service.

Wade found no evidence to support the view that war-time service in the Royal Navy increased the incidence of dyspepsia; the apparent increase was due to the expansion of the Service and inclusion of many of the (pre-war) civilian population. In his view cases of proved peptic ulceration needed to be invalided from the Services unless there were exceptional circumstances under which adequate dietary control was practicable. The general practice was to investigate fully those who complained of dyspepsia for the first time. If the investigation proved inconclusive the patient was returned to duty for a trial period while predisposing factors were dealt with. Should return to hospital be necessary and an ulcer prove to be present the patient was invalided.

Similar conclusions were reached by Allison and Thomas (1941) who in a study of 100 naval ratings suffering from gastro-duodenal dyspepsia pointed out that the history was a more reliable guide to prognosis than the demonstration of an ulcer by X-rays; when pain of a characteristic nature had recurred over a long period they considered there were strong grounds for invaliding. Allison (1941) in a further study of the same series concluded that though dyspepsia was not so frequent in the Navy as in the Army there was the same tendency to attribute the trouble to unsuitable diet; in his opinion psychological factors played a part in the development of symptoms. Some patients who had been dieting themselves in civil life had never had a satisfactory preliminary investigation into the cause of their dyspepsia and Allison suggested that in some of these patients a conditioned reflex may have been set up which even in the absence of an ulcer made it difficult for them to eat ordinary food without getting pain.

Anxiety neurosis was not so common in the Royal Navy as in the other Services (see Chapter XV i). Hypertension and some of its sequelae were often met with and sometimes at a comparatively early age; this *may* have some relation to the great responsibility which might necessarily be thrust upon comparatively young men.

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(ii)

Medicine in the Army

By Brigadier JOHN BENNET
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INTRODUCTION

In a review of war-time medicine there is revealed as one of its main features a high incidence of certain infections punctuated by larger epidemics than are seen in civilised communities in time of peace. The formation of an army involves the close mingling of non-immunes with others seasoned by wider contacts, the latter periodically including healthy carriers of certain infections. Campaigning involves exposure of large bodies of troops to conditions carrying risk of disease spread by dust, flies, water, biting insects and ecto-parasites, in areas where control measures for the prevention of spread cannot be fully implemented prior to occupation. A second feature is formed by diseases due directly to climate, such as the dry torrid heat of the desert, or the prolonged exposure of the extremities to cold. Another group comprising the venereal diseases shows an enhanced incidence in war owing to the dislocation of social life. Diseases of nutritional origin arise in beleaguered bodies of troops, prisoner-of-war camps, and in the armies drawn from countries with dietary habits which cannot be readily adjusted to the rationing immediately available. The need for maintaining the health of large numbers of troops sent abroad to tropical and subtropical countries during a world war creates the need for research into the possibilities of improving the measures of protection and treatment applied to the diseases prevalent in these areas. In many of these diseases to which the soldier is exposed for the first time, states of partial immunity play a large part in influencing the severity of the clinical manifestations, and there may be need for improved methods of protection and treatment for the non-immune. When the vital issues of war are threatened by the incidence of disease, research designed to find adequate measures of control is often urgent, and many advances in medical science of permanent benefit to man in his peaceful callings have been born of necessity during war.

While the incidence of disease can cause great wastage, serious aggravation of this can occur as a result of the policy adopted in treatment. The extensive use of long lines of evacuation to Base hospitals in the clearing of forward medical units of cases amenable to short-term treatment is fraught with wastage of personnel and transport. Moreover, lengthy evacuations and contacts with successive clearing units involve serious risk to the patient's morale, with the result that he may arrive at his destination with physical ailment resolved, but presenting uncertain prospects of rehabilitation for a rôle in a forward area or even in the overseas theatre. The maintenance of morale, liable to be undermined in this way, must always be in the forefront of consideration regarding the tactical use of medical units in the forward area, unless other conditions temporarily take precedence.

EARLY PROBLEMS

Before the first year of the war had run its course, it was plain that the most urgent problem the medical services had to face was one of assessment of fitness for a rôle in the Army of many individuals suffering

TABLE I

Discharges from the Army on Medical Grounds: September, 1939—December, 1942 (inclusive)

	Psychiatric disorders	Tuberculosis		Peptic ulcer	All diseases
		Pulmonary	Other		
Military Officers					
1939–40 . .	124	24	1	37	412
1941 . . .	343	72	10	147	1,082
1942 . . .	485	101	10	116	1,200
Total Officers . .	952	197	21	300	2,694
Military Other Ranks					
1939–40 . .	10,444	2,768	511	9,640	64,657
1941 . . .	20,831	3,545	765	12,783	90,933
1942 . . .	21,693	2,505	593	7,745	64,508
Total Other Ranks .	52,968	8,818	1,869	30,168	220,098

Note: Sept., 1939—Sept., 1941 (incl.). Based on Ministry of Pensions Returns.
Oct., 1941—Nov., 1942 (incl.). Based on Consolidated Returns from Commands.
Dec., 1942. Based on A.Fs. B.3978.

from disabilities, the incidence of which had been previously disregarded to a large extent as serious factors in dislocating the function of an army in formation. As compared with the War of 1914–18, military service was either making an increased demand, physical or mental, on the soldier, or his organism was less able to stand the strain imposed. Some evidence in favour of the latter view was seen in the prevalence of peptic ulcer, on account of which approximately 23,000 cases were discharged from the Army between September, 1939 and November, 1941. This condition did not call for special mention in the official records of the diseases of the War of 1914–18 nor among the conspicuous disablements cited in the corresponding Ministry of Pensions review.(1) Its incidence, however, had shown a rise in the civil population during the inter-war years.(2) Discharges from the Army on medical grounds from September, 1939 to December, 1942 are shown in Table I (above) from which it will be seen that wastage on account of psychiatric disorders was even greater.

Problems of disposal of cases not warranting discharge occupied clinicians as well as administrators. The urgent need was to formulate administrative measures whereby soldiers were classified according to a system which enabled them to be posted to a unit with a prospect of being able to carry out the duties required of them, and to create machinery enabling them to be reallocated to other units in the event of subsequent improvement or deterioration in their fitness. The system adopted was a broadening by progressive subdivisions of that of lettered categories; and, as the machinery of war became more complex and called for greater technical skill, low-grade intelligence and mental instability assumed an importance equal to structural defect. A lettered category was found to be inadequate. It was based on objective criteria, it ignored the man and any compensatory adjustments to his disability that he might have acquired, and it disregarded personal qualities of considerable significance. The need to secure optimum utilisation of available man-power led to the expansion of the existing organisation with the formation of the Directorate for the Selection of Personnel directly under the Adjutant-General in 1941, and the Directorate of Psychiatry as an integral part of the Army Medical Department in 1942.

AVAILABLE STATISTICS

Pre-war medical statistics came mainly from two sources:—

(i) A consolidated monthly return from hospitals showing total admissions by diagnosis. (A.F. A.31.)

(ii) A personal medical record of each case treated in hospital. (A.F. I.1220.)

The system in force for assembling and classifying this documentary material was adequate for the static conditions of peace, but was not well adapted to the fundamentally different situation which arose after the outbreak of hostilities. One of the main difficulties was that a high proportion of military patients in the United Kingdom were treated in civil hospitals. These hospitals were outside the orbit of military medical documentation and submitted neither consolidated returns nor A.F. I.1220. The position was further complicated by the cancellation of A.F. A.31 in an endeavour to save paper work.

Even after civil hospitals took A.F. I.1220 into use in 1942 the quality of documentation remained unsatisfactory, owing primarily to the impossibility of exercising effective control over this contribution to war records. In overseas theatres, difficulties arose from the highly mobile nature of modern warfare, the special problems of forward medical units, the lack of experience of some military medical officers, and the loss of documents in transit, while the establishment of a separate medical statistical section in one of the main overseas commands complicated the situation still further. Had an adequate system of consolidated returns existed, the defects of the personal medical records would have proved less serious, but the cancellation of A.F. A.31 after the outbreak of war, without providing an adequate substitute, effectively blocked this line of approach. In the absence of a uniform consolidated hospital return, each overseas command eventually introduced its own. It is not surprising that these varied considerably from command to command both in quality and in content, with the result that no two sets of figures were truly comparable.

In 1943 the Director-General Army Medical Services called for a special report on the existing statistical machine. Following on the report then submitted, the statistical branch was placed under the Directorate of Biological Research (later Directorate of Medical Statistical Research) with a greatly increased technical staff. There followed a general overhaul of the medical statistical organisation. The absence of complete records for the war years did not mean that valuable information could not be prepared from such records as were available, but it did mean that each survey had to be carried out with due regard to the known limitations of the raw material. A monthly bulletin was started towards the end of 1944 which included figures relevant to current administrative issues together with a series of papers dealing with a variety of problems in the field of medical statistics. The main items of these bulletins and certain other reports were subsequently incorporated in a *Statistical Report on the Health of the Army*, 1943–1945. In general, morbidity figures cited in this report are not expressed in the form of absolute rates per 1,000 strength, but show the relative contributions of individual diseases or disease groups to total morbidity or total medical wastage with the object of indicating the diseases that are characteristic of the command under review. As such the rates shown are seldom directly comparable with those in the statistical volume of the *Official History of the War*, 1914–1918.

DISEASE INCIDENCE, MORBIDITY AND WASTAGE IN THE ARMY

(i) *In the United Kingdom*

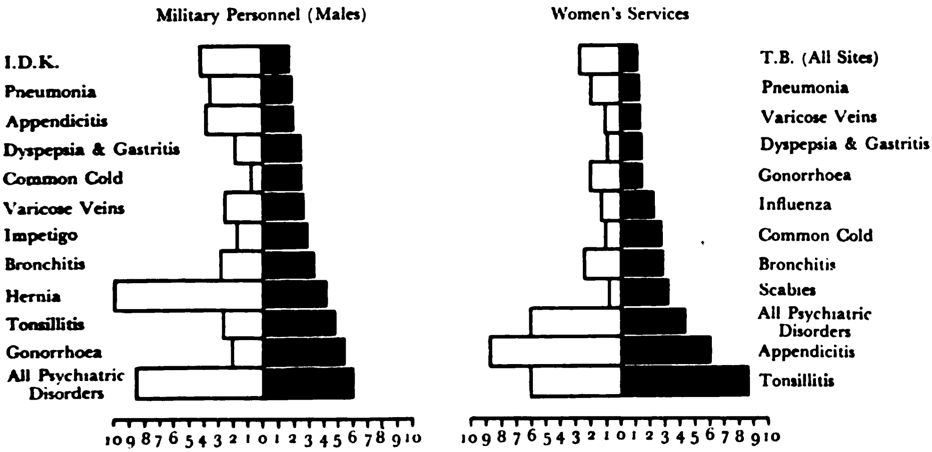
Crude relative morbidity rates and wastage with regard to military personnel admitted to hospital in 1943 are shown in Table II and Chart I. This is the first year for which records are relatively comprehensive, and the last during which the majority of troops were stationed in the United Kingdom; consequently the extent to which the figures cited are enhanced by the addition of cases evacuated from overseas is small, and they can be taken to represent the situation in this country with reasonable accuracy. Psychiatric disorders head the list with 6 per cent. of all cases admitted to hospital. Gonorrhoea comes next with 5 per cent.; treatment in unit lines was not established until the following year. Tonsillitis contributes a similar proportion. Next in order comes hernia at 4·1 per cent. Apart from bronchitis no other condition exceeds a rate of over 3 per cent. Among systemic groups diseases of the skin accounted for 9·2 per cent. of all cases admitted to hospital, and all diseases of the ear, nose and throat 8·2 per cent.

Effective loss to the Army in man-days is more clearly shown by wastage rates, although it does not follow that the activities of an army are more seriously hampered by conditions showing a high relative wastage rate than by those showing a high relative morbidity rate. In assessing the importance of a disease as a source of loss to the Army both frequency of occurrence and man-days lost have to be considered, and both appear in Table II and Chart I. The connecting factor, the

CHART I

RELATIVE MORBIDITY AND WASTAGE

HOSPITAL CASES U.K. 1943



(*Statistical Report on the Health of the Army*, 1943–45)

relative duration of stay in hospital and convalescent depot, is shown in Table II, reference to which reveals that hernia, owing to the time required for its treatment, causes the greatest wastage, 10 per cent., followed by psychiatric disorders, 8·6 per cent. Among recorded specialist groups wastage by psychiatric disorders exceeds that by diseases of the skin and diseases of the ear, nose and throat owing to the much shorter time required for treatment in hospital by these latter groups. An interesting feature of Table II is that accidents make up one-seventh of all cases admitted to hospital and account for one-fifth of total man-day wastage.

Chart I shows the relative morbidity and wastage in the A.T.S. during 1943 for comparison of male and female rates. It will be seen that among A.T.S. tonsillitis accounted for 8·5 per cent. of sick hospital cases, appendicitis for 6 per cent. and psychiatric disorders for 4 per cent. Main items in the record of wastage were appendicitis, 9 per cent., tonsillitis and psychiatric disorders, 6 per cent. each. The high admission rate for scabies shown in the chart represents a period prior to the institution of treatment in unit lines as for males.

(ii) *In the Middle East*

The rate per 1,000 strength of admissions to hospital for all non-battle casualties, excluding injuries, in the Middle East was 578·80 in 1942, 428·42 in 1943 and 395·47 in 1944.

Diseases of the ear, nose and throat, and in particular tonsillitis and pharyngitis, accounted for 15 per cent. of all admissions to hospital, and for about 10 per cent. of all man-day wastage in the Middle East during 1943 and 1944. The relative rates for 1943 as compared with those pertaining to troops in the United Kingdom during the same year (after exclusion of diseases not indigenous to the latter) were as follows:—

	Morbidity		*Wastage*	
	M.E.F.	U.K.	M.E.F.	U.K.
Tonsillitis and Pharyngitis . .	16·4	4·7*	8·4	2·8*
Otitis media and Externa . .	4·4	1·2†	3·3	1·1

* Tonsillitis only
† Otitis media only

(*Stat. Rep. Health of the Army,* 1943–5)

Other conditions contributing prominently to morbidity during the same period were bacillary dysentery, malaria, sandfly fever, P.U.O.,* and infective hepatitis. Bacillary dysentery and P.U.O. showed a fairly uniform annual distribution, whereas in 1944 the relative incidence of sandfly fever fell while that of malaria rose. Factors of location of troops and improvement in diagnostic facilities as the general campaign progressed contributed to the change. A feature of the incidence of infective hepatitis was its higher relative morbidity in the officer group, a difference which would probably be accentuated rather than lessened by age standardisation as, in general, other ranks are younger than officers and the disease is relatively more common in the younger age-groups. The contributions of other diseases were fairly constant throughout the two years. Chart II shows the relative morbidity and wastage in the M.E.F. during 1943. Malaria and infective hepatitis were the most important causes of wastage, and were followed in order of incidence by tonsillitis and pharyngitis, bacillary dysentery, and psychiatric disorders.

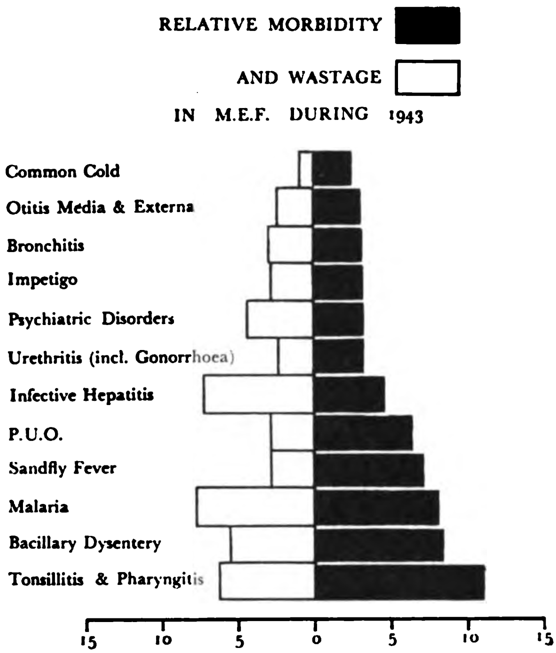
Almost 40 per cent. of all deaths in the Middle East during 1943 and 1944 were caused by injuries and burns. The proportion of injuries which proved fatal was just under 2 per cent. The disease which contributed the highest number of deaths was enteric fever (7 per cent.) although its morbidity rate was of a minor order.

	1943	1944
Officers . .	0·3	0·35
Other ranks .	0·28	0·22

Neoplasms, poliomyelitis, smallpox and pneumonia were other diseases with a high mortality rate in both years.(3)

* Pyrexia of uncertain origin.

CHART II



(*Statistical Report on the Health of the Army*, 1943–45

(iii) *In North Africa and Italy*

The principal causes of admission to all medical units in our forces engaged in North Africa and Italy are shown in Table III. The high incidence of diseases of the alimentary tract, excluding dysentery which is shown separately, was due largely to tonsillitis and pharyngitis. The total sick admission rate fell from 574·83 per 1,000 in 1943 to 440·98 in 1945. Epidemic diseases, malaria, dysentery, and infective hepatitis, showed a marked tendency to lessening incidence as the campaign progressed. In the case of malaria this was attributed to the gradual development of co-operation at all levels born of experience of epidemic incidence during the summer of 1943 in North Africa and subsequently in Sicily. In the control of dysentery credit was given to similar factors, aided after the spring of 1944 by the use of D.D.T. spraying and the availability of sulphaguanidine in unit medical establishments. Acquired immunity was presumed to have played a part in reducing the incidence of infective hepatitis. The reverse trend is seen in the case of venereal diseases and scabies, and was ascribed to increasing contacts with sources of infection as the occupation of Italy progressed, and to freedom and licence incidental to the period following the end of hostilities. Other skin diseases—dermatitis of various kinds, impetigo, epidermophytosis and boils—maintained a high morbidity rate throughout. Disease accounted for more than three-quarters of all cases admitted to medical units.

Table II

Morbidity and Man-Day Wastage with regard to Hospitalised Diseases and Accidents

Relative Morbidity, Wastage and Duration of Stay of Hospitalised Cases in the United Kingdom; Military Personnel; 1943

Individual diseases	1943 R.M.R.	1943 R.W.R.	1943 R.D.S.
Psychoneuroses	4·2	5·8	1·4
Psychoses	0·9	1·7	2·0
Other psychiatric disorders	0·8	1·1	1·3
All psychiatric disorders	5·9	8·6	1·5
Gonorrhœa	5·3	2·2	0·4
Tonsillitis	4·7	2·8	0·6
Hernia	4·1	10·0	2·4
Bronchitis	3·3	2·9	0·9
Impetigo	2·9	1·8	0·6
Varicose veins	2·6	2·6	1·0
Common cold	2·5	0·8	0·3
Dyspepsia and gastritis	2·5	1·9	0·8
Rheumatic conditions (excluding rheumatic fever):			
Non-articular	2·2	2·4	1·1
Articular	0·4	0·6	1·3
Appendicitis	2·0	3·8	1·9
Influenza	1·9	1·0	0·5
Pneumonia	1·8	3·5	1·9
Internal derangement of knee	1·7	4·1	2·4
Hæmorrhoids	1·6	1·7	1·1
Infective hepatitis	1·4	1·8	1·2
Synovitis and arthritis	1·4	1·9	1·4
Boils and Carbuncles	1·4	1·0	0·7
Peptic ulcer	1·3	1·3	1·0
Syphilis	1·2	0·8	0·7
Toxic jaundice	0·6	0·7	1·2
Otitis media	1·2	1·1	1·0
Scabies	0·9	0·4	0·5
Tuberculosis:			
Pulmonary	0·8	1·2	1·6
Other sites	0·2	0·3	2·0
Sciatica	0·7	1·2	1·9
Malaria	0·4	0·3	0·9
Scarlet fever	0·3	0·4	1·2
Nephritis	0·1	0·2	1·7
All other diseases	42·4	36·3	0·9
All diseases	100·0	100·0	1·0 (37·4 days)

Specialist groups	1943 R.M.R.	1943 R.W.R.	1943 R.D.S.
All diseases of skin (excluding areolar tissue)	9·2	6·3	0·7
All diseases of E.N.T.	8·2	5·3	0·7
All psychiatric disorders	5·0	6·6	1·3
All diseases of genito-urinary system	4·2	3·7	0·9
All diseases of mouth, teeth and gums	1·5	0·7	0·5
All diseases of eye	1·4	1·0	0·7
All other diseases	55·1	54·0	1·0
All diseases	84·5	77·7	0·9
All accidents	14·4	20·9	1·5
All battle casualties	1·1	1·4	1·3
All cases	100·0	100·0	1·0 (40·6 days)

Statistical Report on the Health of the Army, 1943–5

TABLE III

Principal Causes of Admission to all Medical Units—BNAF and CMF 1943, 1944 and 1945

Expressed (a) as Ratios per 1,000, and (b) as Percentage of Sick/Total Admissions

	Annual ratio per 1000			Per cent. of *sick* admissions		
	1943	1944	1945	1943	1944	1945
Malaria	107·65	73·53	19·49	18·73	14·34	4·42
Alimentary tract	106·18	62·25	38·89	18·47	12·14	8·82
Skin and IAT (excluding scabies)	82·00	69·66	58·88	14·27	13·59	13·35
Infective hepatitis	49·07	25·08	13·70	8·54	4·89	3·11
Respiratory tract	36·33	31·24	36·35	6·32	6·09	8·24
Venereal disease	31·29	49·86	68·81	5·44	9·73	15·60
Dysentery	26·56	11·51	4·39	4·62	2·25	1·00
Scabies*	(19·54)	(18·89)	(56·02)	(3·56)	(3·69)	(12·70)
Psychoneurosis (excluding Exhaustion)	8·86	19·78	6·30	1·54	3·86	1·43
Total of above	447·94	342·91	246·81	77·93	66·89	55·97
Total of all other sick admissions	126·89	169·76	194·17	22·07	33·11	44·03
Total admissions due to sickness	574·83	512·67	440·98	100	100	100
Battle injuries	63·86	89·60	9·81	9·08	13·86	1·94
Other injuries	65·06	44·41	53·28	9·24	6·86	10·56
Total admissions due to injuries	128·92	134·01	63·09	18·32	20·72	12·50
Total admissions: all causes	703·75	646·68	504·07	100	100	100

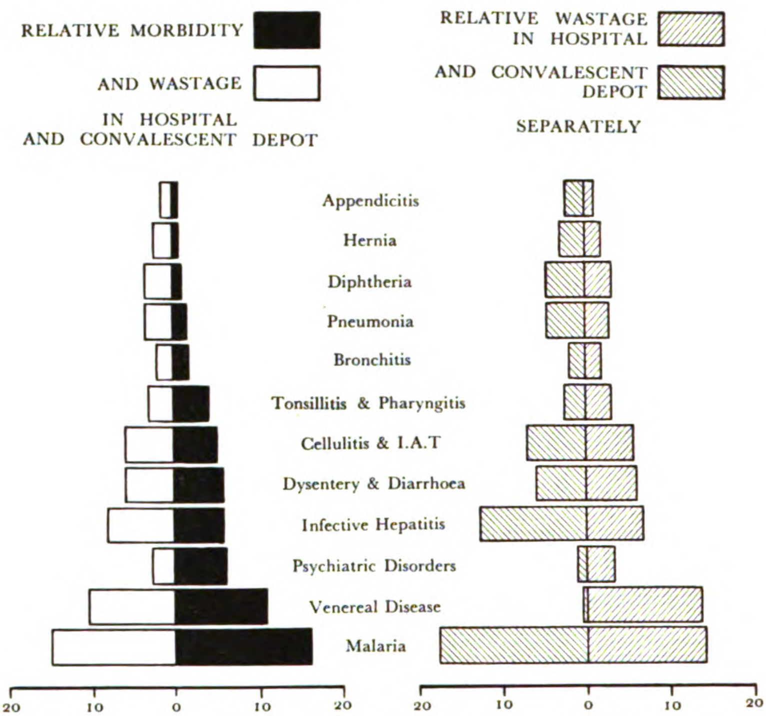
* Scabies figures include cases treated outside medical units.

A comparison of morbidity and wastage during 1944 based on a detailed analysis of all cases admitted to hospital is given in Chart III, which shows that malaria occupied first place and venereal disease second in both categories. In the record of morbidity factors psychiatric disorders occupied third place, whereas infective hepatitis was third in rank as a source of wastage. Dysentery occupied fourth place in both distributions, diphtheria occupied twentieth place in the morbidity scale but the sixth rank in wastage. Excluding diphtheria, these conditions accounted approximately for half the cases admitted to hospital and for half the man-day wastage. Skin diseases and cellulitis accounted for 10 per cent. of total wastage due to disease, accidental injury and battle casualties.

Chart III also shows the relative contributions to wastage by stay in hospital and convalescent depot. The latter accounted for much the larger proportion in the case of infective hepatitis, and more than doubled that incidental to the period of treatment in hospital required for malaria and skin diseases.

CHART III

Morbidity and Wastage in Medical Units in C.M.F. British Army Other Ranks: 1944



(*Statistical Report on the Health of the Army*, 1943–45)

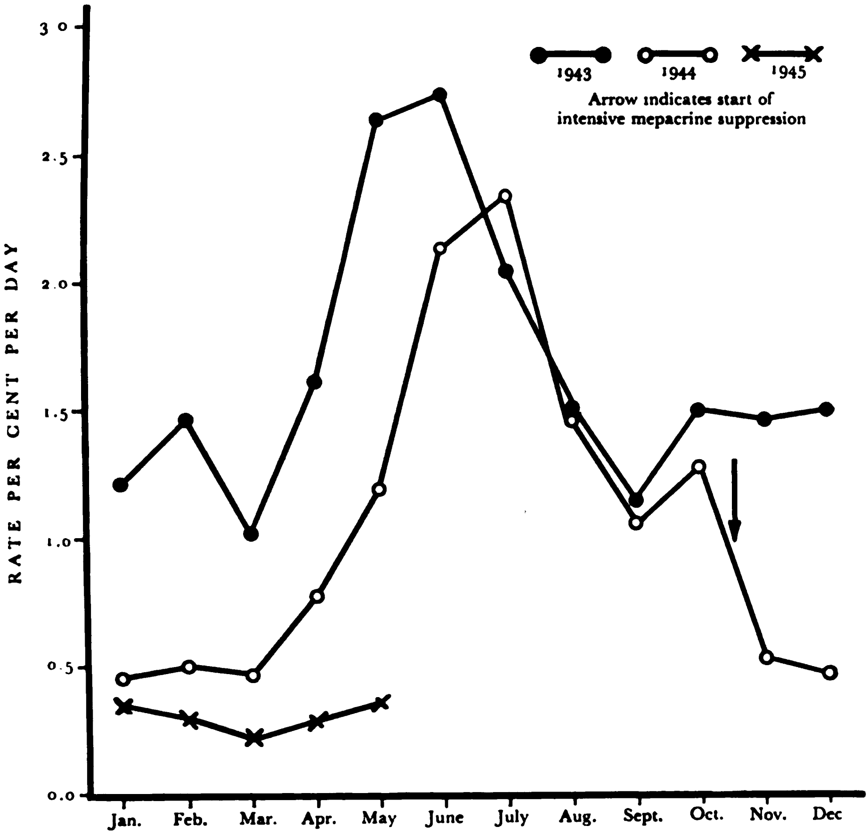
(iv) *In South-East Asia*

With the shift of operations into the jungles of South-East Asia in 1942, we became involved in problems of health maintenance under conditions for which there was no parallel in our military medical history. The words that 'it is only by suffering that the British people learn the best course to take' were borne out by the ultimate success in the battle against the heavy incidence of disease during the following two years. The best course proved to be the proper use of mepacrine and adequate definition of executive responsibility for its use in suppression of malaria, the use of sulphaguanidine in quantities sufficient to permit of its distribution to unit medical officers, and improved measures of personal protection against malaria. These measures, however, could not be implemented before the later months of 1944. In the tactical sphere the use of hospitals in the forward area to minimise wastage from sickness followed on the curtailment of time necessary for the treatment of disease achieved by improved methods.

Marriott[4] reports that the chief problems were malaria, diarrhoea and dysentery, sprue syndromes, anaemia, scrub typhus, skin diseases and venereal disease. He estimates that malaria caused about half of all sickness. Its rate of incidence for 1942, when it was extremely high, is not known, but for 1943–5 it is shown in Chart IV by Hill.[5] In May–June, 1943 it reached a peak of 2·5 per thousand per day and Hill

CHART IV

Incidence of Malaria: 1943–45 (*A.L.F.S.E.A., excluding Ceylon*)



(HILL, I. G. W. (1946) *Trans. Roy. Soc. Trop. Med. Hyg.* XXXIX, 6, 471)

mentions one brigade in which an incidence of 15 per thousand per day occurred. Its control is generally attributed to the adequate use of mepacrine, but Marriott suggests that the use of D.D.T. as an insecticide was contributory.

Next in order of priority of incidence was the group consisting of diarrhoea and dysentery, the rate of which during the period April, 1942 to April, 1945 Marriott estimates at 100 per thousand per annum. Its control was achieved in September, 1944 when sulphaguanidine became available in quantity permitting its use in all cases by unit medical

D

officers. Figures given by Hill show that this was followed by the monthly rate of incidence being reduced to one-fifth of the corresponding rate for the previous year. Marriott supports the contention previously made by Hamilton Fairley[6] on the basis of Australian experience in New Guinea that the vicious circle caused by the presence of a high percentage of cases and carriers in units can be broken by mass treatment with sulphaguanidine. Much of the dysentery in South-East Asia was amoebic, and Hill states that 36·5 per cent. of all cases of diarrhoea during the period January to March, 1945 were of this nature. During the period March to November, 1944 the proportion was 18·75 per cent., and it may well be that the liberal use of sulphaguanidine by unit medical officers masked the more insidious onset of amoebic dysentery with the result that its later morbidity rate represents accumulated cases.

A high prevalence of fungus infections and the aggravating influence of excessive sweating and prickly heat added to the burden of skin disease normally incidental to a campaign. Marriott estimates that skin disease caused the admission to hospital of one man in twenty per annum. A similar admission rate was seen with regard to venereal disease. Scrub typhus began to show its effects in July, 1944, and was at its peak of incidence during the period August to October of that year. Thereafter incidence slowly tapered off until only sporadic cases were encountered in March, 1945. At no time did it account for more than 9 per cent. of admissions, but during October and November, 1944 the death-rate from all sickness in one corps was approximately doubled owing to its high fatality rate. The impregnation of clothing by new and potent mite-repellents proved highly effective.

(v) *In North-West Europe*

Detailed reports of the incidence of disease during the campaign in North-West Europe have not been published, but the quarterly reports of the consulting physician for the third and fourth quarters of 1944 on cases admitted to general hospitals, while not including all admissions, give a general picture of the disease incidence. This is shown in Table IV.

Diarrhoea was the largest cause of admission to Base hospitals during the summer and autumn. The majority of cases were considered to be dysenteric and the Flexner bacillus was frequently isolated from the stools even when they did not contain blood and mucus. The man-day wastage on its account was less than in the Middle East, the average duration of stay in general hospitals being less than one week, and discharge occurring direct to unit.

Skin diseases, reduced by the elimination from the force before D-day of cases liable to breakdown under active service conditions, had a relative casualty rate even greater than in other theatres of operations. Impetigo, boils, dermatitis from various causes and, to a less extent, scabies, were the main factors of incidence. Infection of mosquito and harvest-bug bites was contributory to the dermatitis during the period of July to September, 1944. Acute respiratory diseases were mainly of a minor order, but 10 per cent. were classified as pneumonia. Recurrent winter bronchitis accounted for 50 per cent. of the chronic respiratory cases. Relapses of malaria were common, but one-third of

TABLE IV

Analysis of 28,048 admissions to British General Hospitals in North-West Europe during the period July to December, 1944

The Percentage Figures shown are in Relation to Total Medical Admissions

	July—Sept., 1944		Oct.—Dec., 1944	
No. of cases	10,333		17,715	
		Per cent.		Per cent.
Respiratory diseases:—	1,478	14	4,587	25
Acute	1,148		3,691	
Chronic	330		896	
Skin diseases	1,838	18	2,768	15
Acute diarrhœa	3,172	31	1,459	8
Malaria	1,084	11	348	2
Psychoneurosis	638	6	1,824 (including psychoses)	10
Infectious diseases*	522	5	1,524	8·5
Chronic rheumatism	402	4	1,052	6
Dyspepsia and peptic ulcer	333	3	928	5
Renal disease	155	1·5	544	3
Acute infective hepatitis	157	1·5	585	3
Sciatica	106	1	207	1
Organic nervous disease	109	1	248	1·5
Cardio-vascular disease	52	·5	186	1
*Includes: Diphtheria	42		(faucial 647) (cutaneous 8)	
Typhoid fever	73		13	
Leptospirosis icterohæm.	39		9	
P.U.O.	277		175	
Cerebro-spinal fever	5		11	
Acute rheumatism	23		93	

the total incidence was reported to be indigenous. Typhoid fever occurred as an epidemic in a brigade staff mess; 13 cases were fatal out of 78, and 95 per cent. of cases had received injections of T.A.B. vaccine within the year preceding the onset. The cases of leptospirosis icterohaemorrhagica were mainly contracted in Normandy, and were attributed to conditions of mobile warfare—washing with untreated water from wells and streams, and sleeping in rat-infested ditches. Among the 585 cases of infective hepatitis, 7 per cent. occurred in officers, and the striking excess in relative morbidity among officers noted in M.E.F. and Italy is absent. On the whole, with the possible exception of diphtheria and the outbreak of typhoid fever mentioned, there was no serious epidemic prevalence of disease during the period July to December, 1944, covered by these reports.

The foregoing brief review of disease incidence in the Army in the United Kingdom and overseas operational theatres of the war of 1939–45, with mention of corresponding wastage where figures are available, reveals the predominating importance of psychiatric disabilities in the United Kingdom, the high relative casualty rate of diseases of the skin throughout the Army, and of diseases of the ear, nose and throat in the Mediterranean area. Malaria and dysentery contributed heavily to early disease incidence in the Mediterranean and South-East Asia theatres of war, particularly the latter, but in both the rates were greatly reduced before the end of hostilities. Infective hepatitis was a serious cause of morbidity and wastage in the Mediterranean campaigns.

The annual ratios per 1,000 in respect of the categories used in Table III for the Force in North Africa and the C.M.F. show the progressive control of malaria and bowel disorders in the face of continued active operations. The simple ailments of everyday life represented by diseases of the respiratory tract show a fairly uniform rate which approximates closely to the corresponding figure of 32·37 per 1,000 in the Dardanelles campaign of 1917.(7) Venereal disease and scabies show a rising incidence as the potential sources of infection increased with the progress of the war and its aftermath.

It is difficult to compare the incidence of sickness in the Second World War with that of the First. Adequate comparable statistics are not available except in limited respects for the Mediterranean theatres, but even if figures could be quoted the bearing of them on other factors would have to be considered to place the comparisons on a sound basis. Such factors include the relative duration of the two wars, the maximum strength involved, exact location of operations and seasonal and climatic factors incidental thereto, the degree of hardship undergone, the average age of the troops, and the medical standards adopted for fitness to serve overseas.

DISCHARGES FROM THE ARMY ON MEDICAL GROUNDS

Discharges from the Army on medical grounds during the period 1943–5 are shown in Table V. The population at risk is that of the non-commissioned ranks of the Army as a whole, irrespective of the theatres abroad in which they served. The first two years of the period covered are especially representative of the factors involved, as criteria for discharge on medical grounds were then based on total unfitness for service. From the end of 1944 onwards soldiers of low category for whom no suitable employment was available were discharged, and the crude rates for 1945 are further augmented by the discharges on medical grounds of a considerable number of prisoners-of-war. It can also be presumed that the advent of the end of the war had some influence on the standards adopted by medical boards.

Examination of Table V shows that psychiatric disorders and peptic ulcer retained the lead in this category of wastage which they established in the early years of the war. The former accounted for one-third of all discharges on account of disease during 1943, and two-fifths during 1944. Peptic ulcer was the cause of 13 per cent. in 1943 and rather less the following year. The next in the scale was tuberculosis, 6–7 per cent., followed by bronchitis, 5 per cent. Disease as opposed to injuries and battle casualties accounted for more than 85 per cent. of all discharges on medical grounds in 1943, over 80 per cent. in 1944, and represented an annual loss of 2 per cent. of the total strength.

MEDICAL ETHNOGRAPHY IN THE WAR OF 1939–45

The armies under British command were composed of troops of different ethnic stock, many non-European, in most of the overseas commands, and this afforded an opportunity for comparative observations on the liability of different groups to diseases not commonly current in their normal habitat. Statistical appendices on hygiene reports on the health of troops in the Middle East were drawn up on a demographic basis from 1942 onwards, three categories of personnel being shown—United Kingdom troops, Indians, and Africans. Similar information was compiled in the C.M.F. The morbidity rates shown in these reports for 1943–4 in the Middle East and for 1944 in the C.M.F. were subjected to analytical study by the Directorate of Statistical Research and the results are incorporated in the *Statistical Report on the Health of the Army*, 1943–5. The relative risks imposed by various diseases on different ethnic groups are explored. In respect of the Middle East it was possible to standardise the rates with regard to locality, thereby adjusting differences attributable to varying risk. In the case of the C.M.F. available information did not permit of such correction, but where the conclusions drawn from the relative morbidity rates conform to those indicated in the comparative locality-standardised rates of the Middle East they were regarded as significant. There was general agreement disclosed in the analyses of the Middle East material for the years 1943 and 1944, and the results derived from these, in conjunction with the conclusions drawn from the C.M.F. figures for 1944, are summarised as follows:—

'(i) In both theatres Indian and African troops consistently had an exceptionally low incidence of diphtheria and an exceptionally high incidence of tuberculosis, as compared with United Kingdom troops.

'(ii) Indian troops in both theatres had a low incidence of sandfly fever and gonorrhoea.

TABLE V

Discharges from the Army on Medical Grounds

Crude Six-Monthly Rates per 100,000 *Strength; Military Other Ranks;* 1943–5

(a) Individual diseases	1943 1st half	1943 2nd half	1944 1st half	1944 2nd half	1945 1st half	1945 2nd half
Psychiatric disorders:						
Anxiety neurosis	118·5	138·4	207·4	172·5	228·0	343·0
Hysteria	70·9	65·2	96·6	72·3	86·3	80·0
Psychopathic personality	57·5	55·9	74·1	60·5	64·9	57·6
Mental deficiency	21·7	23·8	32·5	21·3	24·3	24·1
Schizophrenia	19·9	22·8	29·4	24·1	20·3	26·8
Manic depressive psychosis	20·0	21·7	16·8	12·6	9·6	12·7
All others	12·1	10·2	8·5	6·3	8·1	13·1
All psychiatric disorders	320·5	338·1	465·3	369·7	441·5	557·3
Peptic ulcer	128·9	115·0	119·8	89·3	111·0	105·8
Bronchitis	42·2	48·9	58·9	45·8	69·8	62·8
Tuberculosis: Pulmonary	53·9	52·1	66·4	53·4	54·1	57·0
Other	9·4	11·5	10·4	7·3	7·5	9·0
Otitis media	28·2	26·5	27·4	23·8	38·9	69·8
Rheumatic conditions (excluding rheumatic fever):						
Articular	21·0	22·4	24·3	19·6	23·1	21·7
Non-articular	5·8	6·8	6·4	5·9	12·6	12·9
Epilepsy	26·4	21·4	23·8	17·8	17·8	15·4
Deformities of foot	13·5	11·9	11·3	9·1	22·8	30·4
Asthma	10·7	11·9	8·9	12·5	12·9	19·1
Synovitis and arthritis	9·8	10·4	11·3	8·8	13·2	16·6
Sciatica	8·4	8·6	14·3	9·6	12·1	18·5
Neoplasm: Malignant	6·6	7·2	7·3	6·8	5·4	6·6
Benign and unspecified	2·8	2·1	2·4	2·4	2·9	3·4
All other diseases	253·6	252·6	292·5	231·4	304·3	438·5
All diseases	941·7	947·4	1,150·7	913·2	1,149·9	1,444·8

(b) Specialist groups	1943 1st half	1943 2nd half	1944 1st half	1944 2nd half	1945 1st half	1945 2nd half
All psychiatric disorders	320·5	338·1	465·3	369·7	441·5	557·3
All diseases of E.N.T. (including all deafness)	49·3	46·8	49·9	40·6	58·4	102·4
All diseases of skin	27·1	34·1	47·4	38·2	60·0	77·5
All diseases of eye	25·5	22·8	22·1	17·3	17·5	23·1
All diseases of genito-urinary system	17·4	15·4	19·9	14·8	16·7	24·1
All other diseases	501·9	490·3	546·3	432·5	555·8	660·4
All diseases	941·7	947·4	1,150·7	913·2	1,149·9	1,444·8
All accidents	70·3	69·7	98·6	73·6	102·0	125·4
All battle casualties	42·9	100·5	150·5	164·7	352·0	316·3
All discharges	1,054·9	1,117·6	1,399·8	1,151·5	1,603·9	1,886·5

Statistical Report on the Health of the Army, 1943–5 '(iii) In M.E.F. Indian and African personnel had a very high incidence of mumps as compared with United Kingdom troops and a low incidence of infective hepatitis both in 1943 and 1944.

'(iv) Among Indian and African personnel in M.E.F., tuberculosis was the predominant fatal disease, being more fatal as well as more frequent than among United Kingdom troops.

'(v) African personnel were more prone to pneumonia than either Indian or United Kingdom, both in C.M.F. and M.E.F.: but it was not more fatal to them.'

The Statistical Report on the Health of the Army, 1943–1945 also contains comparative studies of the health of troops, European and locally recruited African, in West Africa. The total annual admission rates per 1,000 strength of the two groups were as follows:—

		All causes	Excluding malaria
(a)	*Europeans*		
	1941	1,620	698
	1942	1,436	680
	1943	1,157	726
	1944	1,105	827
(b)	*Africans*		
	1941	632	561
	1942	721	648
	1943	663	621
	1944	851	806

The steady fall in the European rate was due to the successful control of malaria, a conclusion which was confirmed in 1945 when the rate of incidence of this disease in Europeans was one-tenth of that of 1941. The fluctuation of the total rate of sickness in Africans without any characteristic trend under these circumstances indicates their relative immunity to this disease. Table VI shows the comparative importance of diseases contributing to the admission rates.

The diseases to which Africans are relatively immune are malaria, bacillary dysentery and amoebic dysentery, and those to which they are relatively prone are venereal disease, pneumonia, chickenpox and tropical phagedaenic ulcer. While hospital admission rates for pulmonary tuberculosis differ little in the two groups this condition ranked second to pneumococcal infections as a cause of death among Africans. The contributory factors of corresponding rank in the cause of death among Europeans were blackwater fever and malaria.

THE SCOURGES OF PREVIOUS WARS

In any survey of the medical aspects of war it is pertinent to review any change in the status of some of the diseases which have been the scourges of previous campaigns—malaria, dysentery, enteric and typhus fevers. In the War of 1914–18 the last was practically non-existent in our armies, and the incidence of enteric fever was much less than in any previous war. Morbidities from malaria and dysentery were heavy throughout and such success as was achieved was in early and adequate

TABLE VI

Admissions to Hospital in West Africa with respect to Certain Infectious Diseases

Rates per 1,000 *Strength per Year;* 1944. ('*Stat. Rep. Health of the Army,* 1943–1945.')

	(a) Europeans	(b) Africans	Ratio (a)—(b)
Malaria	278·0	45·0	6·2
Venereal disease	81·2*	386·0*	0·2
Bacillary dysentery	65·2	4·6	14·2
Amoebic dysentery	26·0	4·9	5·3
Schistosomiasis	24·3	19·4	1·3
Jaundice	7·2	3·5	2·1
Tuberculosis	2·7	2·6	1·0
Pneumonia	1·9	21·4	0·1
Chickenpox	—	17·8	—
Tropical ulcer	—	8·7	—
Trypanosomiasis	—	1·6	—
C.S.F.	—	1·4	—
Smallpox	—	0·2	—
Enteric fevers	—	0·2	—

* This figure includes cases treated in units.

diagnosis and in the requirements of treatment under military conditions. Diagnostic centres were established in divisional areas and treatment instituted in forward medical units so that dangers of deterioration inherent in the evacuation of undiagnosed cases over long lines of communication were overcome. Malaria, however, could not be cured, nor could its incidence be adequately controlled in an endemic area by the use of quinine. In Base areas and under conditions of static warfare a considerable amount of control over the vector could be achieved, but the measures adopted could not be applied in mobile warfare. The incidence of dysentery and the wastage involved were little influenced by any new approach to the problem apart from early and adequate diagnosis.

(i) *Malaria*

Of all the achievements of medical research dictated by the War of 1939–45 the control of malaria is perhaps the most outstanding. Its pride of place can only be disputed by any corresponding impetus given to the production of penicillin. On no war-time problem connected with disease-incidence has the attack been so massed and so successful on such a wide front as in the case of malaria. New insecticides have been produced which kill the mosquito in its larval or adult stages. Repellents have been discovered which actually do what is claimed for them—prevent bites. The loss of our source of quinine by the fall of Java to the enemy in 1942 pointed the way the following year to an exact definition of the rôle of mepacrine in treatment, and it was found to be vastly superior, particularly in suppression. When mepacrine is used for this purpose by the methods established the serious manifestations of the disease do not occur, and malignant tertian infections can be cured by continuing to administer suppressive doses to troops for one month after they leave the endemic area. Deaths from malaria have virtually disappeared as a source of wastage. Finally, with the synthesis in 1944 of the biguanide, paludrine, the parasite in the human body has been found vulnerable to attack before it enters the red blood-cells, and complete causal prophylaxis of malignant tertian infections has been achieved.

During the Macedonian Campaign of the First World War, 15,000 cases of chronic malaria awaiting evacuation to England had accumulated by the end of 1917,[(8)] and in the following year 34,455 cases were transferred under the 'Y' scheme for sending malarial convalescents home.[(9)] This enormous wastage is almost incredible when viewed in the light of what was achieved in the Second World War. Wastage from malaria can be reduced by:—

(i) the use of suppressive drugs,
(ii) the use of insecticides and repellents, and other methods of personal protection,
(iii) facilities for completing the treatment and convalescence of malaria casualties in their corps areas.

Experience in the War of 1939–45 has shown that the appointment of officers of the Adjutant-General's branch responsible for antimalarial discipline, and the assumption of responsibility by unit commanders for the regular taking of suppressive mepacrine by the troops without risk of default is absolutely necessary if success is to be achieved. The intensity of malarial infection depends on the number of infective bites acquired, and the use of the new insecticides and repellents introduced during the Second World War has achieved enormous reduction of this factor, and incidentally contributed much to the general health and well-being of troops operating in mosquito-infested areas. When the dangerous forms of malaria have been eliminated by properly controlled suppressive treatment, and the intensity of infection reduced by mosquito destruction and prevention of their bites, the condition seen in such cases as may break through the suppressive barrier is readily amenable to short-term treatment, which can be completed in the area of the patient's unit.

The cure of relapsing benign tertian malaria, apart from its natural tendency to eventual self-limitation after residence in a non-endemic area, still eludes us, but by the end of the Second World War there was an established and healthy tendency to regard the uncomplicated case as a minor ailment requiring prompt and adequate treatment for control of the fever and only a short further period for full recuperation. The opposite view is productive of serious wastage of man-power although it may be dictated by the exigencies of a military situation. In the Dardanelles Campaign of 1915 the average number of days spent in hospital on account of malaria was 40·6.[10] In the M.E.L.F. in 1943 it was 24·4 and in 1944 20·6 for the combined stay in hospital and convalescent depot.[11] In South-East Asia a marked reduction of force wastage on account of malaria was achieved after January 1945 in medical forward treatment centres established in the corps area with a holding policy of 3 weeks. In a report *The Utilisation of Hospitals and Manpower* the Operational Research Group, India, showed that in 1945 the average period required for the treatment of a case of malaria in hospital was 8·5 days (*vide seq.*).

(ii) *Dysentery*

Available statistics with regard to dysentery during the two world wars are commonly lacking in taxonomical refinements which differentiate the cause and diagnostic criteria used, so that only the overall rates are available for comparison. In the Middle East the contribution of bacillary infections to these rates has always been high. In the War of 1914–18 the proportion of the total incidence in Egypt and Palestine contributed by amoebic dysentery did not exceed 7 per cent.,[12] and in the M.E.L.F. during the years 1947–9 the corresponding figure varied between 1·6 and 3 per cent.[13] The Middle East is therefore suitable for our purpose of forming a comparative estimate of bacillary dysentery during the two world wars. Table VII shows the incidence of dysentery, unqualified, in Egypt and Palestine in the First World War,[14] and in the Middle East in the Second World War.[15] Deaths also are shown. These figures show that the incidence of dysentery was no lower in the Middle East during the Second World War than it was in Egypt and Palestine in the First World War, but whereas over 3 per cent. of all admissions died in 1916–18 the case mortality was negligible in 1942–5. Even if the distribution of cases into the different types of dysentery varied in the two world wars the dramatic change seen in the case mortality is unlikely to have been substantially affected thereby.

The application of new therapeutic substances to treatment and the use of D.D.T. as an insecticide were the main advances introduced during the War of 1939–45 in the control of bacillary dysentery. Sulphaguanidine was not available in the Middle East in sufficient quantities to permit of its use in regimental medical establishments until 1943, and D.D.T. for routine spraying not until 1944, but even after these innovations the incidence does not appear to have been reduced to a lower figure than the average for 1916–18. In the C.M.F. a considerable reduction of incidence was attributed to these factors (*vide ante*) and Hill[5] reported that in South-East Asia the incidence of dysentery was reduced to one-fifth following the use of sulphaguanidine by unit

TABLE VII

Figures for Dysentery

	Ratio per 1,000 strength			Case mortality per cent.
	Year	Admissions	Deaths	
First World War . British and Dominion Troops	1916	29·78	0·43	1·45
	1917	23·27	0·75	3·2
	1918	21·23	1·14	5·38
Total . . .	1916–18	24·51	0·80	3·25
Second World War British troops	1942	43·8	0·07	0·16
	1943	30·3	0·015	0·05
	1944	27·8	0·006	0·02
	1945	27·0	0·014	0·05

medical officers. In the opinion of Marriott[4] and of Hamilton Fairley[6] on the basis of their respective experiences in South-East Asia and New Guinea a lower incidence could be achieved, and epidemic incidence broken, by the use of sulphaguanidine in unit medical establishments.

When we come to examine wastage caused by bacillary dysentery in the two world wars the evidence of progress achieved is readily substantiated. From information available in the Casualties and Medical Statistics volume of the *Official History of the War* (First World War)[15] it is possible from the sample given to work out approximate figures for the average period of stay in hospital. The figures obtained from this source are compared in Table VIII with the average length of stay in hospital for a large sample of dysentery and diarrhoea cases in the Middle East in 1942.

The reduction is dramatic, and none of the provisos which can be raised are such as could alter the situation materially. A further point to be borne in mind is that the First World War figures include cases from all theatres, whereas those for the Second World War refer exclusively to the M.E.L.F. It is unlikely, however, that this consideration could account for more than a small fraction of the differences recorded in the average length of stay in hospital.

Apart from the average stay it is interesting to examine the analysis of total cases in the two samples examined into various lengths-of-stay groups. The groups selected in Table IX are governed by those available for the First World War. It will be seen that in the Second World War, except for cases of amoebic dysentery, some 90 per cent. of all dysentery cases were out of hospital within 28 days as compared with 22 per cent. in the First World War.

TABLE VIII

Average Stay in Hospital for Dysentery and Diarrhoea (in days) British Troops

	First World War	Second World War (MEF 1942)
Dysentery:		
Amœbic . .		40·2
Bacillary . .		15·8
Unspecified .		14·7
All . . .	87·6	16·8
Diarrhœa. . .	21·1	10·6

(A.M.D.5 Statistics).

(iii) *The Enteric Group of Fevers*

Available statistics give the incidence of the enteric group of fevers in the war of 1939–45 as shown in Table X.

The closest comparison with the First World War is provided by the incidence and case mortality in the Middle East (which includes Palestine, Cyprus, that part of North Africa between Egypt and Tripolitania and including both, the Sudan, Eritrea, Greece and Iraq) in 1943–5 and the corresponding figures for Egypt and Palestine in 1917–18. It is accepted that the Middle East is an endemic area. There is reason to believe that the carrier rate is high and a characteristic feature of the incidence of the enteric group of fevers in this part of the world is the short, sharp outbreaks frequently traceable to a carrier. Sporadic incidence plays a relatively small part. This is the picture one would expect in a partially immunised population exposed to recurring severe risk of massive infection. In point of time the comparison may be less appropriate. In 1917 and 1918 there were active campaigns in progress in which powers of resistance were probably lowered by fatigue and current disease, whereas after the North African campaign ended in May 1943 conditions in the Middle East were relatively static. On the other hand static conditions entail a wide range of employment of natives in fixed installations, and natives in contact with food distribution are a potent source of infection by reason of the carrier state.

The differential incidence of the enteric group of fevers in the Middle East during the above periods is shown in Table XI.

The most notable feature is the high percentage of the total in the First World War contributed by cases in which no final diagnosis was possible, 68·2 per cent. in 1917–18 as compared with 21·7 per cent. in 1943–4. This may be due to improvement in laboratory methods in the latter

TABLE IX

Percentage Distribution of Dysentery and Diarrhoea Cases by Length of Stay in Hospital

British Army—First World War and Second World War

Stay (in days)	Dysentery						Diarrhœa	
	First World War	Second World War*					First World War	Second World War*
		All dysentery	Amoebic dysentery	Bacillary dysentery	Dysentery unspecified			
1–7	4·6	·9·2	2·1	7·2	15·9		40·6	33·0
8–14	8·3	48·1	5·3	51·0	49·3		25·4	50·8
15–28	9·1	32·0	31·6	33·7	27·5		11·4	13·9
29–45	12·1	7·1	27·3	6·3	5·2		8·6	1·8
46–75	20·9	3·0	27·6	1·6	1·5		9·2	0·4
76–105	14·7	0·4	3·8	0·2	0·4		2·9	0·1
106–180	21·6	0·2	2·1	0·1	0·1		1·7	—
181–270	6·1	0·0	0·3	—	—		0·2	—
271–365	1·7	—	—	—	—		0·0	—
366 and over	1·0	—	—	—	—		0·0	—
Total . .	100·0	100·0	100·0	100·0	100·0		100·0	100·0

(A.M.D.5 Statistics).

* Based on M.E.F. cases in 1942.

TABLE X

Admission Rate for all Cases of the Enteric Group Fevers occurring among British Personnel

Ratio per 1,000 *Strength*

Command	1942	1943	1944	1945	1946
Army M.E.	0·84	0·80	0·74	0·81	1·44
India	1·58	0·74	1·20	0·72	1·00
C.M.F.		0·51	0·66	0·20	0·28
S.E.A.L.F.				0·49	0·25
B.A.O.R.					0·06

(A.M.D.7.)

TABLE XI

Number of Cases of Enteric Group of Fevers Admitted to Hospitals in the Middle East 1917–18, *and* 1943–4 *and Rate per* 1,000 *Strength of the Force*

	1917–18[16]				1943–4[13]			
	1917		1918		1943		1944	
	Ad-mis-sions	R/1000	Ad-mis-sions	R/1000	Ad-mis-sions	R/1000	Ad-mis-sions	R/1000
Typhoid	14	0·08	31	0·13	164	0·45	105	0·52
Para. A	75	0·40	75	0·32	58	0·16	20	0·10
Para. B	80	0·43	46	0·20				
Group	404	2·17	285	1·23	72	0·20	24	0·12
Total	573	3·07	437	1·89	294	0·81	149	0·74
Group percentage of total	68·2				21·7			

period, or to defects in diagnostic standards in the former, which is more probable. It creates difficulty in attempting to arrive at the individual rate of incidence or case mortality of any of the three specific infections. When we compare the ratios per 1,000 of the total incidence we find the lower rate in the Second World War sample. Table XII shows the case mortality for the same periods with the addition of 1945. This was maintained in the region of 8 per cent. throughout the period 1943–5 and approximates to the mean of the divergent figures for

1917–18. In the First World War the overall percentage case mortality from enteric group fevers in Egypt was 6·4 and in Mesopotamia 8·7.[17]

TABLE XII

Case Mortality Rates, Enteric Group Fevers, Middle East, British and Dominion Troops

	Year	Admissions	Deaths	Case Mortality
First World War .	1917	573	27	4·71
	1918	437	51	11·67
Second World War .	1943	294	24	8·16
	1944	149	12	8·05
	1945	114	9	7·89

1917–18[16] 1943–45[13]

Statistics showing the case mortality in proven cases of typhoid fever are available in respect of the Middle East Force during the years 1943–4, when it was 11·5 per cent. of 279 cases.[13] In 2,472 cases occurring during the War of 1914–18 in France, Italy, Egypt and Mesopotamia it was 9·8 per cent.[18]

The incidence of typhoid fever in the Army in India during the years 1930–45 affords evidence of a controlled low rate maintained by protective inoculation under conditions in which incidence is mainly sporadic. Table XIII shows these rates:—

TABLE XIII

Typhoid Fever. Sick Rate per 1,000. *Army in India*

1930	1·40	1934	0·50	1938	0·35	1942	0·92
1931	1·04	1935	0·51	1939	0·39	1943	0·41
1932	1·10	1936	0·27	1940	0·40	1944	0·69
1933	1·02	1937	0·13	1941	0·37	1945	0·38

(A.M.D.7.)

The abrupt fall seen in 1934 and maintained thereafter followed the introduction of a rejuvenated and more virulent strain of *S. typhi.* in the preparation of the heat-killed and phenol-preserved vaccine in use throughout the Army, and is difficult to account for in any other way than by improvement in immunisation by a more satisfactory antigen.

A feature of the incidence was the maintenance of a low rate throughout the Second World War despite the accommodation of troops in hutted camps with field-work sanitation.

Statistical investigation of the comparative incidence and case mortality of the enteric group of fevers among protected and unprotected men of the Army in the War of 1914–18 revealed 'that the influence of protective inoculation on the liability of infection is undoubted, and equally undoubted is the very much lower case mortality in typhoid fever'.[19] It was stated at the same time that the case mortality from typhoid fever in unprotected men was considerably higher than in civil hospitals during the ten years preceding the war. This was attributed to age-group factors and to the exposure and hardship incidental to campaigning. Case-mortality rates in armies during war are therefore not comparable with rates in civil life on an equal basis. It is frequently stated that we assume too tacitly that the control of the enteric group of fevers can be achieved by active immunisation. Wenyon[20] states that 'a great deal has been done under the general heading of hygiene and sanitation, which includes feeding, clothing and housing, and one is sometimes led to wonder if the low incidence of certain food and water-borne diseases may not be due to these measures rather than to some of the protective inoculations to which the troops had to be subjected'. The figures we have quoted show no more than that the control of the enteric group of fevers achieved in our armies in the First World War was maintained in the Second.

The effects of the substitution in the latter part of 1943 of vaccine prepared from alcohol-killed and alcohol-preserved organisms for the standard heat-killed and phenol-preserved vaccine is a matter for post-war study. It was not until late in 1945 that all troops in the United Kingdom orbit of supply, which includes the Middle East, had been inoculated with it. In India the change was not made.

(iv) *Louse-borne typhus*

The prevention of disease due to uncleanliness and verminous infestation in our armies during the First World War was well maintained in the Second. Exposure of our troops to contact with typhus infection through the need to employ native labour in Egypt during an epidemic of unusual severity in 1943, the harbouring of starved and half-clad Polish troops and refugees evacuated from typhus-stricken concentration camps in Russia via Iran in 1942–3, the occupation of North Africa and Naples under conditions of typhus incidence similar to those in Egypt, and finally in 1945 the overrunning of Western Germany where the disease had been prevalent since 1940 and concentrations of prisoners were heavily infected, and refugees were scattering and spreading infection widely; all these risks failed to overcome to any serious extent the protection afforded by sound hygienic control in our forces. To the measures applied in 1914–18 new insecticides and prophylactic inoculation were added. The method of mechanical dusting evolved by the Rockefeller Foundation Louse Research Team which enabled disinfestation of clothing to be carried out without undressing, was a notable advance in the technical field; 20,000 civilian employees were so treated in Naples without a single case of typhus arising among them, while among 25,000 who could not be treated regularly a number of cases occurred.

In 1943 over 200 cases of louse-borne typhus occurred in the Middle East Forces. The cases occurred in personnel exposed to contact with natives in the supervision of labour, and the absence of infestation and cross-infection in unit and hospital was noteworthy. In Iran where control presented difficulty on account of the widely scattered small bodies of troops involved, there were 42 British admissions and 118 Indian, a rate per thousand for 7 months of 0·78.[21] In Algeria there were 36 cases in 1943, a rate per thousand of 0·104. In Naples only 2 cases occurred among the occupying troops.[22] In Germany no exact records of infections in the Army are available, but in Sandbostel Camp where the infection was particularly virulent, and in Belsen where there were 60,000 victims of the disease, the staffs of three British hospitals, immunised, provided with protective clothing, and treated by dusting with D.D.T., worked unscathed. There were, however, 21 cases, none of them fatal, in the immunised personnel of a field ambulance. The experience of the Second World War is that an army can live and work in contact with typhus infection of epidemic prevalence and suffer only insignificant casualties.

In reviewing the campaigns of the War of 1939–45 stress has been laid on the relationship of advances in applied science of recent origin to reduction of disease incidence. There has been, however, considerable knowledge of methods of control of such conditions as malaria and dysentery for many years, even prior to the War of 1914–18, and although they are admittedly less applicable in mobile than in static warfare—a contrasting feature of the two world wars—these older principles and hygienic control of disease incidence still require to be applied if the full benefits of the more modern methods are to be obtained.

In most of the theatres of the War of 1939–45 subject to endemic and epidemic prevalence of such conditions as malaria and dysentery, casualties from these causes were very high in the earlier parts of the campaigns. To some extent this is to be expected in unseasoned troops recently arrived from home, but mention of lack of experience and awareness of the need for individual and unit attention to the local requirements of health discipline is lamentably common in the records of these early years. Commenting on the bearing of this on the incidence of malaria in the Middle East, Richmond and Gear[23] state:—

> 'The chief one [lesson learnt] was that the work of special units in dealing with mosquito breeding and adult destruction, though frequently adequate in permanent camps, simply must be supported by unit and personal effort in the field if malaria incidence is to be reduced to manageable proportions. Usually it is only a forceful example of an outbreak which drives this need home. . . . It is almost a psychological law that no amount of propaganda, exhortation or training, will in the actual absence of the hazard, make an army malaria conscious. Actual experience and direct knowledge were the most potent influences in the Middle East in such conversion.'

On the lines of similar experiences in South-East Asia, Marriott[4] makes a plea for intensified propaganda:—

> 'Orders are essential but they are by no means enough. Men often have a sort of hostility to orders. If they are to co-operate wholeheartedly they require to be honestly convinced of the vital importance of the measures advocated. The need is to "put over" the simple essential facts to all ranks as vividly as possible by means of lectures, demonstrations, leaflets and films. Unending repetition is essential. We could have taken a lesson from the excellent security propaganda about "careless talk". Now is the time to get inspired education in tropical hygiene established as part of the whole Army's routine training—as important as fighting training. One of the most important sections in any medical directorate should be a section for expert propaganda.'

The stage has been set for the reinforcement of older methods by the formation of an Army Kinema Corporation which shows and distributes military educational films. The other recommendations embodied in these words must be adopted in peace-time training if this is to be adequate. While the prime necessity, however, is to confront the administrative and executive authorities with the relevant information in such a way that it will be accepted with conviction and integrated in their action, success will always depend on man-management, the foundation of all sound military discipline.

OTHER DISEASES OF WAR

(i) *Cerebro-Spinal Fever*

Cerebro-spinal fever can claim an intimate association with war. A factor in its incidence of particular war-time significance is the mingling of non-immunes from rural areas with those seasoned by town dwelling. In the Second World War this was brought about by the formation of the Army and the evacuation of children from the large cities. A formidable epidemic occurred in the First World War commencing in January 1915 and affecting the troops and the civil population in the United Kingdom, and to a much less extent, the troops in France and

Flanders. No serious outbreak occurred in any other theatre of war. In the Second World War the incidence of the disease began to rise in December 1939 and it rapidly assumed proportions never previously experienced in Britain, while among the troops in France there was an equivalent rate at approximately the same time. In other oversea commands the incidence of the disease was negligible.

While the incidence of cerebro-spinal fever in the War of 1939–45 exceeded all previous rates, the factors responsible for the corresponding wastage underwent drastic modification. Modern chemotherapy reduced the case mortality in France to 3 per cent. in contrast with a rate of 40 per cent. in 1918. The severity of the disease was controlled so that patients could be sent to convalescent depots and rehabilitated for return to duty. In addition much saving in man-power accrued from the changed policy adopted with regard to carriers and contacts. The isolation of these and treatment of the former practised in the War of 1914–18 were highly wasteful as men were temporarily lost to the Army and the necessary administrative organisation was considerable. Further, these measures were ineffective. In the War of 1939–45 the static concept of the carrier problem was replaced by that of 'a highly complex dynamic equilibrium with an ever-changing carrier pattern' (Banks), and attempts to control infection by isolation of carriers were abandoned. Routine post-nasal swabbing of contacts ceased in 1940. These measures have been replaced by the mass treatment with sulphonamides of semi-closed communities such as military units, a procedure the technique for which was worked out in the American Armies when their formation later in the war had given rise to the same problem.

(ii) *Diseases due to Climate*

Extremes of climate may affect the bodily organism when a part or whole is exposed for abnormally long periods while still unconditioned, or when it is unable for other reasons such as infection or exhaustion to respond by adequate physiological adjustments. In the case of heat the effect may be direct, causing failure of the heat-regulating mechanism of the body, or indirect as a result of salt loss through excessive sweating. Unless adequate precautions are taken these conditions are liable to arise during any hot weather and are not unknown during summer in Britain. They have been of special significance in the Army during the sea transport of troops in hot climates. In operations in Mesopotamia in June 1915 many died from heat stroke in the advance to Amara, and available statistics show that in 1917, 6,242 British cases were reported, an admission rate of 74·4 per thousand strength with a case mortality of 8·39 per cent.[24]

In the Second World War the incidence of all forms of effect of heat in the Persia and Iraq Force during 1942 and 1943, excepting local lesions of the skin, is shown in Table XIV.

In the War of 1914–18 emphasis in prevention was on protection from heat by special clothing, shade, working at night, cool drinks, and on treatment at fixed heat-stroke stations to which it was not always possible to transport patients in time for treatment to be effective. In the War of 1939–45 a more rational and fundamental approach was made. Emphasis was on acclimatisation, adequate rest and sleep at night, adequate water and salt intake, instruction to men on the care of their health in hot

TABLE XIV

Effects of Heat

	1942		1943	
	Admission per 1,000 strength	Deaths per 100 cases	Admission per 1,000 strength	Deaths per 100 cases
British .	88·7	1·35	11·5	2·31
Indian .	3·2	8·87	0·3	9·76
Whole Force	17·5	2·05	3·5	2·80

climates, responsibility of commanders in man-management and preventive measures, mobile anti-heat installations, and on the training of medical officers in the rational treatment of hyperpyrexia, dehydration and salt depletion. Acclimatisation was so effective that British troops soon became able to work all day in the open in the hottest weather, unencumbered by clothing and sun helmets.[25]

At the other extreme of temperature the effects of exposure of the extremities of shipwreck survivors in rafts or in open boats in northern latitudes during winter have been studied during the Second World War, and form the subject of a separate contribution to this work. Not differing fundamentally from 'immersion foot' as this condition has been called, the trench foot which became prominent as a cause of disability in the Army in France and Flanders during the First World War, and was the subject then of investigation by the Medical Research Committee, was seen in the Army in Italy during the winter of 1944–5. There is nothing to add to our knowledge of its causation, prevention and treatment. It was again shown that the condition should not arise in well-disciplined units if the necessary supplies of suitable footwear are available and the rules for care of the feet drawn up in the First World War are observed.

(iii) *Deficiency Diseases*

Outbreaks of disease the fundamental cause of which was readily demonstrable as a deficiency of an essential factor or factors in the diet provided for British troops in the field were few and of minor significance in overall incidence during the War of 1939–45. Conditions arising in prisoner-of-war camps are reviewed elsewhere in this work.

The incidence of sprue in India and South-East Asia was a factor of some importance, and during the decade prior to the Second World War the work of Castle and Rhoads[26] had revived the earlier concept of its essential deficiency nature. It was clearly shown by the Sprue Research Team, India Command,[27] however, that signs of vitamin deficiency are features of the phase of remission which occurs in the natural course of the disease. Further, the condition was virtually absent in prisoner-of-war camps in the Far East in which conditions due to vitamin-B complex deficiency were rife. Valuable statistics showing the relation of incidence of the disease to that of bacillary dysentery were drawn up by the Sprue Research Team who showed that in India the seasonal incidence of sprue tended to precede that of dysentery, thus setting aside another disputed factor in its causation.

The importance of sprue as a factor in wastage of man-power stimulated further research covering the whole field of fat absorption in all its phases, but the precise mechanism whereby the condition arises still eludes us. A suggestion that oxidative rancidity of fats may play some part in the aetiology of sprue receives support from the not infrequent unit or local incidence of some outbreaks among troops in India. The condition was formerly not uncommon among European civilians in South-East Asia, but has been rarely seen since the installation of food refrigerators in their houses.

The provision over an indefinite period of food in standard packaged rations of the 'K' type used during the war does not solve the difficulty. The rôle of these in rationing is for emergency use for short periods. If these are extended, monotony of diet brings in its train loss of appetite which opens the way for other manifestations of ill-health. The vital factor of variety in the soldier's diet cannot be set aside for an indefinite period, particularly if he is deprived of food conventional in his normal diet.

Anaemia was very common among Indian troops engaged in the operations in South-East Asia, and a conference of the Central Command, India, was held in November 1944 to explore the problem it presented. The general conclusions in so far as they bear on the cause were embodied in a resolution that every effort should be made to provide non-vegetarian Indian troops with four ounces of meat daily. Scruples of religion or custom and the lack of supplies of livestock for killing according to rites as ration meat frequently meant that sepoys in the front line were deprived of meat for many weeks on end. The resolution taken was based on the conviction that 'Severe anaemia was very much more common in Indian troops; that there was strong reason to believe that this was due to lack of haemopoietic tissue reserves in patients subjected to red-cell destruction or loss, and that this inadequacy of tissues was probably related causally to the lack of meat in the diet supplied'.[29] The Operational Research Group, India, in a Report on Man-power Wastage state that improvement in the health of Indian other ranks followed the supply of milk in their ration introduced as a temporary measure until difficulties in the supply of meat could be overcome.

OTHER MAJOR CAUSES OF WASTAGE

(i) *Diseases of the Skin*

The high relative casualty rate of skin disease in armies during war and peace arises largely from the fact that a minor degree of personal disability may incapacitate a man for the full performance of military duty. The military system is such as to make it difficult to compare the rate with that in civil life, but if comparable statistics could be kept there is no reason to believe that they would show any lower rate in the civilian sphere. While the vast majority of conditions represented under diseases of the skin in military statistics neither threaten life nor seriously impair health in the individual, the collective results of their incidence in an army constitute a serious amount of wastage.

Comparison of the incidence of skin diseases in the Army in the two world wars is only possible, except to a limited extent, on a broad basis. In the War of 1914–18 emphasis in France and Flanders was on parasitic infections which, apart from their uncomplicated state, were shown to be responsible for over 60 per cent. of all cases of pyodermia. Static conditions of warfare facilitated administrative arrangements for the services provided by mobile laundries and bath units, and these led to a steady fall in the incidence of disorders grouped as 'inflammation of connective tissue' (I.C.T.), subsequently designated 'inflammation of areolar tissue' (I.A.T.), and of scabies and pediculosis. When phases of movement or active fighting occurred the incidence of these conditions rose, but in 1918, apart from this, the incidence of scabies tended to be stabilised at about 12 per 1,000 per year.[30]

The Second World War was more mobile and the provision of such amenities as laundering and baths was more difficult. While the introduction of new and more rapidly effective methods of treatment and of more potent insecticides and repellents increased our ability to control skin diseases, hazards incidental to new drugs used in treatment and chemicals used for the impregnation of clothing and equipment added to the risks of cutaneous affections to which the combatant was exposed. Moreover, scabies was probably more highly endemic in Europe and Asia during the decade that ended in 1945 than during many previous decades, and it cannot easily be eradicated in an army living in close contact with a civilian population. This meant that during the Second World War it was impossible to prevent drafts from arriving oversea in an infected state. Nevertheless the incidence of scabies in the Army in

North-West Europe in 1944–5 was never more than about 12 per 1,000 per year.[31] After the end of hostilities, however, the rate received impetus from the contacts with civilian sources of infection. In the Middle East the so-called 'desert sore' occurred in considerable numbers and proved as intractable to treatment as in the War of 1914–18. Our knowledge as to the nature of the factors responsible for the occurrence of this disorder and its slowness to heal is still imperfect. Operations in the jungles of South-East Asia contributed to the relative casualty rate of diseases of the skin a heavy incidence of fungus infections.

Much attention was given during the war to the assessment of dermatological conditions with a view to determining the possibility of their aggravation by conditions of service abroad. Cases likely to show deterioration or frequent relapses were restricted to service in suitable climates. This contributed much to the drive for maximum utilisation of man-power, which further involved, in the domain of dermatology, adequate measures of active rehabilitation instead of long periods spent in hospital incidental to a static outlook on chronic skin disease. In the United Kingdom successful efforts were made to teach the subjects of these disabilities satisfactory personal adaptation to their disease compatible with the performance of useful work, and the culture of physical fitness made a notable contribution to the improvement of morale in the individual and his group.

Generally throughout the Second World War there was much activity in military dermatological practice in hastening cures by new methods of treatment and their application in forward medical units when circumstances were favourable. In the records of campaigns with regard to which statistics of actual incidence are available the tendency was towards a lessening rate. Table III shows that in North Africa and the C.M.F. the combined rate for diseases of the skin and I.A.T. (excluding scabies) treated in all medical units fell from 82 per 1,000 per annum in 1943 to 58·88 in 1945. In the Middle East the corresponding figures for cases in British Army Troops treated in hospital were 71·77 in 1942 and 61·03 in 1944.[13] That the problem presented by this incidence is not necessarily connected with war conditions is seen by the incidence of skin diseases, including I.A.T., in British Army Troops in M.E.L.F. in 1947 when the annual rate per 1,000 strength was 62·77 for cases treated in hospital and 70·08 for cases treated in all medical units.[13] Of the former figure 41·85 and of the latter 47·00 per 1,000 were contributed by boils, carbuncles, cellulitis, and other septic conditions, excluding impetigo.

The fact that many of the conditions grouped under diseases of the skin are of a minor nature prompts inquiry as to how far their incidence and the resulting wastage can be combated by work done in unit medical establishments. Marriott[4] states that in South-East Asia 95 per cent. of the cases which had to be admitted to hospital might never have become serious if they had been efficiently treated immediately they began. This applies to many parasitic and fungus skin disorders and cases of skin sepsis, and emphasises the need for regular inspections of the men and adequate supervision of early treatment by the unit medical officers. Active propaganda with emphasis on such aspects as are calculated to improve morale is also necessary. A note of warning is sounded by MacKenna[32] with regard to dermatological conditions in which lack of specialist care may result in haphazard treatment and the development of dermatitis medicamentosa.

(ii) *Venereal Diseases*

Owing to defects in statistical material it is difficult to compare the incidence of venereal disease in the Army in the United Kingdom during the two world wars. The restitution of statistical methods in 1943 was followed within a year by the treatment of gonorrhoea in unit lines and to this some deficiencies in returns were incidental. There is, however, some reason to believe that educational measures and improvements in the organisation of prophylactic centres resulted in an appreciably lowered rate during the Second World War. This is seen in the rate of incidence of syphilis which was between 2 and 2·5 per 1,000 strength in United Kingdom troops in 1943[13] as compared with 5·49 in 1915.[33] The figure for United Kingdom and Dominion troops in the United Kingdom in 1916 was 6·53 and in 1917, 10·54.[34] In oversea commands during the Second World War the rate of incidence of venereal diseases was not uncommonly up to five times greater than in the United Kingdom, and in some, after the cessation of hostilities, it was considerably more, so that there was little cause for complacency with regard to preventive measures. In the field of wastage evidence of progress in the Second World War rests on a solid foundation. In the First World War the average number of days spent in hospital in 1915 by other ranks who had contracted gonorrhoea in the United Kingdom was 26·4, and in the case of syphilis the corresponding figure was 38·9.[33] As the war progressed, however, little was achieved in reduction of wastage. This is seen in a sample analysis of 1,043,653 cases admitted to hospital during the period 1916–20 throughout the Army at home and oversea.[16] The numbers of cases of gonorrhoea and syphilis in the sample and the period spent in hospital were as follows:—

First World War	No. of cases	Period spent in hospital		
		Less than 1 month	1—3 months	3—6 months
Gonorrhoea	25,426	15·2 per cent.	68·1 per cent.	13 per cent.
Syphilis	12,453	12·7 per cent.	74·4 per cent.	11·6 per cent.

The advent of the Second World War found modern chemotherapeutic methods firmly installed in the treatment of gonorrhoea and this reduced the wastage considerably. In 1943 the average duration of stay was 15 days in the United Kingdom and 19 in the Middle East. Following the introduction of penicillin the treatment of gonorrhoea was carried out in unit lines and 90 per cent. of cases were cured within 24 hours. While advances in the treatment of syphilis have been concurrent, the policy of retaining the patient in hospital until the primary sore is healed has precluded such a dramatic change in the wastage from this disease, though a considerable reduction has taken place (see Table II).

(iii) *Jaundice*

One of the most fascinating subjects for review in the medical aspects of the War of 1939–45 is afforded by conditions with jaundice as the presenting feature. These were widely prevalent and attracted much interest. They include infective hepatitis—the catarrhal jaundice of the War of 1914–18 with our conception of its pathology revised—and jaundice associated with the treatment of syphilis and the parenteral administration of human blood and some of its products.

Infective hepatitis has earned recognition as one of the scourges of two world wars, particularly in the Mediterranean theatre of operations. Reference has been made to its rate of incidence and rank in wastage. During the War of 1939–45, work aimed at clarifying its aetiology and method of spread was very extensive and much of it was carried out in the Army. Investigation failed to show that conditions of bad hygiene and poor sanitation were a factor in its rate of incidence, and the natural method of infection remains uncertain.

Jaundice associated with the arsenical treatment of syphilis had been known since this was introduced in 1910, but during the Second World War there was a mounting incidence which early in 1943 reached the height of 45 per cent. of cases treated, a rate rarely known previously. It had been presumed to be a manifestation of the toxic action of the drug, but in the middle of 1943 it was suspected that contamination of syringes used in treatment was the cause. The implementation of instructions for improved standards of sterilisation, and laying down that a sterilised syringe and needle should be used once only before the re-sterilisation of both, led to a dramatic fall in incidence. The work of the Directorate of Medical Statistics on the age incidence of this condition and its bearing on evidence of immunity suggested that the icterogenic agent was not that of infective hepatitis, and the absence of any coincident decline in the known toxic effects of arsenic showed that the drug used was not a significant factor in causation. Statistical studies of jaundice following the transfusion of whole blood or plasma lent support to the view that the icterogenic agent in these cases was probably identical with that responsible for the cases associated with the treatment of syphilis.

REHABILITATION

While dramatic changes took place in the fields of preventive medicine and therapeutics during the War of 1939–45 these must not occupy attention to the exclusion of work which is perhaps less impressive at first sight but is nevertheless of great importance in the smooth running of an efficient military medical organisation.

A patient cured of his physical ailment may not be *ipso facto* fit to rejoin his unit. The position has been summarised by MacKenna[32] who states:—

> 'A man who is in hospital for only a few days can usually be returned to his unit for duty. A man who has been in hospital for a few weeks must pass through a convalescent depot and a holding battalion before he is hardened sufficiently to return to active duties. The longer he is in hospital, the more time has to be spent, medical personnel made available, and special facilities arranged to rehabilitate him for active service'.

Latent adverse reacting tendencies may be activated by influences incidental to military conditions, and patients who have been in hospital for long periods owing to the nature of their disabilities, the policy of evacuation adopted, or delayed disposal for other reasons, are apt to develop impaired morale and present a picture of indeterminate disease based on their own somatic resources or those of other cases with which they have been in contact. In the War of 1914–18 casualties from the effects of gas showed a tendency to develop a state of invalidism due in many to environmental factors resulting from evacuation, and the recognition of the part played by these influences led to improved methods of management. It was found that firm control of patients, the avoidance of unnecessary evacuation and the restriction to a minimum of periods spent in hospital, prevented them from falling into a morbid state and developing the functional symptoms which so often delayed recovery.[35] The heavy initial wastage from 'N.Y.D.N.' or so-called 'shell-shock' casualties evacuated to the Base in 1916 was remedied to a considerable extent in 1917 by admitting them to centres situated about twelve miles behind the front line where sorting took place and cases suitable for short-term treatment were retained and thence they were returned to their units.

In the Second World War from 1941 onwards the Army was always short of men fit for the strain of a fighting arm in battle, and the work carried out in convalescent depots became of vital importance. Specialists in physical medicine were trained to supervise rehabilitation, and in these units with their emphasis on orderly, controlled remedial exercises, graded physical training in an atmosphere of military discipline, and with the patients removed from the emotional influences incidental to periods of sick leave spent at home, reacting tendencies were controlled, and much was contributed to maintenance of the man-power for which the need was so vital.

In addition to services in connexion with rehabilitation, Army specialists in physical medicine did pioneering work in the field of physical development. The urgent need during the War of 1939–45 to make the fullest use of all potentially fit to serve in the Army directed attention to the youths who did not conform to the physical standards required for acceptance. Physical-development centres were organised and in these systematic training, where necessary corrective of specific postural defects, was applied with a view to improvement of stamina and physique. A special feature of the organisation was the provision of a high-calorie, attractive diet to give full scope for the increase in weight which was usually required. Over 70 per cent. of the cases sent to these centres attained standards which enabled them to serve in the Army after a period of graduated training averaging six weeks. The success of the work points to the advantages which could be expected to accrue to the nation by its wider application in our health service.

TACTICAL USE OF HOSPITALS

The primary task of the Army Medical Services is the maintenance of Army man-power in a state of fighting efficiency. Expressed otherwise, this means the control of man-power wastage, comprising, of medical significance, (i) reduction in effective strength, i.e. loss of military potential due to time spent in hospitals and convalescent depots and in transit back to the unit; (ii) dead wastage, i.e. deaths through wounds and sickness and evacuations from the force; (iii) category wastage, i.e. the number of men downgraded and only fit for limited employment.

In an oversea force under conditions of quiet activity, reduction of effective strength on account of sickness, and the absence from the unit this involves, is the most serious drain on man-power. This has important bearings on medical planning with regard to the number of hospital beds required for a force, and their location. The criterion of the ideal use of hospitals is the most rapid return to duty of the patient. This depends on the following factors: (i) the site of discharge of cases curable after short-term treatment and needing no prolonged convalescence; (ii) the most rapid cure in each case—diagnosis and treatment of many cases will be delayed by excessive transfers from hospital to hospital; (iii) the cure of the maximum number of cases without evacuation from the force.

It is an accepted axiom that no casualty should be sent further to the rear than his physical condition warrants and the military situation demands. To implement this policy in the Second World War, which was characterised by lengthy lines of communication in all theatres, it was necessary to site a proportion of Base medical units well in advance of the Base and to make the maximum use of medical units available in divisional, corps and army areas. In the case of divisions, the addition in the later stages of the war of field dressing stations as divisional troops permitted retention within divisional areas of sick who would otherwise have had to be evacuated. In the case of a corps, when the tactical situation permitted, it was found an advantage to group the medical units together, thus a corps medical centre permitted the maximum number of sick to be retained within the corps area. Similarly the allocation of general hospitals to armies allowed sick to be retained within the army area, and this saved their evacuation to the Base.

In South-East Asia during 1944 and 1945 the tactical siting of hospitals presented certain special features, in that vast distances with limited communications were involved in evacuation, and air transport was used for the majority of patients sent to advanced Base hospitals. These were grouped in centres situated in Eastern Bengal, and in the forward area treatment was administered in field ambulances, malaria forward treatment units (introduced in 1943 in a limited rôle), and casualty clearing stations. The large hospital cover afforded by this combination of advanced Base hospitals and forward medical units made it possible to keep in the force all patients likely to be fit within two months, and to evacuate only the longer term cases to India. During the period March 1944 to January 1945 the average monthly admissions, excluding battle casualties, from malaria and all other conditions expressed as percentages of the strength were:—

	Officers	B.O.Rs.	I.O.Rs.
Malaria . . .	1·53	4·52	3·57
All other conditions .	3·72	6·86	4·31
Total sick . .	5·25	11·38	7·88

Force wastage depended on the policy for dealing with these cases. Six per cent. of all cases of malaria and 20 per cent. of all other conditions admitted to hospital were evacuated to India, i.e., out of the force. Deaths from sickness constituted only 0·03 per cent. of the force monthly for officers and I.O.Rs. and 0·04 per cent. for B.O.Rs., and downgradings of medical category were of negligible proportions. The magnitude of force wastage, i.e. the wastage occasioned by men being evacuated from or otherwise lost to the force and requiring drafts from India to replace, was computed as:—

	Officers	B.O.Rs.	I.O.Rs.	
Deaths . . .	0·03	0·04	0·03	per cent. of the force per month
Malaria . . .	0·09	0·31	0·21	
All other conditions .	0·74	1·37	0·86	
Total . . .	0·86	1·72	1·10	

In addition there was reduction in effective strength owing to cases admitted to hospital and treated within the force. Medical policy was adjusted to meet wastage. The key to the situation lay in the treatment of patients as far as possible in units located in the corps area. The malaria forward-treatment units were transformed into medical forward-treatment units in 1945 to deal with all acute fevers, dysenteries of non-amœbic type, and other short-term sickness evacuated from field ambulances. They worked successfully at a bed state of 600–900, were readily mobile and were in fact complementary to the casualty clearing stations with which they were eventually grouped to form corps medical centres. Changes in their establishments of personnel to include specialists and nursing sisters, and in their war equipment, rendered them suitable for treatment of illness likely to be cured within three weeks. The position reached was that field ambulances on a holding policy of seven days were curing one-third to one-half of all sick, and the medical forward treatment units were extending the proportion of forward cures by discharging 45 to 60 per cent. of cases transferred from field ambulances. By January 1945 the evacuations to India had fallen to:—

	Officers and B.O.Rs.	I.O.Rs.
Malaria . . .	0	4 } per cent. of admissions
All other conditions .	6	10 } per cent. of admissions

representing a reduction in force wastage to:—

Officers	B.O.Rs.	I.O.Rs.
0·25	0·4–0·7	0·5–0·7 { per cent. of the force per month

the higher figures representing infantry, the lower all other arms.

In a report *The Utilisation of Hospitals and Manpower* by the Operational Research Group, India, from which the foregoing figures are taken, the beds required in the force for sick casualties of different categories occurring at the rate of 100 admissions per day are calculated from graphs used to estimate the time taken to cure various percentages of admission. For the period January to March 1945, after the adoption of the policy of forward treatment, these calculations show in table overleaf.

Similar records and estimates are found in the report for other categories of casualties. The results are a notable achievement. It is true that they were gained during a phase of a campaign when the enemy was retreating, reduced to impotence in the air and deprived of adequate supplies, and also when our problems incidental to the prevention and treatment of prevalent disease had been largely solved. They represent the emphasis on forward treatment, the note on which

Ultimate Disposal of Cases	Percentages of total			Beds required in								
				Field Ambulances			Corps Centres			Advance Base Hospitals		
	Malaria fever N.Y.D.	Other medical cases	Spec. groups: skin, ven., eye, E.N.T.	Malaria fever N.Y.D.	Other medical cases	Spec. groups; skin, ven., eye, E.N.T.	Malaria fever N.Y.D.	Other medical cases	Spec. groups: skin, ven., eye, E.N.T.	Malaria fever N.Y.D.	Other medical cases	Spec. groups: skin, ven., eye, E.N.T.
B.O.Rs. Evacuated to India	0	4	7	0	12	21	0	40	35	0	32	185
Cured in Base Hospital	4	20	20	12	60	60	40	200	100	54	440	584
Cured in Corps Centre	46	36	39	138	108	117	388	302	382	0	0	0
Cured in Field Ambulance	50	40	34	208	146	164	0	0	0	0	0	0
	100	100	100	358	326	362	428	542	517	54	472	769

B.O.Rs.

Beds required	Forward area	Advanced Base Hospital	Total
Malaria	786	54	840
Other medical	868	472	1340
Spec. groups	879	769	1648

Average period of treatment in the force: Malaria . . 8·4 days
Other medical . 13·4 „
Special groups . 16·5 „

our conception of the best use of hospitals in the War of 1939–45 ended in South-East Asia, where the proportion of sick casualties to wounded was high and the nature of many of the former enabled cure to take place in the forward area. Whether similar results could be achieved in an army carrying on a defensive rôle under vigorous attack in mobile warfare is doubtful, but their contribution to the problems of prevention of wastage and maintenance of morale cannot be questioned. Before the end of hostilities our conception of an adequate corps medical centre composed of medical units with a definite holding policy was broadened to include all specialist services and necessary treatment facilities incidental thereto, with the exception of those exclusively concerned with disabilities requiring long-term treatment in cases fit for evacuation. The disposal and cure of the latter type of cases is best effected by speedy evacuation to the Base or United Kingdom by air.

SOME LESSONS LEARNED

Medical aspects of the War of 1939–45 cannot be reviewed without giving rise to reflection on the lessons they bear for the medical service of the fighting forces in any future war. It has been shown how technical advances have led to enormous reduction in wastage. It must be borne in mind, however, that as the machinery of war becomes more complex and the personnel engaged in the field and the factories more highly trained, wastage matters more and its prevention takes on added importance. In dealing with this, priority must be given to measures of prevention of disease applied at the source. The foundation of success at this level in the Army is good man-management and military discipline, and the responsibility for these rests on commanders. They must practise their full authority on matters of health discipline and accept responsibility for implementing such measures as are designed to achieve this and are controlled by regulations. The rôle of the regimental medical officer, who is the immediate adviser of the unit commander in such matters, assumes added importance. With the trend towards more elaborate and increasing specialisation his status requires safeguarding. When it is considered what qualities are necessary for the efficient performance of his duties, it becomes apparent that a medical officer who displays them performs work that can be classed as specialised. The efficient unit medical officer has been described as 'a specialist in man-power conservation'.[4] He should have energy and initiative, a personality which will ensure within reason that his necessarily tireless propaganda on matters of health discipline is accepted with conviction, and a sound knowledge of preventive medicine and maintenance of morale in all their aspects. His efforts to conserve unit man-power must be reinforced by the retention of cases requiring short-term treatment only in the divisional or corps area whenever tactical considerations permit, and the facilities available at this level should include any specialist service required for efficient handling of such cases. Considerations of man-power preservation and maintenance of morale must be the guiding factors in policies of treatment adopted throughout the theatre.

The impact of the war on medicine accelerated the tempo of progress, bringing much of permanent benefit to mankind. The control of malaria has been cited as an outstanding example of this. The understanding reached of conditions presenting jaundice as their main feature is another of many which come into the same category and are dealt with in succeeding chapters of this work. The medical records reveal a comradeship of physicians, pathologists, hygienists and others as they bent to the common task of solving the problems presented by disease in the fighting forces and removing obstacles in the way of maintenance of health. These problems may be fundamental to success in war and therefore call for the utmost vigour and effort directed to their solution by the medical scientists of the nation. The same spirit is apparent at an international level on which observations on obscure conditions in different armies were collated and seen at first as a dim outline to which further work gave added form and finally pointed the way to completeness. Rapid growth in the structure of knowledge of virus diseases of the lungs bears witness to the value of this co-operation. The task of controlling malaria, successfully carried out in the face of deprivation of further supplies of quinine while adequate resources for the large-scale production of mepacrine were still lacking, was a triumph achieved only by the closest international co-operation.

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(iii)
Medicine in the Royal Air Force

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The many and varied problems which presented themselves to the consultants in medicine required an administrative as well as a clinical solution. Most of the purely clinical problems in the Royal Air Force were of an individual nature, but others affecting fairly large numbers of persons, particularly members of aircrew, had to be dealt with according to an established policy modified from time to time in the light of experience. Several of these problems merited particular attention on account of the numbers of persons involved or the serious nature of their implications; it is these problems which are discussed here.

CARDIOVASCULAR PROBLEMS

Effort Syndrome

It was anticipated from the experience of the War of 1914–18 that very large numbers of cases of effort syndrome would be likely to develop in the Services in the course of the 1939–45 War, and soon after September, 1939, the possibility of providing special hospital facilities for treatment was considered by the Air Ministry, but it was ultimately decided that R.A.F. cases which required special treatment should be transferred to the E.M.S. centre at Mill Hill.

Experience of such cases in the 1914–18 War showed that they occurred most commonly among those subjected to severe physical exertion, particularly when this was demanded of persons of inadequate physique and stamina. On the whole, the duties of R.A.F. personnel during the 1939–45 war, whether aircrew or ground crew, were less exacting physically than were those of Army personnel, particularly the infantry. It might, therefore, have been reasonably anticipated that there would be fewer cases of effort syndrome in the Royal Air Force than in the Army. Moreover, it is well known that the syndrome occurs chiefly in men who give a personal or family history of nervous instability, who frequently are undersized, of a physique and stamina below the average and who show an inadequate personality. It was reasonable to suppose that persons of this type were unlikely either to volunteer for aircrew duties or to be accepted for service if they did, and consequently effort syndrome in aircrew was not expected to be of common occurrence. Ground crew personnel too, at any rate in the first year of war, were expected to show a low incidence because at that time they were largely volunteers and of Grade I category.

Therefore, although there was every reason for not expecting many cases of effort syndrome in the Royal Air Force, the almost complete absence of cases came as a surprise. As one year of war followed another the physique and morale of entrants for ground duties naturally did not maintain the original high standards, but even so the number of patients with typical symptoms of effort syndrome remained very low.

What then was the explanation of the virtual absence of effort syndrome, at any rate in the Royal Air Force? There can be little doubt that there are fashions in diagnosis, as in treatment, and that the absence of these cases was due primarily to the employment of other diagnoses to describe them. Whereas a high proportion of the psychoneurotics in the 1914–18 War showed mainly cardiac neuroses or hysterical pareses, in the 1939–45 War symptoms such as headache, depression and amnesia were more common. It is probable that during the previous war the mere term 'disordered action of the heart' used to describe these cases in itself stimulated the production of neuroses which were primarily cardiac in type. Without doubt many of the cases invalided under the diagnosis of neurosis had some or all of the symptoms ascribed to effort syndrome, but these were less to the fore than in the past, when electrocardiograph and X-ray examinations, and consultations with heart specialists, inevitably aggravated the cardiac manifestations of neuroses.

From every point of view the disappearance of effort syndrome, disordered action of the heart, or soldier's heart, as diagnoses was a matter for congratulation. The neurotic is only too delighted to feel able to attribute his symptoms to a lesion even vaguely connected with the heart, especially if he hopes that it will carry a pension with it.

Hypertension in Flying Personnel

Before the outbreak of war routine physical examinations were carried out annually on all officers, irrespective of their medical categories, and on all members of aircrews. One of the most important features of these examinations was the estimation of the systolic and diastolic blood-pressure. No definite limits were officially laid down regarding the degree of hypertension which should be regarded as compatible with continuance of aircrew duties, but it was held as a general rule that air-crew personnel should not be allowed to continue flying when the systolic pressure exceeded 150 mm. of mercury or the diastolic 100. It was stated before the war in A.P.130 para. 107(v) 'it is rarely advisable to accept a candidate for a permanent commission with a diastolic pressure which is over 90 millimetres of mercury on repeated examination'. In 1941, Appendix L, entitled 'Medical Examination of Candidates for Service Aviation in War-time' was issued for insertion in A.P.130. In para. 4(v) of this appendix it was stated that candidates (for aircrew) with a diastolic pressure persistently over 100 mm. of mercury should be rejected and that those with a pressure persistently over 90, who had more than a faint trace of albumen in the urine, should also be rejected. It was further stated that no one should be rejected on the diastolic pressure alone until the president of the examining board had personally estimated the blood-pressure.

Great importance was attached to blood-pressure as a decisive factor in assessing fitness for flying duties because of the risks to aircraft and crew which would result from any sudden incapacity developing in a pilot while flying; for example, hemiplegia or a coronary occlusion might occur in a man suffering from hypertension. However, the age group to which nearly all pilots belonged was such that sudden catastrophes of this type were extremely unlikely and no such case came to the notice of the consultants in medicine.

No differentiation in the standards regarding high blood-pressure between pilots and other members of aircrew had been made as late as 1944. Clearly, however, the sudden development of complete incapacity in a pilot would be fraught with infinitely greater risks of disaster than the same event in the case of a non-pilot member of aircrew, and for this reason medical boards were more likely to allow full flying categories to non-pilots who suffered from mild hypertension than pilots with the same condition.

Occasionally, pilots with definite hypertension were allowed to continue their duties as second pilot only, and in at least one such case an officer was awarded the Distinguished Service Order. However, early in 1944 the navigator in a Mosquito aircraft fell dead within a few minutes of landing after an operational sortie. There was no known history of cardiovascular disease in his case, but at autopsy he was proved to have had a coronary occlusion. The consultants in medicine did not hear of any other case of coronary occlusion which had occurred during or immediately after a flight.

A large number of trained members of aircrew were continually being referred to medical specialists and consultants with a diagnosis of hypertension. Most of these showed none of the ordinary symptoms attributed to hypertension, such as tinnitus, vertigo and headaches; and the discovery of the supposed hypertension was often made at a routine examination, either for commission or service oversea, or after an illness or accident. Only a very small number of such cases showed any real evidence of pathological hypertension, and in most of them the somewhat raised blood-pressure was purely transient, due to excitement and tension during medical examination. Sometimes the raising of the blood-pressure was only apparent and the fault was due to inability to estimate the diastolic pressure with accuracy. It has been found that in some 10 per cent. of persons there is no sudden change in the murmur heard over the brachial artery as the pressure falls in the cuff of the sphygmomanometer, and it is not uncommon to find readings varying between 80 and 110 mm. of mercury recorded as the diastolic pressure in the same person by different observers who have taken the blood-pressure within a few weeks. In fact an appreciable elevation of the diastolic pressure is exceedingly unlikely in persons below the age of 40 unless there is a corresponding elevation of systolic pressure. Occasionally, patients were referred to specialists by their medical officers who had recorded the systolic pressure as 130 to 140 and the diastolic as 110 to 120. Clearly such readings were the result of a difficulty in ascertaining the true diastolic pressure and it was not necessary to pay attention to them.

Unfortunately, instances did occur when personnel were grounded owing to supposed high blood-pressure. Needless to say such a procedure was extremely bad for the morale of the person concerned as it engendered unnecessary anxiety, and this was particularly true when the member of aircrew remained grounded for several weeks or even months pending arrangements of consultations and boards. In view of such unfortunate occurrences, usually due to over-conscientious and inexperienced unit medical officers, the Air Ministry issued an instruction in 1942 under which no member of aircrew under the age of 35 was to be taken off flying duties on grounds of hypertension without reference to a medical specialist or consultant, and then only after three readings of blood-pressure taken at different times, if possible by independent medical officers. The number of members of aircrew unnecessarily diagnosed as suffering from hypertension materially decreased after this instruction was issued.

Many candidates for aircrew were referred by aircrew medical boards to specialists and consultants on account of blood-pressure slightly above average. In the majority of these cases the blood-pressure was found to be within normal limits on re-examination. Candidates at examinations for aircrew were often tense and excited and this probably accounts for most of those with over-average blood-pressures. The same phenomenon has for years been encountered at medical examination for life insurance.

However, there were a few cases from time to time among candidates for aircrew who were 35 or older, for instance potential air gunners and flight engineers, where there was genuine hypertension, and such men were not recommended for acceptance.

The position regarding hypertension in flying personnel in 1944 was generally as follows: all those who showed symptoms, such as breathlessness, vertigo, headaches or tinnitus in conjunction with hypertension were grounded and many of them were sent to hospital for investigation. Those with symptomless hypertension were usually grounded or given a category allowing them to fly as second pilot only if the systolic pressure was persistently over 160 mm. Hg. and the diastolic over

100 mm.; these limits were often not applied to members of aircrew other than pilots, but the urine in all such cases was examined carefully for albumen, and microscopically for cells and casts, and if the findings were abnormal the patient was usually sent to hospital for further investigation. It was found that in cases of essential hypertension with a normal urine, the results of tests of renal function such as the Van Slyke or the water-excretion test were almost invariably within normal limits, and there was no evidence that the routine performance of such tests in cases of hypertension was justifiable.

Hypertension in Non-flying Personnel

This was a much larger problem in the war-time Air Force as a whole than it was in flying personnel, owing to the very large numbers of administrative and other non-flying officers who joined the Service after the outbreak of war.

There was an urgent call during the crisis of 1940 for officers to carry out ground duties and many were accepted for home service only. The standards of physical fitness were considerably relaxed during this period and indeed in some cases officers were commissioned without any medical examination on entry. Many of them were over 50 years of age and some even as old as 65. Hypertension, even when quite considerable as shown by systolic pressure of 200 and diastolic of 120, was not regarded as a bar to service at home. Unfortunately, some of these officers, whose physical condition clearly only fitted them for sedentary duties, were posted as station defence officers and later to the Royal Air Force Regiment. Among these were many with hypertension, who soon developed symptoms when exposed to the stress of drills, marches and ground defence operations. Subsequently, too much of the time of No. 1 Central Medical Board was occupied in invaliding such cases or recategorising them as fit only for sedentary duties.

In 1942 when the training of Royal Air Force Regiment personnel became more strenuous and approached commando standards, many of the officers were found to be unfitted physically by reason of age, hypertension and other disabilities for such service, and the Air Ministry issued an instruction which enabled medical boards to pass officers as 'unfit for strenuous duties with the Royal Air Force Regiment' without, however, necessarily downgrading their category.

During the first year of war a number of instances occurred of the invaliding of officers in non-flying branches from oversea owing to hypertension discovered at routine examinations, even though patients themselves had no symptoms and were apparently fit. In view of such cases the Air Ministry, in March, 1941, issued an instruction to all principal medical officers both at home and oversea, in which it was pointed out that mild degrees of symptomless hypertension were consistent with efficient service at home and oversea for many years. It was stated that provided the systolic pressure was below 200 mm. Hg. no action need be taken, and personnel serving oversea need not be transferred to the United Kingdom solely on account of a raised blood-pressure. This did not of course apply to cases where symptoms attributable to the raised blood-pressure were present. Comparatively few patients were invalided home on grounds of hypertension after the issue of this letter, though it was unfortunately true that officers as late as 1944 were sometimes encountered, whom medical officers and boards oversea had unnecessarily returned home owing to a supposed high blood-pressure, which on arrival in the United Kingdom was found to be only slightly above the average.

It was found useless to attempt to retain men with genuine hypertension if they complained of symptoms. Most of these are subjective, for example vertigo or headaches, and even if it was thought that the subject was exaggerating them, invaliding was the best course, because such officers or airmen were able to report sick unnecessarily whenever they pleased. Cases of this kind were relatively uncommon and most of the patients, particularly the officers, continued to give effective service, although as might be expected there were a certain number of cases of coronary occlusion or cardiac decompensation occurring among those retained in the Service.

Organic Heart Disease

Organic heart disease was uncommon among R.A.F. personnel because all of them were examined before entry by Ministry of Labour boards or, if they were to be aircrew, by R.A.F. medical boards. Nevertheless, cases of obvious organic valvular disease were sometimes encountered even among aircrew personnel, and some of these lesions must quite clearly have been present before entry. In many of these cases the physical signs were so obvious that it was inconceivable that any qualified medical man could have missed them had he listened to the heart conscientiously. The probable explanation of such failure to diagnose obvious conditions was that medical officers posted to aircrew medical boards frequently continued their somewhat monotonous work for too long, and thereby temporarily lost their powers of attention and concentration. The relatively large number of cases passing through medical boards, which were not infrequently of necessity understaffed, may also have been a contributory factor.

Though an organic valvular lesion, in particular aortic regurgitation, is often consistent with perfect compensation and physical efficiency in ordinary life, the conditions of operational aircrew duty in the air were such that few persons with an organic heart lesion could carry on successfully for long. Fatigue, high altitude, stress, cold, and irregular hours of sleep were likely to produce symptoms sooner or later. Occasionally, a pilot with chronic valvular disease was encountered who had successfully completed a tour of operational duties, but such cases were very rare. Except in very special cases, aircrew were taken off flying duties completely if they were found to have a definite valvular lesion, though occasionally it was felt justifiable to allow limited flying duties, such as instructing, to be continued.

Valvular lesions were discovered more often among ground staff as these men had not been subjected to examination by a Royal Air Force medical board on entry. In many, the lesions became apparent as symptoms developed during the relatively strenuous period of a recruit's training, and such cases were usually invalided forthwith. Some ground personnel who, in spite of a valvular lesion, had succeeded in becoming fully trained in a trade, were found at routine examinations to have a lesion, most often aortic, without ever having experienced any symptoms. In these circumstances patients of high morale and good physique otherwise were recategorised to Grade III. It was considered unwise to retain anyone with an organic valvular lesion who wished to be invalided, because it was always easy for such a man to complain of symptoms which no medical officer could ignore. However it was found that the majority of persons with organic heart disease were keen, efficient and anxious to remain in the Service, though they were unfit for really strenuous duties. It has been shown from the experience of medical specialists and consultants that retention was justified in the majority of cases; if symptoms developed later, invaliding was advised.

Many of these patients gave no history of rheumatic fever; had they done so at their entry board a more careful examination of the heart would probably have been made and more of the lesions would have been detected.

Myocarditis

There were cases of acute rheumatism which produced myocarditis, with or without endocarditis or pericarditis, among the younger personnel in the Royal Air Force, particularly aircraft apprentices. Patients with acute rheumatism who showed definite evidence of endocarditis or pericarditis were almost invariably invalided, but it was found that a rheumatic myocarditis was usually transient and that after a period of prolonged rest the patient made a complete recovery.

Many patients, both young and middle-aged, were diagnosed as suffering from myocarditis on very slender evidence. In many such cases the chief symptoms were palpitation, shortness of breath and vague precordial discomfort. On investigation no objective evidence could be found of heart disease and it seems probable that most of these cases were of the effort syndrome type of anxiety neurosis. Needless to say, it is most undesirable that neurotics should be labelled as cases of heart disease.

Not infrequently the diagnosis of myocarditis was also made after acute infective diseases, tropical or otherwise. Here again many of the patients were clearly psychoneurotic. A diagnosis of myocarditis should only be made if there are objective findings to support it, such as cardiac enlargement as judged by a displaced apex beat and radiography, and definitely abnormal electrocardiographic findings.

Coronary Disease

Symptoms resulting from coronary sclerosis were not uncommon, as might be expected in a Service containing large numbers of personnel of 45 years of age and more. Practically all occurred in persons of middle-age and over, though there were a very few cases below 30 years of age, in whom a diagnosis of coronary occlusion was made mainly on electrocardiographic evidence. Two patients among aircrew were allowed to return to flying after a period of prolonged observation.

Officers of particular value and experience who had coronary occlusions were often retained in the Service. They rarely returned to duty in less than four months; the period was often longer. A flying category higher than second pilot in a dual-fitted aircraft was very seldom given. Patients were kept under close medical supervision for at least two years and were examined by a medical specialist or consultant at least every six months. Oversea categories were allowed only in very special cases. The policy of retaining valuable personnel, particularly officers, appeared to be justified by results.

Patients who suffered from angina of effort were invalided, except for a few officers in branches, such as accounts, where the work was purely sedentary.

Cardiac Arrhythmias

Sinus arrhythmia is often very obvious, especially in the young, and must be considered normal. When the heart rate of an apparently healthy young adult is found to be rapid at a medical examination, slowing of the rate during expiration is strong evidence that the tachycardia is emotional in origin and of no pathological significance.

Extra systoles, both auricular and ventricular, are also commonly encountered, and they were disregarded except in persons of over middle age with other evidence, clinical or instrumental, of myocardial damage.

Other forms of arrhythmia were relatively rare. Among them were seen a few cases of paroxysmal auricular fibrillation and flutter, which had occurred without any obvious underlying cardiac lesion; some of these were treated successfully with quinidine. In one case transient attacks of fibrillation occurred after recurrences of benign tertian malaria. It is probable that paroxysmal arrhythmias often fail to be detected as the attacks are often short and there is no opportunity of examining the patient during an attack. As they usually cause little or no disability the patient often disregards them.

Congenital Heart Lesions

Cases of coarctation of the aorta have been encountered far more frequently among R.A.F. personnel than among the civil population. The explanation lies probably in the fact that in the Royal Air Force the blood-pressure of young men is frequently taken, whereas in civil practice, even for life assurance, blood-pressure readings are very rarely taken in persons below the age of 40 years. Hypertension in an apparently healthy young adult should arouse suspicion of coarctation. R.A.F. cases showing no symptoms and having good morale and stamina, were allowed to carry on at full duty. It is probable that a proportion of candidates rejected by Air Crew Medical Boards owing to hypertension were cases of coarctation.

Not infrequently systolic murmurs were detected at routine examinations where there was no evidence of valvular lesions, yet the character and type of the murmur was not like those usually associated with purely functional bruits. Some of the murmurs of this kind may be due to small patencies in the ventricular septum. Often they have been known to be present since early childhood. Provided the subject was in first-class condition in other respects, particularly as regards morale, he was allowed to remain on full duty whether ground or aircrew. Unfortunately, when the murmur had been detected in the course of an intercurrent illness such as malaria, such cases were sometimes invalided from oversea with unjustifiable diagnoses of chronic valvular disease. As previous medical documents were often not available oversea the consultants in medicine often gave the officer or airman a certificate stating that the murmur was considered to be of no pathological significance, in order that, should queries arise at a later date, information about the murmur might be available to medical officers who detected it.

ALBUMINURIA

It has long been recognised that varying amounts of albumen are found in the urines of some 5 to 10 per cent. of all young males, who show no evidence of renal, cardiovascular or other disease. It is not therefore surprising that albuminuria should be found so frequently at examinations for fitness for aircrew duties and at other routine examinations. Similarly, at examinations for life assurance albuminuria is a frequent finding, especially in young men. In most cases the amount of albumen is small, generally under half a part per thousand. Life assurance statistics in America appear to show that, taken in bulk, those with albuminuria give a rather less favourable mortality experience than those with normal urines. However, this result is probably no indication that all albuminuria in young and healthy persons is potentially dangerous, as it is likely that, among the cases from which the statistics were derived, there were a proportion of cases of nephritis, who might perhaps have been excluded by more careful investigation and selection.

The frequency of albuminuria is such that rejection for this cause alone would be a serious source of wastage in any Service, and therefore it was essential to make an attempt to distinguish between albuminuria which was pathological and that which might be regarded as benign.

In the first place it must be remembered that prolonged exertion, such as football or rowing, invariably produces albuminuria, sometimes to a very marked extent. Exposure to cold and perhaps less frequently emotional stress are also causal factors. It is important, therefore, when albumen is found at a routine examination, to make inquiries about such points and to test further specimens.

Whereas prolonged and strenuous exercise almost invariably causes albuminuria, the degree of exertion required for its production varies very greatly and in quite a high proportion of people even the relatively slight exertion associated with being up and about, carrying on a normal life, is enough to produce small amounts of albumen in the urine. It is found, however, that if the urine is examined in the early morning before the patient gets out of bed albumen is absent. This condition has therefore been termed orthostatic or postural albuminuria. It is a relatively frequent condition and there is practically general agreement among clinicians that it has no pathological significance.

Orthostatic albuminuria was a troublesome problem for aircrew medical boards. The majority of their candidates, at any rate in the first few years of war, were civilians. In order to obtain a true morning specimen of urine a candidate had to be held for the night and arrangements made to collect a specimen before he dressed next morning. Consequently many of the boards adopted the system of instructing the candidate to go to his own private medical attendant for further investigations. This naturally caused delay, and the reliability and value of the results of investigations were very variable. Aircrew medical boards had no microscope and no facilities for any urinary examination except for albumen and sugar. Moreover, there was at first no authority to refer civilian candidates for aircrew to nearby E.M.S. hospitals for investigation.

Aircrew candidates who were already in the Service presented fewer problems, if albumen were discovered, as they could be referred back to their medical officers with instructions about any necessary investigations. Unfortunately, especially in the earlier years, these cases were often admitted to hospital where they spent relatively long periods under investigation instead of being dealt with as out-patients. Not infrequently various tests for renal function including urea-clearance tests were done; such tests were unlikely to give any information of value in persons with albuminuria who showed no other signs of disease, and they placed an additional burden upon the pathologist.

The important points to determine about a case of symptomless albuminuria are:

(i) is albumen present in an early morning specimen passed before the patient gets up ?

(ii) are there any abnormalities, such as red cells, white cells or casts in the centrifuged deposit ?

If the answer to both these questions is in the negative and the candidate is in other respects completely fit the case can be regarded as one of orthostatic albuminuria and the individual accepted as fit; if albumen is again discovered at a later date, no further investigations should be undertaken unless fresh developments have occurred.

If albumen is persistently present in both early morning and day specimens and particularly if the amount is considerable the candidate is best rejected for aircrew. This applies even more strongly if there are abnormal constituents in the deposit.

The majority of cases of symptomless albuminuria discovered at routine examinations proved to be of no pathological significance. Occasional instances were encountered where the detection of albumen led to the discovery of renal disease. As an example, a young pilot was examined for fitness for service oversea; owing to the discovery of albumen, microscopical and bacteriological examinations of the urine were carried out which showed pus cells and *Bacillus coli*. Investigations at hospital showed well-marked impairment of renal function. In spite of these findings the patient remained perfectly fit and free from symptoms. He continued to fly very successfully in a photographic reconnaissance unit.

URINARY CALCULUS

Appendix F of 'Air Publication 130' laid down some general principles about the disposal of patients with urinary calculus among Service personnel. It was there stated that as a general rule patients who had had urinary calculus, even though apparently cured, should not be categorised as fit for more than limited flying duties at home (dual-fitted aircraft only and with another pilot) for a period of two years from the date of the attack; if no recurrence took place after the first year, they were to be thoroughly investigated radiologically, biochemically and bacteriologically, and, if found fit, to retain the same category for a further year. At the end of that time the above tests were to be repeated and if they were satisfactory such patients were to be boarded at the Central Medical Establishment where the question of raising the category to allow full flying duties could be considered. These directions were not absolute and it was open to consultants to make other recommendations in special cases. It was also stated that the remarks regarding calculus should in general apply equally to those suffering from renal colic, which could not be definitely shown to be due to calculus. The directions were written primarily with reference to pilots.

In war-time, particularly when bombers ceased to carry a second pilot, there was little opportunity of flying for any pilot with the category put forward in Appendix F. In consequence any pilot so categorised was for practical purposes grounded. Moreover, even in higher formations, such as commands and groups in operational commands, officers holding staff appointments were often expected to travel by air in the course of their duties, and an inability to pilot an aircraft restricted their usefulness to a considerable extent.

No special instructions were laid down about those who had passed a calculus after one or more attacks of renal colic; this is by no means an uncommon event in cases of renal calculus among those under middle age, and often after passing a calculus no further symptoms develop, provided there is no persistent urinary infection or pathological condition, such as hydronephrosis.

Bearing these facts in mind the instructions in Appendix F were interpreted liberally by the consultants provided there was no evidence of residual infection; if no stone could be demonstrated radiologically it was assumed either that it had been passed or there had never been a calculus.

The restrictions on pilots with urinary calculus were made on account of the fear that an attack of renal colic in the air might incapacitate a pilot to such an extent as to endanger life and aircraft, but clinical experience and the facts themselves did not appear to justify such restrictions: no instance of a patient developing an attack of renal colic in the air had been reported to the consultants in medicine up to 1944. It is interesting to note that in 1940 a pilot flying a heavy bomber perforated a duodenal ulcer and was able to bring the aircraft back to base and land it safely. Probably, if such a major catastrophe as a perforation failed to incapacitate a pilot, an attack of renal colic would not be fraught with great risk.

These considerations enabled the consultants to return to flying duties many pilots who had suffered from attacks of renal colic, with or without the proven presence of a calculus, in periods far shorter than those suggested in Appendix F.

In 1943 the question of the disposal of cases of urinary calculus was discussed at a conference of the consultants in medicine and surgery. It was recommended that an attack of renal colic in any member of aircrew, provided the stone had been passed, removed at operation, or was not demonstrable, should involve only two months of ground duties on home service after return to duty. After this period, provided there was no evidence of persistent disease, a restricted flying category (dual-fitted aircraft only and with another pilot) should be allowed for a further period of two months. At the expiration of this period, that is four months after return to duty, he should be categorised as fit for full flying duties at home, and after a further three months as fit for full flying duties at home and abroad, provided urinary sediment was normal, the subject was free from all symptoms and a straight X-ray revealed no abnormality.

The scheme allowed pilots who had suffered from renal colic or calculus, provided their progress was normally satisfactory, to be fit for operational duties at home in four months and for full duties at home and abroad in seven months.

Renal calculi occurring in persons over middle age are more likely to be associated with persistent urinary infection and therefore an increased liability to recurrence. In such cases the consultants rarely felt it justifiable to recommend a category for oversea service, particularly in the tropics, where the relative oliguria is likely to cause recurrence.

DIABETES MELLITUS

It has been estimated from surveys carried out in the United States that there must be approximately 300,000 persons in the United Kingdom suffering from diabetes although there are no definite figures to indicate the incidence: of these, the majority are over military age. Diabetes, when satisfactorily controlled by insulin, is consistent with good health and physical efficiency, and there is no doubt that a small number of diabetics succeeded in joining the Royal Air Force as aircrew and managed to avoid discovery by medical boards in the early days of war. A doctor stated that to his knowledge four of his former patients, taking insulin, were carrying out aircrew duties successfully; this suggested that there must have been others. One successful night-fighter pilot was by chance discovered to be taking 70 units of insulin daily, but the discovery was only made after he had flown nearly 500 hours. However these are exceptional cases and diabetes of any severity was a cause for rejection for service; therefore the only problems which arose in relation to the disease were due to its development in those who were already serving.

There were very few diabetics in the Royal Air Force before the war ; one of the cases was that of a senior officer and the others were among technical officers. During the first year of the war practically all persons discovered to have diabetes were invalided, but, as the man-power situation became more difficult, it was decided that diabetes need not necessarily involve invaliding, particularly if the diabetic was an officer or a highly trained and valuable non-commissioned officer.

By 1942 there were quite a number of known diabetics, almost all officers, who had been retained in the Service, and in that year the consultants in medicine submitted a memorandum on the subject, in which they emphasised that diabetes, even when severe enough to require treatment by insulin, did not necessarily prevent the patient from carrying out ground duties efficiently. It was recommended that mild diabetics who did not require insulin should be allowed to remain on limited flying duties and those taking insulin to have a full ground category of A4B if they were senior officers. However, these recommendations were not accepted by the Air Ministry, who made a definite ruling that no diabetic, whether on insulin or not, could be allowed to fly or proceed oversea.

In addition to cases of true diabetes, many persons were found to have glycosuria at a routine examination at medical boards and elsewhere; when this occurred among personnel below the age of 35 it was shown to be due in most cases to a low renal threshold, and the number of true diabetics discovered at routine examination was negligible. Unfortunately, in the early days of the war patients in whose urine a reducing substance had been found were often sent to R.A.F. hospitals for investigation. In most cases of this kind no abnormality could be discovered and much time was wasted in hospital. For example, four airmen were transferred from Eastbourne to Halton because their medical officer alleged that he found sugar in the urine; all investigations were completely negative and it seemed almost certain that a deteriorated Fehling's solution must have been used in testing the urine. The attention of medical officers was thereafter drawn to the importance of testing with Benedict's solution before accepting reduction as an indication of glycosuria, and medical officers were instructed to send their patients showing signs of glycosuria to the nearest convenient hospital, either E.M.S. or Service, as outpatients to have blood-sugar tolerance curves carried out.

An undue length of time was also spent in hospital by many diabetics who were retained in the Service, while they underwent stabilisation. This was because medical officers were too anxious to achieve a complete and permanent absence of sugar in the urine in all cases. This object, however desirable in theory, can rarely be attained without making the patient liable to insulin reactions.

There was a tendency during the war for diabetics, both civilian and Service, to take a relatively high carbohydrate diet, and during 1944 and 1945 few diabetics were taking less than 200 g. of carbohydrates daily. Diabetics could obtain a certificate backed by a medical practitioner which entitled them to draw three civilian meat rations, three civilian fat rations, and an increased amount of cheese. The majority of diabetics drew these extra rations to supplement the relatively low allowances of protein and fat in the civilian ration; these extra rations could be drawn by Service diabetics, whether living out or in messes.

There was a tendency early in the war to have sugar tolerance curves carried out at frequent intervals on diabetics retained in the Service, presumably with the idea that information would be obtained about their progress. It later became more generally realised that the sugar tolerance curve is of little value either in treatment or prognosis and the employment of this investigation tended to be limited to the diagnosis of symptomless glycosuria, where undoubtedly it must remain the ultimate criterion in differentiation between diabetes mellitus, renal glycosuria and glycosuria showing a lag curve.

The number of Service personnel who have developed diabetic coma has been negligible and only two fatal cases came to the knowledge of the consultants in medicine; these were unfortunately not diagnosed until the condition was advanced.

Diabetics who developed the disease in the Service were taught the general principles of dietetics. Every R.A.F. hospital had a copy of *The Diabetic Life* by Dr. R. D. Lawrence, which the patient was encouraged to read. He was taught to test his urine using Benedict's method and also the technique of insulin injection. The majority of retained patients used zinc protamine insulin with or without soluble insulin and few needed more than one injection a day.

A follow-up in 1944 of officers with diabetes retained in the Service showed that they had continued to give effective service and had experienced no real difficulties with diet or insulin even when living in messes.

The consultants in medicine found on the whole that diabetics were co-operative and keen to remain in the Service. Most of them knew far more about the management of diabetes than their medical officers, and they varied their diets and insulin dosage without necessarily consulting a medical man. However, there were a few who were invalided for temperamental reasons or because they were unusually insulin-sensitive or insulin-resistant. The consultants in medicine felt that it was unwise to try to retain diabetics who were not anxious to remain in the Service, as it was too easy for them to report sick at frequent intervals. It was not found necessary to recommend special postings for diabetics to enable them to live in their own homes.

Extremely few cases of diabetes have been reported as due to trauma. Dr. E. P. Joslin, with his enormous experience of diabetes has never seen a case, and among the millions of wounded in the War of 1914–18 diabetes does not appear to have developed either after head or abdominal wounds. Experience among R.A.F. personnel in the War of 1939–45 has not brought to light any case of diabetes which could reasonably be attributed to trauma.

(iv)

Medicine in the Emergency Medical Services

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INTRODUCTION

In planning the medical services for war, there is a natural tendency and indeed an essential need to concentrate upon provision for the treatment of war-time casualties—wounds, gas gangrene, head injuries, the effects of enemy air raids, etc. The surgeon comes into his own and develops his craft with ample occupation for his skill. But the physician also has his part to play in war-time, and it is no minor rôle. Not only may medical complications accompany surgical casualties, but warfare brings in its train diseases, epidemics, malnutrition and its deficiency problems, mental strain and psychical disorders. The need for medical care in war is appreciated by all students of history. The plague of Athens, probably typhus fever, so well described by Thucydides, the dysentery and malaria of the Walcheren Expedition in 1809, the cholera of the Crimea and the enteric fever of the South African War are all illustrative examples. There is also the need to provide prophylaxis and medical treatment for the civilian population, a need recognised by friend and foe alike; for the enemy cannot allow infectious disease to run rife among the population of an occupied territory, because it will inevitably spread among his own troops.

In setting up the Emergency Medical Service in Great Britain under the shadow of threatened war, the provision was primarily for the casualties of war. But the medical side was well provided for and the physicians and resident medical officers were fully occupied with clinical work in the Emergency Hospitals. Many of them exercised their vocation under entirely new conditions. They had to work in unfamiliar hospitals and there was no longer a completely static or representative population from which their patients came. Instead of the local hospital area the patients came from a much wider regional area. The young men and women were in the Services and many went oversea. Certain classes of the community were evacuated from urban to rural areas in order to space out the risks of aerial bombardment over as wide an area as possible. The pre-arranged plans for evacuation made by the Ministry of Health and the Board of Education concerned school children, younger children with their mothers, expectant mothers and some other priority classes of the population. Plans were made for the evacuation of 3,000,000 persons; some 1,230,000 took advantage of the offer. During the battle of the flying bombs in the summer of 1944, which menaced London and Greater London, apart from those who went at their own expense, there went from London 818,000 people—228,000 mothers and expectant mothers, 537,000 children, and 53,000 old, invalid and blind persons. These evacuated persons brought with them into new districts diseases and ailments, which required medical treatment. Further disturbance of the normal population was caused by transference of industrial workers. Again, the Emergency Hospitals provided treatment for military and Air Force patients, so that physicians occasionally encountered cases of tropical diseases such as amoebic dysentery, malaria, blackwater fever and more rarely kala azar in patients invalided from oversea. The evacuation of the chronic sick from London and the coastal towns brought a number of them into hospital beds. These chronic diseases provided new opportunities for study and teaching. The co-ordination effected by the Ministry of Health between the municipal and county hospitals and the voluntary hospitals in which the administrators and medical staffs of both classes of hospital played a patriotic and unselfish part; the 'up-grading', as the term went, to describe the steps taken by the Ministry to bring up the less well provided hospitals to a normal standard of efficiency; the additions made to existing hospitals in the form of hutted wards, treatment rooms and special departments; the organised provision made by the Ministry of special equipment, for example, X-ray apparatus, electrocardiographs, physical therapy apparatus and new and modern drugs; the provision of pathologists and well-equipped laboratories through the Emergency Hospitals Pathological Service and the Emergency Public Health Laboratory Service; the Blood Transfusion Service; all this comprehensive work of administration and organisation, described in the *Emergency Medical Services*, Volumes I and II of this History, enabled physicians to diagnose their patients' maladies with greater accuracy and to treat them with the full resources of modern medicine. For the first time the physician was able, in a previously isolated part of the country, to diagnose and treat his patients with all the resources of a leading London or provincial teaching hospital. There was also a wider distribution of specialists in medicine than had hitherto been the case. Thus the general physician could obtain the advice of a neurologist on a case of nervous disease, of a dermatologist on some skin lesion, etc.

In addition, the Emergency Medical Service made provision, at certain suitably placed institutions, of treatment centres specially staffed and equipped to deal with patients requiring certain forms of specialist treatment. The establishment of these centres enabled much larger numbers of cases to be dealt with efficiently by experts than would otherwise have been possible, owing to the limited number of specialists available. The medical special centres established for the treatment of the following disorders were:—

Neurosis	14
Rheumatism	3
Effort syndrome	1
Skin diseases	25
Children's diseases	18

The number of beds in each of the centres was variable and elastic, and no difficulty was found in accommodating all the cases requiring treatment. The consultant advisers at headquarters, appointed by the Minister of Health, advised on the arrangements necessary to provide efficient treatment for the different types of cases admitted to these centres, and regional advisers were appointed also.

To sum up, from a heterogeneous collection of over 3,000 medical institutions of various grades under a variety of systems of administration, upwards of one thousand hospitals, well equipped and as efficiently staffed as the shortage of man and woman-power would permit, were welded into a homogeneous hospital service. These participating hospitals, in addition to their normal obligations which had prevailed in peace-time, were required to treat all patients, civil and military, for whom the Minister of Health had accepted responsibility, and to transfer patients to other hospitals in the Service in order that the necessary number of beds might be available for new admissions in the areas where they were required.

Such was the new hospital environment in which hospital physicians dealt with disease during the war. Through the Emergency Hospital organisation the resources of modern medicine were made available to civilians and Service patients on a wider scale than had hitherto been possible. The clinical manifestations and the advances made in the study of the more important diseases occurring during the war will next be considered.

GENERAL INFECTIVE DISEASES

The epidemiology and public health aspects of general infectious diseases are described in the *Civilian Health and Medical Services*, Volume I of this History. A brief account is given here of the chief infectious diseases with which physicians were concerned during the years of the war. The notifications of the principal infectious diseases in England and Wales furnish an illustrative account of the incidence of these diseases, with the exception of tuberculosis (see Appendix A, Table I). The mortality of infectious diseases from 1938 to 1945 is given in Appendix A, Table II.

The incidence of the common infectious diseases, with the exception of a decline in that of diphtheria, continued to be appreciable in war-time.[(1)]

Scarlet Fever, Measles and Whooping Cough

The incidence of scarlet fever, apart from an epidemic period in 1943, gradually declined and the already low fatality rate fell still lower. Measles and whooping cough prevailed widely. For both diseases 1940 and 1941 were years of epidemic prevalence. The death rates were low. Repeated trials were made of pertussis vaccines in the prophylaxis and treatment of whooping cough, but the results appeared to be inconclusive.

Diphtheria

There was a gratifying decline in the incidence and mortality of diphtheria. These reductions can fairly be ascribed to the intensification of prophylactic inoculation of anti-diphtheritic vaccine. Diphtheria is a preventible disease and the steps towards its eradication were accelerated during the war.

Smallpox

The few outbreaks of smallpox that occurred were speedily controlled, through vaccination of patients and contacts, hospital isolation and disinfection.

Enteric Fever

There was an appreciable amount of both typhoid and paratyphoid fevers during the war years. In 1941 the number of cases of enteric fever (typhoid and paratyphoid) was more than double the mean of the preceding three years, the rise being almost entirely accounted for by three extensive outbreaks of paratyphoid B fever at Bristol, Liverpool, Birmingham and Leicester. Through the Emergency Public Health Laboratory Service a greater proportion of cases of enteric fever were investigated bacteriologically, and it is highly probable that the observed rise in notification of this disease was partly attributable to more accurate diagnosis. The work of Felix and others on bacteriophage typing of typhoid and paratyphoid bacilli, now indispensable for accurate diagnosis, was a notable advance and is described elsewhere. Prevention also earned its laurels in the war years. It is a great tribute to the local authorities of London, Coventry, Liverpool, Bristol, Plymouth, Exeter, Birmingham and elsewhere, that in spite of enemy action in the destruction of sewers and water mains, not a single case of enteric disease was attributable to the damage.

Bacillary Dysentery

Table I shows the progressive rise in the notifications of dysentery in England and Wales since 1938, a rise interrupted only in 1939. Dysentery is a widespread infection in this country and is chiefly due to the Sonne bacillus, the remaining cases being due to eight or nine types of *Sh. flexneri* with a small miscellaneous residue of little importance. The notifications in the war years do not represent the full prevalence of dysentery, for a substantial proportion of cases went unnotified through pressure of work on a depleted medical service, and because bacillary dysentery in this country shows great clinical variation, many mild cases passing unrecognised. Symptoms may be absent or slight; there may be a simple diarrhoea in which mucus or blood may or may not be present; sometimes vomiting may be a prominent feature. If 'asylum dysentery' be excepted, the disease is usually mild, but it is occasionally infectious to infants and young children. It is doubtful whether chronic carriers exist, except in institutions for the insane, in which reinfection is always to be suspected. Infection is derived from patients, particularly if ambulant, from convalescents and from healthy infants who harbour and excrete the organisms. A certain number of cases of amoebic dysentery in Service patients coming from abroad were treated in E.M.S. Hospitals.

Influenza

This disease, which wrought such havoc in 1918–19, proved not to be a serious menace in this war. There was moderate epidemicity in 1940 and again in 1943, but in 1945 the number of deaths was the lowest recorded for thirty years.

Scabies

This disease had a high and rising incidence in Great Britain from 1930 onwards. This increase was heightened when war began. (See *Civilian Health and Medical Services*, Volume I.)

EPIDEMIC NERVOUS DISEASES

Acute Poliomyelitis

Tables I and II in Appendix A show that the incidence and mortality of acute poliomyelitis and polioencephalitis declined during the war years, as compared with the 1,489 cases of poliomyelitis, with 174 deaths reported in 1938. There were, however, 128 cases of polioencephalitis with 54 deaths in 1940. Oversea epidemics of poliomyelitis occurred in Sicily, South Italy and Malta.

Encephalitis Lethargica

This disease, which appeared in Great Britain in epidemic form in 1918 during the First World War, still occurs in this country, although the fresh cases notified are comparatively few. Table I, Appendix A shows that the number of cases occurring annually from 1938 to 1945 were respectively 194, 159, 211, 187, 148, 109, 79, and 76. Table II shows that the number of deaths for the same period, e.g. 516 in 1938, 729 in 1940 and 461 in 1945 far exceeded the number of notified cases, being mainly due to sequelae from earlier years. Encephalitis Lethargica is still a disease to be reckoned with. For other forms of encephalitis see Chapter X.

Cerebro-spinal Fever

War favours epidemics of cerebro-spinal fever owing to overcrowding and lack of adequate ventilation in camps and billets, which assist droplet infection, and through the movements of troops, which lead to the introduction of fresh and virulent strains of the meningococcus. From the end of 1914 until 1918, cerebro-spinal meningitis was epidemic on an unprecedented scale in Great Britain, the case mortality-rate averaging 72 per cent. In 1938 MacNalty[2] directed attention to the maintained incidence of notifications of the disease and the increased number of Group I meningococcal infections, and considered it probable that another period of epidemic prevalence was approaching. This forecast was fulfilled and was aggravated by the outbreak of war, and by the introduction of fresh strains of the meningococcus by troops coming from oversea. In 1940 the disease began rapidly to increase and continued to do so until late in 1941. The total of notifications in 1940 was nearly fourfold that of our previous worst experience in the year 1915. From 1942 to 1945 the incidence and case-mortality gradually declined (see Tables I and II, Appendix A). In character the disease displayed its usual severity, and in distribution it prevailed widely. The clinical manifestations were more clearly elucidated, and for an account of the four special syndromes—chronic meningococcal septicaemia, the encephalitic syndrome (fulminating and acute), the pure adrenal syndrome, and the mixed or encephalitic adrenal syndrome—reference should be made to Chapter VI in this volume. Fortunately, the use use of the sulphonamide drugs and later that of penicillin, in treatment, achieved the lowest fatality-rate on record; in some outbreaks the low figure of 4·8 per cent. was attained. The annual fatality-rates for the period 1941–4 were, in succession, 19·5, 20·0, 23·6, and 25·6, rates which imply a saving of approximately 15,000 lives. Chemotherapy has provided a powerful weapon against this deadly disease.

Investigations were made into the sequelae of cerebro-spinal fever during the war years. Colonel E. C. G. Maddock[3] inquired into the after-history of 1,075 persons who had recovered from cerebro-spinal fever whether treated or not by sulphonamides. Degen *et al.*,[4] in a paper entitled 'Sequelae of cerebrospinal meningitis—a follow-up study of 986 cases', found there was an appreciable incidence of persistent symptoms following the disease. These sequelae of organic origin were mainly due to:—

(*a*) Slow organisation of meningeal exudate and formation of adhesions, as in hydrocephalus and in ocular, facial and limb palsies;

(*b*) Inflammatory extensions of the meningitis, as in labyrinthitis with deafness;
(*c*) Metastatic inflammations, as in choroiditis or panophthalmitis, and arthritis;
(*d*) Focal damage to the central nervous axis, as in blindness of central origin, aphasia and hemiplegia; and probably
(*e*) More general damage to the central nervous axis as in sequelae which resemble the post-concussional syndrome, e.g. headache, dizziness, mental depression, insomnia and failure of concentration and memory.

This is a formidable catalogue of sequelae, but it must be remembered that the organic lesions occurred only in a small proportion of cases. A large proportion of patients presented functional nervous sequelae which under appropriate conditions usually entirely subsided. Ultimate efficiency, except when there were organic sequelae (of which perhaps deafness was the most persistent and troublesome) was not lowered by an attack of cerebro-spinal meningitis. Chemotherapy cut short the acute stage of the malady and appeared also to diminish the risk of organic sequelae.

OTHER INFECTIVE DISEASES

Tuberculosis

Tuberculosis during the war is considered in the *Civilian Health and Medical Services*, Volume I, but some reference to the subject may be made here. In the War of 1914–18 there was a general rise in tuberculosis throughout Great Britain, mainly attributable to contact infection, overcrowding, and breaking down of bodily resistance to infection by prolonged physical or mental strain. It was feared that history would repeat itself, and the rise in mortality during the first three years of the war supported that fear. This is shown in the table on opposite page.

But in contrast to the First World War the mortality afterwards was not progressive, the figures of deaths for the years 1942–4 showing a pronounced fall to the pre-war level. The figures for 1945 show a continuance of the fall to a new record low level.

The most disquieting feature was that deaths among children from pulmonary tuberculosis and tuberculous meningitis increased substantially during the war. A proportion of the deaths in the non-respiratory form was due to persons (chiefly juveniles) drinking infected milk.[5] The appreciable general decline in mortality from tuberculosis has been maintained in the post-war years, but in certain industrial areas in the North of England and in Scotland there has been a disquieting rise in mortality.[6] Miniature or mass radiography was greatly developed during the war and has proved an important aid to early diagnosis. Recent work on chemotherapy, especially that relating to streptomycin and promin (a synthesised sulphone), encourages the hope that, eventually, a drug will be found which will destroy the tubercle bacillus in man.

Tuberculosis Mortality in England and Wales during the War Period

Year	Respiratory	Other forms	All forms
1939	21,542	4,081	25,623
1940	23,660	4,484	28,144
1941	23,633	5,037	28,670
1942	20,989	4,560	25,549
1943	21,342	4,307	25,649
1944	20,104	4,059	24,163
1945	20,013	3,942	23,955

Venereal Diseases

War circumstances favour the spread of venereal diseases, and the Second World War was no exception to this rule. The increase was most marked in females. Great advances were made in treatment. The sulphonamide drugs were first found efficacious in the treatment of gonorrhoea, but with the advent of penicillin a great advance was made in the treatment of both gonorrhoea and syphilis. Penicillin reduced the time required for the treatment of gonorrhoea to a few days, and that for syphilis from a year to approximately ten weeks, though in both these diseases 'following-up' was essential. For further information see Chapter V in this volume, and the *Civilian Health and Medical Services*, Volume I.

Malaria

At the outbreak of war in 1939, when the risks of malarial infection introduced into this country from oversea again became imminent, the Ministry of Health had an efficient organisation to hand, based on the work and experience of the First World War, and an expert staff conversant with the problems that were likely to arise (see Malaria, in *Civilian Health and Medical Services*, Volume I). That these precautions achieved their aim is evident from the insignificant number of cases of indigenous malaria that occurred. Anti-malarial work made great advances during the war and was another triumph of preventive medicine. It is described in Chapter VII in this volume. New and potent drugs, such as 'mepacrine' and 'paludrine', for the prophylaxis and treatment of the disease were used successfully for military patients infected with malaria abroad, who were warded in the Emergency Service Hospitals.

Epidemic Hepatitis

In the war years there was a largely increased incidence of jaundice throughout Europe, North Africa and the Middle East, with an increased mortality from hepatic necrosis. Much new light was thrown upon the disease as the result of war experience and the observation of cases in the Emergency Medical Service Hospitals. A clinical account of the disease will be found in this volume (Chapter IX), while its epidemiology and instances of other forms of infective jaundice which called for attention and study during the war years will be found under the heading Infective Jaundice in *Civilian Health and Medical Services*, Volume I.

The Chief Fatal Diseases (other than Acute Infectious Diseases)

England and Wales: Principal Certified Causes of Death, 1939–45

Causes of death (classified by 1938 Revision of International List)	Number of deaths (including those of non-civilians) registered in England and Wales						
	1939	1940	1941	1942	1943	1944	1945
Diseases of the Heart . .	125,938	136,476	122,086	116,866	120,737	124,143	128,323
Other diseases of circulatory system .	14,553	15,732	14,296	14,248	15,041	15,577	16,057
Intracranial lesions of vascular origin .	48,672	51,683	48,173	48,381	48,945	50,877	52,691
Cancer—malignant disease	67,154	68,922	69,227	70,419	72,155	72,110	74,291
Bronchitis .	31,436	46,281	34,051	26,863	31,420	27,186	29,655
Pneumonia (all forms) .	23,403	29,195	26,418	20,828	24,763	20,040	19,984
All diseases of respiratory system .	6,720	8,645	6,430	5,744	6,344	5,903	6,118
Diseases of digestive system	18,700	19,502	18,456	16,913	16,637	16,226	15,832
Non-venereal diseases of genito-urinary system .	23,112	24,157	22,842	21,656	21,280	20,912	20,527
Other defined diseases .	24,109	24,978	24,460	22,117	21,677	20,032	20,627
Old age, senility	17,267	19,232	17,782	15,852	16,673	16,325	16,982
Operations of war . .	319	27,411	25,662	9,192	8,978	16,286	5,239

The percentage contributions to the total deaths made by the more important groups in the above table were as shown on opposite page, the deaths of non-civilians registered in England and Wales being included.

Percentage Contributions to Total Deaths

	1939	1940–41	1942–43	1944	1945
Diseases of heart and circulatory system and old age . . .	31·6	29·2	30·5	31·7	33·1
Intracranial lesions of vascular origin	9·7	8·9	9·9	10·3	10·7
Cancer, malignant disease . .	13·4	12·4	14·5	14·7	15·2
Bronchitis, pneumonia and other respiratory diseases . .	12·3	13·5	11·8	10·8	11·4
Diseases of digestive system .	4·6	4·2	4·4	4·3	4·3
Non-venereal diseases of genito-urinary system . . .	4·6	4·2	4·4	4·2	4·2
Violent causes (including operations of war)	5·0	9·5	6·1	7·4	5·1

The above table shows the principal certified causes of death during the years of the war from diseases, other than from acute infectious diseases, which have already been considered. To this table is added a statement of the percentage contributions to the total deaths made by the more important groups.

As in previous decades, by far the largest proportion of deaths was due to diseases of the heart and circulatory system. Rheumatic fever as a cause of heart disease was less frequently encountered than in the past, and the majority of these deaths were due to degenerative changes in the heart and blood-vessels and occurred in adults and old people. If to these deaths be added the deaths from old age, many of which are presumably due to myocardial failure, we find that these diseases were responsible for an average of over 30 per cent. of the total deaths. This figure is considerably increased if to it be added further deaths from intracranial lesions of vascular origin, which were responsible for about 50,000 deaths in each year.

The next killing disease was 'cancer', which included carcinoma, sarcoma, the gliomas and other forms of malignant disease. The annual number of deaths rose from 67,154 in 1939 to 74,291 in 1945. It is still a question, however, whether an ageing population which is more susceptible to cancer, and improved methods of diagnosis, were not chiefly responsible for the increase noted.

Bronchitis, pneumonia (all forms) and other respiratory diseases came next in order. The influence of climate and influenza on mortality from these diseases was noteworthy. The winter of 1940–1 was severe and in all forms of respiratory disease the deaths appreciably rose in 1940. Deaths from diseases of the digestive system rose appreciably in 1940, but thereafter declined and were 15,832 in 1945 as compared with 18,700 in 1939.

Diseases of the genito-urinary system, which include the various forms of nephritis, were appreciably lower after 1940.

For purposes of comparison the figures of deaths from operations of war have been included in the table. It will be noted they were comparatively insignificant as compared with the deaths from diseases of the heart and circulatory system and cancer. The Navy and the Air Force protected the British people from the terrors of invasion by a ruthless enemy and from air-raids, the effects of which would otherwise have been seen not only in a higher rate of death from bombing casualties but also in deaths from exposure, tuberculosis, deficiency diseases and malnutrition.

CHIEF GENERAL DISEASES OF THE WAR PERIOD

Diseases of the Heart and Circulatory System

In the chapter on Cardiology in this volume it is stated that the numbers of men invalided from cardiovascular causes, organic and functional, in the war of 1939–45, were only a small fraction, one-fiftieth, of the large numbers invalided from this cause in the War of 1914–18. Disordered action of the heart (D.A.H.) or valvular disease of the heart (V.D.H.) were noticeably absent from the casualty lists of the second war. This is explained by increased knowledge of the medical profession on the subject of cardiovascular disease largely due to the work of Mackenzie, Lewis, Parkinson and others, the use of the electrocardiograph, X-rays and estimations of blood-pressure and the availability of cardiologists for consultative purposes in the Services, through the recruiting boards and in the Emergency Medical Service hospitals. Functional diseases of the heart greatly diminished as compared with the War of 1914–18. In that war pensions for 'functional' diseases of the heart were awarded to 44,855 persons, as compared with 938 so far awarded to persons, both male and female, suffering from this disability in the War of 1939–45. Here, however, caution must be exercised in drawing a comparison between the two sets of figures. The group labelled 'functional disease of the heart' in the Ministry of Pensions statistics for the War of 1914–18 was the initial diagnosis for pensions purposes of a heterogeneous class which, eventually, was found to include numbers of cases of pulmonary tuberculosis, gastric diseases, neurosis, etc. In the War of 1939–45 the term 'functional disease of the heart' was abandoned, and the diagnosis of 'effort syndrome' was only made after exclusion of the heterogeneous cases which had been included under the term 'functional disease of the heart' in the First World War. The 938 cases mentioned above were those pensioned for 'effort syndrome', and their diagnosis was on a much more critical and accurate basis than were the 1914–18 War group of functional cardiac disorders. Paul Wood(31) in 1941 came to the conclusion that the diagnosis of 'effort syndrome' should be abandoned, and that the cases, formerly so diagnosed, should be classified as 'psychoneurosis' or 'anxiety neurosis'. He suggested as an example of a proper diagnosis : 'anxiety neurosis (effort intolerance)'. It can therefore be justly said that in the past war the diagnosis and prognosis of cardiovascular disease attained a high degree of scientific accuracy.

The aetiology of cardiovascular disease is complex. Rheumatic fever, though diminishing, is still responsible, according to P. Stocks's estimate, for heart disease in at least 300,000 persons of both sexes in Great Britain. J. Parkinson[7] quoting these estimates in his Harveian Oration delivered in October, 1945, urged that a national effort for the control of rheumatic fever should be made, and that there should be set up a Central Committee to organise and extend existing special facilities, such as supervisory clinics and long-stay hospital schools, thus providing greater opportunities for much needed research into causation and prevention. In 1946, at the request of the Minister of Health, the President and Comitia of the Royal College of Physicians appointed a special committee for this purpose.

During the war the medical examination of potential recruits was an important part of medical service, and many were rejected for heart disease. The major problem for cardiologists was to detect the presence of rheumatic heart disease when it was early and symptomless, a stage not seen except incidentally in peace-time practice. From 1940 to 1945 medical boards referred 2,500 recruits to J. Parkinson [32] for a cardiological opinion before acceptance for military service, and of these 609 (24 per cent.), were judged to have chronic rheumatic valvular disease. The commonest reason for reference was the presence of a systolic murmur; others were displacement of the apex beat, an altered first heart sound, a noticeable third heart sound, arrhythmia and tachycardia. Radioscopy proved to be invaluable in early diagnosis, but electrocardiography was of little value. In no less than 80–90 per cent. of these early cases convincing X-ray evidence in support was found.

As already remarked, degenerative lesions (arterio-sclerosis, atheroma, chronic myocarditis and endocarditis, occlusion of the coronary arteries and the effects of hypertension) are responsible for the greater proportion of cardiovascular cases at the present day. When once the degenerative process has started, little can be done to remedy the mischief; it is impossible to put new 'rubber' into damaged blood-vessels; and the effects of the wear and tear of life inevitably become apparent in old age. One aetiological factor, syphilis, in the production of cardiovascular disease undoubtedly plays a much less important part since effective treatment for syphilis has been made generally available during the past thirty years. This is shown by the comparative rarity of thoracic aneurysm.

Treatment. In the treatment of cardiovascular diseases great advances were made during the war. The most striking success was achieved in malignant, infective or subacute bacterial endocarditis which, until the advent of penicillin, was almost invariably a fatal disease; treatment with sulphonamides or with sulphonamides combined with heparin being successful only in a few cases. Towards the end of the war, it was found that penicillin, in adequate dosage, could cure over 60 per cent. of cases. The addition of heparin to penicillin therapy appeared to have no advantage and might be attended with the risk of haemorrhage and embolism.

Three successful cases of treatment of the disease by streptomycin were recorded by Priest and McGee[8] in America.

Treatment of cardiac disease and circulatory failure by digitalis advanced and became more scientific. The catheterisation of the right auricle by Cournand[9] in America led to the scientific demonstration by McMichael[10] and his colleagues in England that venesection and digitalis will reduce venous pressure and improve the cardiac output in cases of circulatory failure.

Further, during the war cardiologists studied coronary thrombosis and angina pectoris. Experience showed that in both these conditions the prognosis with appropriate treatment was not so grave as was previously believed. In coronary thrombosis, if the patient survives the first attack, a second, third or even fourth attack need not necessarily prove fatal. The patient should rest for some time after the attack, and after convalescence limit his activities as far as possible and give up tobacco entirely, if he has previously been a heavy smoker. Apart from these restrictions, he may continue with his work, provided it does not entail strenuous, prolonged or sudden exertion or much travelling. If an attack is threatened, immediate rest is imperative, and rest, sedatives and a sheltered existence are the best prescription for the patient's after-life. Anticoagulants such as heparin either alone or in conjunction with dicourmarin have been employed, but their efficacy in the prevention of further attacks has still to be evaluated.

As regards the prognosis of angina pectoris, the American figures of Parker, Dry, Willins and Gage[11] in 1946 based on an analysis of 3,440 cases of the disease, first seen at the Mayo Clinic between 1927 and 1936, showed that this may be more favourable than was formerly believed.

In treatment of the attack of angina pectoris, the established remedies of rest and nitroglycerine or amyl-nitrite are essential. To prevent attacks, drugs, like thiouracil or methyl-thiouracil, have been used with the aim of reducing the general metabolism of the body and so lessening demands on the heart. Surgical or chemical blocking of the afferent cardiac nervous paths has been tried, but such methods are not unattended with risk. The question of surgical treatment in cardiovascular disease generally lies outside the province of this paper; experimental work in this field, chiefly initiated in this country by O'Shaughnessy, was for the most part in abeyance during the war.

CANCER

The administrative arrangements of the Ministry of Health for the diagnosis and treatment of cancer are described in the *Civilian Health and Medical Services*, Volume I.

Mortality. The total number of deaths attributed to cancer during the years 1939–45 showed a progressive annual increase (as given above); the increase applied to both sexes. When, however, the death-rate is set out in a form in which the figures have been standardised to meet changes in the age and sex constitution of the population, it is found that while the rate for males increased during the years 1939–45, that for females declined from the year 1940 onwards. For example, the comparative mortality index for females fell steadily from 0·984 in 1940 to 0·940 in 1944 and then to 0·936 in 1945. The trend of mortality in relation to cancer sites is described in Appendix C.

Cancer of the Lung

Advances were made during the war in the study and treatment of cancer of the lung, and an account of the modern outlook on this condition is here given. Clinical experience and hospital and post-mortem records all testify to the increasing prevalence of malignant disease of the lung. Between four and five thousand people die annually from bronchial carcinoma, which is now one of the most commonly recognized forms of cancer. Thirty-five years ago the condition was a rarity in the practice of Brompton Hospital, London. The death-rates per million (standardised) during the first decade of this century were 10·2 for males and 7·0 for females, and the corresponding figures for 1937 were 100·9 and 23·2.

The age-incidence is usually in middle life, between 45 and 55 years in men and at a slightly younger age in women, but the disease may develop at a later age and may occur in children. Pathologically, the largest proportion of primary pulmonary neoplasms are squamous and oat-celled carcinomata arising in the large bronchi. Other forms are columnar-celled carcinomata, endotheliomata, sarcomata and superior sulcus tumours. G. A. Mason[13] states: 'More rarely the condition formerly known as "diffuse pleural endotheliomata" is met; this is characterised by a diffuse thickening of both pleural layers, by effusion, and eventually by matting and invasion of the mediastinum and its viscera. It is now regarded as a low-grade poorly differentiated bronchiogenic carcinoma'.

Symptoms. Persistent cough is a common early symptom, and after that pain, dyspnoea, lassitude, haemoptysis, wasting, fever, clubbing of the fingers, etc. Pressure symptoms may be present, due either to direct pressure from the tumour, or from secondary deposits in its neighbourhood. There may be collapse of a lobe of the lung, paralysis of the recurrent laryngeal nerves with hoarseness of the voice, paralysis of the phrenic nerve, congestion of the veins of the head and neck, with oedema and marked dilatation of the superficial veins of the chest wall. The first sign of the growth may be a pleural effusion. If the fluid is blood-stained, it is highly suggestive of malignancy, and, in any case, should be examined for neoplastic cells. The condition may be unrecognised until secondary growths have appeared, e.g. secondary nodules in the skin or symptoms of cerebral tumour (de Wesselow).

Diagnosis. Clinical examination should include bronchoscopy. In some cases the growth can be seen and a specimen can be taken for biopsy, though many growths are in bronchi inaccessible to such inspection. The sputum should be examined for neoplastic cells as advised by Dudgeon and later by Bamforth.[14] X-ray examination and screening of the chest are essential.

Treatment. Treatment depends on the type of carcinoma, as ascertained by biopsy, the situation of the tumour and the presence or absence of secondary growths. Removal of the lung by surgical operation (pneumonectomy) is occasionally very successful.[15] Deep X-ray therapy may prolong life for two or three years, and in some rare instances has been followed by no recurrence of the lesion or secondary deposits. Apart from these two procedures, little can be done save to relieve pain by morphine.

British Research in Cancer

The chief bodies dealing with research in cancer in Great Britain are the Imperial Cancer Research Fund, which is under the aegis of the Royal Colleges of Physicians and Surgeons, the British Empire Cancer Campaign and the Medical Research Council. There is also much valuable work being done in the research laboratories of the Middlesex Hospital and the Cancer Hospital in London and in other university and hospital laboratories in Great Britain. Research into the cause and treatment of cancer was of necessity limited by the war, but the discovery by Professor Dodds that stilboestrol has a beneficial effect upon cancer of the prostate was an event of great importance. At the Imperial Cancer Research Fund Laboratories much work was done on Bittner's 'milk factor' in relation to carcinoma of the breast, on the bio-chemistry of cancer, and more recently still by Professor W. E. Gye, Professor J. Craigie and Professor Ida Mann on the important question of detection of a possible cancer virus.[16] [17] [18] The use of the electron microscope in the histological study of cancer was another noteworthy advance.

RESPIRATORY DISEASES

Pneumonia

A comparison of the notified cases of pneumonia with the deaths from this disease gives a case-mortality which is highly misleading. As is subsequently explained, the discrepancy seems due to several factors of which the most important is undernotification of pneumonia. This is readily apparent from the following table of the notifications and deaths from pneumonia (acute primary and influenzal) in England and Wales during the years of the war; for purposes of comparison it includes also the figures for 1938.

Pneumonia (Acute Primary and Influenzal)
England and Wales

Year	1938	1939	1940	1941	1942	1943	1944	1945
Notifications	45,160	42,312	47,875	50,942	42,698	52,407	38,631	34,371
Deaths	29,646	26,991	33,903	29,298	22,217	30,339	21,723	21,112
Case-mortality (per cent.)	65·6	63·8	70·8	57·5	52·0	57·9	56·2	61·4

This table shows an astonishingly high proportion of deaths as compared with the number of notified cases. The case-mortality averaged 60 per cent., whereas the hospital case-mortality for pneumonia (all forms) before the advent of the sulphonamide drugs and penicillin was as low as 4 or 5 per cent. Since the introduction of these drugs it has been further lowered. Among admissions to E.M.S. hospitals in 1943 pneumonia (excluding influenzal and other secondary forms) showed no significant increase among men and a decrease among women with no consistent age variation in either sex.

At the request of the Editor-in-Chief, Dr. Percy Stocks of the General Register Office made a sample analysis of the cases attributed to pneumonia admitted to E.M.S. hospitals during the years 1940–5. The cases were distinguished according to the Medical Research Council classification as lobar pneumonia, broncho-pneumonia, and pneumonia (unspecified).

In the sample of cases of pneumonia (all forms) there were in males 5,546 cases with 30 deaths, yielding a case-mortality of 0·54 per cent.; in females there were 384 cases with 2 deaths (both in the year 1943), giving a case-mortality of 0·52 per cent.; the total number of cases thus analysed was 5,930, yielding a total case-mortality of 0·54 per cent.

The death-rate from acute lobar pneumonia in the chief London hospitals in 1924 was about 20 per cent. Since the introduction of sulphonamide therapy and penicillin, it has fallen to about 5 per cent. The sample figures cited above for E.M.S. hospitals record a much lower case-mortality, but these were Service cases, for the most part under 30 years of age and with good powers of resistance.

To return to the high case-mortality from pneumonia recorded in the above table, the chief explanation of this apparently high case-mortality rate was failure to notify. The numbers of deaths and notifications for primary and influenzal pneumonia in 1945 were as follows:—

Age group	Notifications (corrected)		Deaths	
	M.	F.	M.	F.
0–	4,593	3,734	3,689	2,903
5–	2,773	2,090	142	113
15–	4,533	3,682	796	713
45–	4,700	2,761	2,894	1,469
65 and over	2,160	2,102	4,098	4,189
Not stated	116	105	—	—
Total	18,875	14,474	11,619	9,387

At ages 65 and upwards it will be observed that the figures for deaths greatly exceed the notifications, but it is a reasonable assumption that at all ages a considerable proportion of cases of pneumonia were not notified. Estimates based on the figures of the Survey of Sickness for a year from May, 1946 suggest that only about one-quarter of the cases of pneumonia in adults is notified.

While under-notification appears to be the chief cause of the apparent high death-rate for pneumonia in England and Wales, it cannot be the whole explanation. 'Pneumonia' in medicine is a very comprehensive term including lobar pneumonia, broncho-pneumonia, the respiratory complications of influenza, and many obscure conditions. Certain specific micrococcal infections (pneumococcal, streptococcal and staphylococcal) have for many years past been differentiated in the laboratory, although the distinction is not so easily made at the bedside. With the advent of the sulphonamide drugs and afterwards of penicillin dramatic cures were seen in these pneumonias, and, with the inevitable tendency to acclaim any new discovery as a panacea, it was believed that chemotherapy was about to abolish the fatality of pneumonia, and that it would be no longer as Osler termed it, 'the friend of the aged'. Now this belief, current from 1938 onwards, was partly true and partly false. The pneumococcal, streptococcal and staphylococcal pneumonias could be cured by chemotherapy, although in some cases the danger arose that inadequate dosage might lead to the development of drug-resistant strains. Reference to the first table for pneumonia shows an appreciable decline in mortality for the years 1944 and 1945, by which date penicillin was in use in E.M.S. hospitals, but throughout the war there was much pneumonia, and in 1943 the deaths were appreciably in excess of those for 1938 although, as already stated, the admissions of Service patients suffering from pneumonia to E.M.S. hospitals did not increase in the former year. Penicillin was not available for civilian cases of pneumonia until the war ended, and it seems probable that a proportion of the deaths from pneumonia in England and Wales during the war years was either due to the patients not receiving the benefits of modern therapy or because they did not seek medical care for their illness at an early stage.

Another reason may be that some of these deaths from 'pneumonia' were due to a virus (see Primary Atypical Pneumonia below) or to some other aetiological factor which did not respond to the sulphonamides. The whole question is one deserving of further investigation.

Bronchitis

Bronchitis and other respiratory diseases likewise showed no excess in hospital admissions of Service cases in 1943, but the rates for bronchitis in each sex increased rapidly with advancing age. (*Rep. of the C.M.O. of the Ministry of Health for* 1939–45, p. 218. H.M.S.O., London.)

Bronchitis was an appreciable cause of mortality during the years of the war and in the cold winter of 1939–40 it was responsible for the high figure of 46,281 deaths as compared with 31,436 deaths in 1939 and 29,655 in 1945.

Bronchitis as a cause of death is at best an index of respiratory infection and is hardly dissociable from the other more specific lung inflammations. Only the mortality figures are available ; these rise and fall in association with catarrhal and influenzal outbreaks, and they closely follow the trend of the pneumonia curves. They are intimately related to weather conditions and indicate a heavy toll of infant and aged life, but there is nothing to show that they were affected in any way by war-time conditions.

Delayed Resolution in Pneumonia

In 1943 the Committee on Health of the Corporation of Glasgow published a *Report on Pneumococcal Pneumonia in Glasgow During the Years* 1938–42.[(19)] This concise yet comprehensive report was the work of seven collaborators on the medical staff of the Corporation and in many respects was an amplification of the work of T. Anderson[(20)] during the same period.

An interesting reference was made in the report to delayed resolution, which ranked in the series of cases under review as the most notable complication. Its incidence was variable, but it occurred in no less than 24 per cent. of all cases in the comprehensive Group IV and reached a maximum of 31 per cent. in the group affected by Type II infection. It has been observed that the condition becomes commoner as age advances, the incidence in patients over 40 years of age being almost twice as great as in patients under 40. Anderson has referred to it as 'one of the most disturbing features of the case of pneumonia receiving chemotherapy . . .' 'In the person over 40 years, and in those with bacteriaemia', he continues, 'the tissue resistance may be lacking; it might be reasoned that failure to restore the inflamed lung to normal is likely to be due to a failure of tissue resistance'. This problem was further discussed in a paper by Anderson and Ferguson[21] which appeared in 1945. This article dealt with a series of 126 patients over the age of 35 treated in equal numbers (chosen at random) by sulphathiazole and penicillin respectively. Delayed resolution was equally represented in the two groups, and the authors concluded that 'Slow resolution which is so common with these modern therapeutic measures is the price we must pay for stopping an infective process too quickly'. The results of treatment by the two therapeutic agents employed were substantially similar, and no reason could be found for the abandonment of properly controlled sulphonamide treatment for the average case. It was considered, nevertheless, that there might well be a small proportion of acutely ill, cyanosed and dyspnoeic patients over 40 years of age for whom penicillin (possibly because of its low toxicity) would represent a definite improvement over the sulphonamides; and it was further submitted that massive bacteriaemia associated with a low white cell-count called for the employment of penicillin.

There were a number of cases of delayed resolution in pneumonia seen in the English Emergency Service hospitals. Most of these cases had been treated with sulphathiazole and about 20 per cent. with penicillin. The patients were all over 35 years of age. The lesson appears to be that no patient over 30 years of age who has suffered from pneumonia should be discharged from medical care or hospital until a radiograph of the chest shows that complete resolution has taken place after appropriate treatment.

Primary Atypical Pneumonia

One of the diseases responsible for the increased incidence of primary pneumonia is primary atypical pneumonia which has been specially studied of late years. An account of the pathology of the disease by Professor S. P. Bedson will be found in Chapter XXVI, and we are indebted to Professor Charles Cameron for the following clinical account of the disease.

From the year 1935, medical literature has contained an increasing number of references to a clinical condition which has come to be known as 'primary atypical pneumonia'.

Since the outbreak of war in 1939, the occurrence of the illness among Service personnel has focused attention more closely upon it. The main incidence is in young adults and its occurrence in a boys' school was described in 1942 by Herxheimer and McMillan.[22] The disease differs clinically and radiographically from the main types of primary and secondary pneumonia, and it does not conform with the seasonal influences which are characteristic of the latter groups. Specific laboratory findings are negative. There are no constant bacteriological pictures, and no cellular changes in the blood have been recognised. The absence of leucocytosis is a prevailing feature. The disease is communicable by droplet infection and may occur in endemic or epidemic form. Its course is not influenced by the sulphonamides, and its resemblance to other virus pneumonias—and particularly to that of psittacosis—has led to the belief that it is of virus origin. This view is strengthened by reason of the fact that pulmonary lesions indistinguishable from those of primary atypical pneumonia can be produced in animals by several viruses. The symptoms are those of malaise with slight fever, and physical signs are few and often absent. X-ray examination shows a patchy consolidation of the lungs usually at the base. The patchy consolidation is interstitial with monocytic infiltration of the alveoli, haemorrhagic, and often accompanied by acute bronchitis and bronchiolitis. So far as it has been observed, the natural history of the disease is usually benign and complete recovery is the rule. An associated meningo-encephalitis has, however, been reported in a few instances. As an interesting point, it should be mentioned that cold agglutinins in high titre are said to be developed during the illness in 80 per cent. of cases. These are found constantly in one other infectious disease only, namely, trypanosomiasis; and the reaction if confirmed may prove to be valuable in diagnosis and in epidemiological surveys.[23]

No figures dealing with the incidence of the disease are available. The condition is not related to influenza, although it may resemble that disease clinically; and it has not been identified with any of the known forms of virus pneumonia. Nevertheless, it is probably not a 'new' condition, and Drew[24] pointed out in 1943 that it had been described by Bartels as far back as 1861. In most instances the diagnosis is dependent upon a radiological finding during the course of a brief febrile illness. There have been no reports of the disease in Scotland, but cases conforming to the type have been encountered in small numbers in the Service tuberculosis clearing wards of the Emergency Medical Service hospitals.[24] [25] [26] [27]

Conclusion

In conclusion it may be said that the war experience of pneumonia showed that beside the types which responded favourably to chemotherapy, there was a considerable amount of 'pneumonia' with an appreciable mortality. This apparent high rate of mortality, averaging 60 per cent., was chiefly explained by failure of notification. Part of it was also due to the facts that some cases came under medical care too late for treatment to be effective; others did not receive appropriate modern treatment or proved resistant to it; or in a minority of cases the 'pneumonia' was due to viruses or some other aetiological factor for which no adequate therapy is at present known.

DISEASES OF THE DIGESTIVE SYSTEM

Deaths from diseases of the digestive system in England and Wales numbered 18,700 in 1939, rose to 19,502 in 1940, and thereafter gradually diminished, being 15,832 in 1945. A proportion of these deaths was due to haemorrhage or perforation from gastric and duodenal ulceration, but the figures by no means represent the widespread incidence of these maladies during the war years. In the chapter on Dyspepsia this subject is considered in detail, and it is sufficient here to quote the concluding paragraph.

'It is clear that with peptic ulcer there had developed, almost unsuspected, a large ulcer population between the wars and that when these individuals were taken away from their accustomed occupation, put into uniform and deprived of their careful diet, so many developed recurrences as to form a problem of the first magnitude for the Service authorities. Attempts to retain such men in the Armed Forces resulted in relapses and repeated hospitalisation and it was found early on that in practice it was better, as a general rule, to invalid the majority of these men as soon as diagnosed, to treat them, until healed, in E.M.S. hospitals and then to ensure, through the machinery of the Ministry of Labour, that they returned to occupations in civilian life, which, while suitable to their condition, would also be of use to the country.'

Experience in E.M.S. Hospitals

With regard to the experience of gastric and duodenal ulcers the rates of incidence of these ulcers for men per 1,000 admissions to E.M.S. hospitals for the years 1942 and 1943 can be given. They were as follows:—

Ages . .	15–	25–	35–	45–	All ages	Scottish All ages
Duodenal 1942	17	31	44	52	29	52
1943	12	28	44	32	26	45
Gastric, etc.						
1942	3	8	16	8	8	9
1943	3	7	13	23	7	3

Out of 1,623 ulcer patients at ages under 45, there were 1,278 with duodenal ulcer, giving a ratio of one gastric to 3·7 duodenal. Pyloric ulcers were included with the gastric ulcers of which they formed 8 per cent. The total ulcer rate for women under 25 was only one-sixth of that for men of the same age-group, and at ages 25–34 one-tenth.

The admission-rates for gastric and duodenal ulcer increased during the years 1944 and 1945, being 43 and 58 per 1,000 respectively.

The rates for gastro-enteritis varied little with age, and were lower in 1943 than in 1942. Appendicitis frequently declined with advancing age, and was much higher among women than men, the rates being about 137 and 64 respectively at ages 15–24, 78 and 37 at 25–34, and about 30 and 20 respectively after 35 years.

The deduction can fairly be drawn that the stress and strain of war conditions and military service caused a high incidence of dyspepsia and gastric and duodenal ulcer. The majority of patients had suffered from dyspeptic or ulcer symptoms previously, and the war provoked a recurrence.

Diagnosis. In addition to X-ray examination with barium meals, etc. the development of the flexible gastroscope by Wolf and Schindler in 1932 has greatly assisted diagnosis in experienced hands. There is increased accuracy in the differential diagnosis between gastric ulceration and gastric carcinoma. Schindler's belief that the use of the gastroscope would establish chronic gastritis as a common disease does not appear to be borne out by recent findings (see Chapter II). The plan pursued in investigation of Service patients during the war summarised the best diagnostic procedure. All patients were admitted to hospital, thoroughly investigated by all the recognised clinical, biochemical and radiological methods, and within a week, after consultation between the clinician and the radiologist, a positive diagnosis and decision as to the patient's disposal was reached.

Treatment. With modern treatment in E.M.S. hospitals, it was found that when the patient's stay was sufficiently prolonged, less than 1 per cent. of ulcers failed to respond to medical treatment.

Rest in bed for six weeks (and under modern conditions preferably in hospital) puts the patient under the most favourable condition for healing of the peptic ulcer. Initially, reliance is placed on hourly or two-hourly milk feeds. When pain has subsided, the diet can be gradually increased to a bland ordinary diet in which milk has a predominant part, for extra protein is beneficial. Additional fat in the form of cream, butter and olive oil is recommended, particularly for patients with duodenal ulcer. The triple carbonate (sodium bicarbonate, magnesium carbonate and bismuth carbonate) or magnesium trisilicate in powdered form suspended in water allays pain and promotes healing. Colloidal aluminium hydroxide and magnesium trisilicate, which absorb acid in the stomach and release the chloride in the intestine, have also been found beneficial. In duodenal ulcer atropine or belladonna as an antispasmodic often relieves the pain which these patients suffer in the night-time.

Once the ulcer has been healed and with a supply of magnesium trisilicate or the triple carbonate in reserve, many patients can continue an active life without recurrence. Worry and undue stress or strain should be avoided, for the psychological aspect of peptic ulcer is all-important. Acute emotional stress may give rise to relapse, haemorrhage or perforation. It is noteworthy that, during the autumn of 1940 and the early months of 1941, when the civilian population of London were subjected to heavy and continuous night-bombing attacks, a great increase in the number of perforated peptic ulcers occurred.

Tobacco and alcohol should be given up during treatment and are best avoided altogether by peptic ulcer subjects.

The treatment of haemorrhage continues to be a serious problem. Formerly the patient was treated on starvation principles with an appreciable case-mortality (15 to 20 per cent.). Meulengracht introduced liberal feeding, and in 1935 claimed a mortality of 2 per cent. in 251 patients so treated. L. J. Witts[28] using a modification of Meulengracht's diet also obtained good results and the diet shortened the stay in E.M.S. hospitals. Drip blood transfusions were found to be of service in severe cases of haemorrhage, and the combination of these with a liberal diet in hospital practice during the war is considered to have lowered the mortality from gastro-duodenal haemorrhage. Cases of ulcer with recurrent haemorrhages are less commonly subjects for operation, but are given repeated blood transfusions. G. Gordon-Taylor[29] considers that partial gastrectomy is still required for recurrent haemorrhage from chronic gastric or pyloric ulcers, and possibly for some cases of chronic duodenal ulcer. Most cases of acute and chronic duodenal ulcer respond favourably to medical treatment. Acute perforation of a peptic ulcer demands surgical treatment. The use of sulphonamides and penicillin has improved the prognosis in operative treatment of perforation.

Conclusion. War experience revealed a high incidence of peptic (gastric and duodenal) ulceration in the Armed Forces and in the civilian population. This was not a feature of the War of 1914–18 and is due partly to the fact that between the two wars there had been a rise in the occurrence of peptic ulceration, the subjects of which were prone to have recurrence of their disease under the stress of war conditions. Before and during the war considerable advances were made in the diagnosis and medical treatment of peptic ulcer with a consequent lowering of mortality.

GENERAL COMMENTARY

During the present century medicine has made great advances both in diagnosis and treatment. Instruments of precision, such as X-rays, the electro-cardiograph, the gastroscope, the bronchoscope, and pathological and biochemical tests have made the diagnosis of diseases more accurate and scientific, and sovereign remedies have been discovered in therapeutics. Experimental physiology made discoveries in the laboratory which have been applied in the wards to the cure of disease. One of the early demonstrations was when myxoedema was proved to be due to thyroid gland deficiency which could be remedied by the administration of thyroid extract. Then later came the discovery of insulin by Banting and Best for the treatment of diabetes, the outstanding work of Gowland Hopkins and Sir Edward and Lady Mellanby on vitamins and their application to the cure of deficiency diseases, and the discovery that liver extract could transform pernicious anaemia from a hopeless into a curable disease. Similarly, in rarer diseases, such as disease of the adrenals, glandular extracts now ward off a fatal issue. Concurrently with these boons to mankind came the triumphs of preventive medicine and of immunology.

The years of the war saw further therapeutic advances, especially in chemotherapy, following on Ehrlich's discovery in 1909 of salvarsan or '606', the first really effective remedy for syphilis. The investigation of organic arsenical compounds continued so as to find the best cure for trypanosomiasis and allied diseases. Similarly, organic compounds of antimony were developed for the treatment of leishmaniasis and other tropical diseases.

Since Domagk in 1935 discovered that prontosil, a long-known dye, was effective against streptococci, a large number of sulphonamide drugs less toxic and more potent than prontosil have been prepared. In 1945 it was estimated that 5,485 compounds of the sulphonamide family had been synthesised and tested mainly in America and Great Britain. Only a small number of these have been introduced into human medicine, but they have proved very effective against certain infections, for example infections due to streptococci, pneumococci, meningococci and gonococci for which there were formerly no specific drugs. Sulphanilamide became official in the *British Pharmacopoeia* (Addendum) of 1941 and the Seventh Addendum of this publication in 1945 added sulphacetamide, sulphadiazine, sulphaguanidine, sulphapyridine and sulphathiazole. Trials of the sulpha drugs in the treatment of early cases of leprosy have been encouraging. Subsequent discoveries in chemotherapy have by no means destroyed the value of the sulphonamides. They are easier to administer and are effective against certain organisms which are not sensitive to penicillin. The clinical application of penicillin is an outstanding success of the war years, and is elsewhere dealt with in this History. The Japanese capture of Java denied us the main source of quinine, but British chemists succeeded in producing the synthetic anti-malarial drugs, and thus were able to supply the Services with vast quantities of mepacrin and pamaquin. Intensive laboratory and field research was organised to produce new insecticides and insect repellents, like D.D.T. (dichlor-diphenyl-trichlorethane) and lethane. These were also important against lice, the carriers of typhus; sandflies that carry sand-fly fever and kala azar; and many other insect vectors. This summary does not include many other war advances in therapeutics, such as the study of isotopes, and the discoveries of dicoumarin, an anti-coagulant; pethidine hydrochloride, an analgesic anti-spasmodic; methedrine hydrochloride, a sympathomimetic pressor substance; thiouracil for thyrotoxicosis; phenytoinum for epilepsy; and pentamidine, a new trypanocide. Phenoxetol, a new anti-bacterial compound, is especially effective against pyocyaneus infection. Many innovations in material and methods have taken place in the administration of anaesthetics.[30]

In the face of countless difficulties British Medicine, as the chapters in this volume reveal, was not only maintained at a high level during the war, but medical research increased its armamentarium and enabled physicians to treat effectively some diseases which previously had been regarded as invariably fatal, for example, the use of penicillin in malignant endocarditis, and in certain cases of visceral actinomycosis.

Within the limits of the present century the crude death-rate has fallen by 31 per cent. to a mean level of 12, and the expectation of life has increased by sixteen years.

Yet there remain many dragons for medicine to combat in the field of disease. Deaths from diseases of the heart and circulation and cancer increase year by year; over 150,000 patients are in mental institutions, and many more are stated to be in need of psychiatric treatment. Rheumatic and chronic and degenerative conditions, prevailing in an increasingly ageing population, call for further study and attention. Much has been achieved but much more remains to be done.

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APPENDIX A

TABLE I

Notifications in England and Wales in each Year, 1938 *to* 1945, *including those of Non-Civilians and from Port Health Districts*

Disease	Notifications, partially corrected*						Total after diagnosis revision	
	1938	1939	1940	1941	1942	1943	1944	1945
Cerebro-spinal fever	1,288	1,500	12,771	11,077	6,029	3,303	2,309	2,063
Continued and relapsing fevers	7	12	10	6	4	6	7	6
Diphtheria	65,008	47,343	46,281	50,797	41,404	34,662	23,199	18,596
Dysentery	4,170	1,941	2,860	6,670	7,296	7,905	13,025	16,278
Encephalitis lethargica (acute)	194	159	211	187	148	109	79	76
Erysipelas	16,671	14,141	13,123	12,232	11,598	11,833	11,148	9,853
Malaria (contracted at home)	2	2	2	2	2	4	9	7
Measles	?	?	409,521	409,715	286,341	376,104	158,479	446,796
Ophthalmia neonatorum	5,168	4,594	4,390	4,195	4,517	4,502	3,660	3,314
Paratyphoid fever	388	745	1,947	3,705	390	328	258	234
Plague	—	—	—	—	—	—	—	—
Pneumonia (acute primary and influenzal)	45,160	42,312	47,875	50,942	42,698	52,407	38,631	34,371
Poliomyelitis (acute)	1,489	744	951	876	581	410	464	784
Polioencephalitis (acute)	96	87	128	83	93	46	68	74
Puerperal pyrexia	9,307	9,252	7,627	7,356	8,542	8,354	7,944	7,013
Scarlet fever	99,278	78,101	65,302	59,433	85,084	116,033	92,671	73,687
Smallpox	18	1	1	—	7	—	16	4
Tuberculosis (respiratory) †	37,879	34,930	36,151	39,499	40,629	42,410	—	—
Tuberculosis (other forms)†	12,810	11,276	10,421	11,465	11,990	11,932	—	—
Typhoid fever	934	734	886	1,058	468	385	284	301
Typhus	—	2	—	—	—	—	—	26
Whooping cough	?	?	53,617	173,330	66,016	96,136	94,044	62,691

* These totals, which correspond with the numbers published in the quarterly and annual reports of the Registrar-General, incorporate such corrections as were reported on the weekly cards. The original notifications, comparable with those of 1944, can be estimated approximately by multiplying the figures by the following factors ascertained from 1943 records:—C.S.F. 1·045; Diphtheria 1·044; Dysentery 0·958; Measles 0·988; Poliomyelitis and Polioencephalitis 1·035. For other diseases the correction is immaterial.

† Formal notifications only throughout.

TABLE II

Deaths from Notifiable Diseases in England and Wales in each Year, 1938 to 1944, including those of Non-Civilians

Disease (1938 Revision of International List)	No. of deaths at all ages, according to the classification in use from 1940 onwards							
	1938	1939	1940	1941	1942	1943	1944	1945
Cerebro-spinal fever	655	517	2,584	2,163	1,206	780	592	555
Relapsing fever	—	—	1	—	—	—	—	—
Diphtheria	2,861	2,133	2,480	2,641	1,827	1,371	934	722
Dysentery (all forms)	112	96	185	329	198	124	157	165
Encephalitis lethargica (acute and sequelae)	516	572	729	704	590	495	417	461
Erysipelas	342	248	214	190	141	124	119	119
Malaria	26	20	46	19	20	21	13	28
Measles	1,524	303	857	1,145	458	773	243	729
Paratyphoid fevers	15	22	52	66	20	15	10	15
Pneumonia (acute primary)	27,467	23,403	29,195	26,418	20,828	24,763	20,041	21,112
Pneumonia (influenzal)	2,179	3,588	4,708	2,880	1,389	5,576	1,682	
Poliomyelitis, acute	174	95	107	113	82	63	87	97
Polioencephalitis, acute	82	48	54	47	50	27	22	42
Puerperal sepsis	682	649	498	499	522	519	462	342
Scarlet fever	311	181	154	133	104	134	107	84
Smallpox	3	—	—	—	—	—	3	—
Tuberculosis (respiratory)	21,282	21,542	23,660	23,633	20,989	21,342	20,104	20,013
Tuberculosis (other forms)	4,257	4,081	4,484	5,037	4,560	4,307	4,059	3,942
Typhoid fever	144	90	83	82	69	57	45	32
Typhus fever (louse borne)	—	—	—	—	—	—	—	2
Whooping cough	1,052	1,229	678	2,383	799	1,114	1,054	689

APPENDIX B

CAUSES OF MEDICAL ADMISSIONS FROM THE SERVICES (NON-CIVILIANS) TO E.M.S. HOSPITALS

Annual proportionate morbidity rates for men admitted to E.M.S. hospitals from the Services during the years 1942 and 1943 are given in the *Annual Report of the Ministry of Health for* 1939–44, pp. 220–5; for 1944 in the *Annual Report*, pp. 100–1, for 1945; and for 1945 in the *Annual Report* for 1947, pp. 100–1. In the 1947 *Report*, pp. 102–3, are also given the proportionate morbidity rates for women admitted from the Services during the two years 1944–5. The tables are based on a one-in-five sample of the hospital records. The sample of men totalled 26,759 compared with 40,767, 36,720 and 47,753 in the three years preceding. Only a few R.A.F. personnel are included in the tables.

The following observations were made from a study of these tables: diseases of the heart and arteries, together with cerebral haemorrhage, showed rates increasing rapidly with age after 35. Neoplasms accounted for 17 per 1,000 non-infective and non-respiratory diseases among men and 32 among women, the rates increasing rapidly with advancing age. Psycho-neuroses showed a progressive increase, the sequence for men in the four years from 1942 being 70, 73, 100, 106, and for women 51, 59, 92, 66. Gastric and duodenal ulcer in men showed rates of 37, 33, 43, 58 per 1,000 in the four years. Diabetes rates were only 1 or 2 for men under 45 years of age, increasing to 36 at ages 55 and over. Anaemias showed a rate of 9 per 1,000 women as compared with 1 for men.

Infective and respiratory diseases added 333 to each 1,000 other illnesses causing admission in 1945 compared with 281, 334 and 356 in the three years preceding. Pneumonia rate increased from 36 in 1944 to 47 in 1945, but tuberculosis showed no change. The group of 'other infective diseases' consisted largely of malaria, for which the rates in the four years 1942 to 1945 were 3, 6, 115, 88; the next in importance being dysentery with rates 2, 3, 10, 15 in the four years, Vincent's infection with 17, 16, 9, 9, diphtheria with 4, 4, 6, 6, and scarlet fever with 2, 5, 6, 6 per 1,000. Acute hepatitis and jaundice increased at ages under 45 years, from 35, 31, 20 at ages 15–, 25–, 35–44 in 1944 to 40, 45, 32 in 1945. For diseases of the veins men's rates were much higher than those of women, averaging about 80 at all ages and reaching a maximum of 35–44 years. Acute sore throat showed a remarkable decline with advancing age for both sexes, rates being at about 100 at ages under 25, falling to about 40 at 35–44 and 20 or less after 45. The frequency of appendicitis declined with advancing age, and was much higher among women than men. For genito-urinary diseases, non-venereal, the men's rate was 40, varying little with age and the women's rate was 131. Skin diseases, excluding scabies, formed one-fifth of all non-infective and non-respiratory diseases among men under 25, the proportion declining with age to about one-eighth at 45–54, whilst among women the proportion was about one-tenth with no important age variation. For diseases of bones, joints and muscles the rate was 75 for men and 35 for women. These latter observations are based upon the rates of proportionate morbidity in 1942 and 1943.

APPENDIX C

THE TRENDS OF MORTALITY IN RELATION TO CANCER SITES

P. Stocks[12] has summarised the trends of cancer since 1921–30, as follows:—

Males. For all sites combined there has been no important change at 45–65, but the rates continued to rise at higher ages until about 1936 and then ceased to rise. Lip and tongue cancer mortality has declined at each age, the fall being very pronounced at 45–65. For mouth, pharynx and oesophagus the rates at 45-65 have fallen continuously; at 65–75 they increased in 1931–5 and then declined, but at 75–85 the rise continued for the oesophagus. Gastric cancer rates at 55–85 continued to increase, particularly during 1939–41, but fell back in 1942. Rectal cancer has declined at 45–65 but continues to increase at higher ages; and other intestinal cancer rates, after increasing in 1931–5, have fallen continuously at 45–75 and become stationary at 75–85. Liver cancer rates continue to fall, probably through improving certification of the primary site. Gall bladder rates, after increasing, have returned to about 1921–30 levels, but the pancreas shows considerable increases, especially after 65. Laryngeal cancer has declined progressively at 45–65, but increased until 1941 at 65–85, with some improvement in 1942. Lung cancer shows a 5- to 7-fold increase in certified mortality since 1921–30 and the rate of increase tends to become greater. Prostatic and urinary cancer rates also continue to rise. Cancer of the scrotum and penis declined up to 1941 at 45–75 but increased at 75–85; in 1942 rates increased at each age. Other skin cancer has declined at each age, but the bones show no improvement.

Females. For all sites combined there has been a fall of about 5 per cent. in cancer rates at each age. Mouth and oesophagus rates at 45–55 have fallen appreciably and at other stages, after increasing, have tended to fall since 1936–8. Gastric and intestinal rates have declined considerably at 45–75, but rectal cancer shows little change. Liver and gall bladder rates have fallen, whilst pancreatic cancer has increased at each age. Lung cancer shows a three- or fourfold increase since 1921–30, relatively less than for males. Uterine rates have declined uniformly in each age-group, but the ovary shows a continued increase in certified mortality. Breast cancer rates, which increased by 1931–5, have changed little in recent years at ages 45–75. Urinary cancer continues to increase. Skin cancer rates, after rising at 45–65, have returned to 1921–30 levels, and at 65–85 they have improved considerably.

CHAPTER II

DYSPEPSIA

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INTRODUCTION

THE significance of any disease in a fighting Service depends largely on its capacity to cause unfitness for duty. In this respect gastro-duodenal disorders ranked high during the War of 1939–45. In the 1914–18 War neither peptic ulcer nor dyspepsia of other types formed a problem of any magnitude and there is no mention of duodenal ulcer in the *Medical History of the War*(1). Up to the end of 1915 the discharges from the Army for inflammation and ulceration of the stomach totalled 709.(2) To the end of 1941 (from September, 1939) the number of discharges for peptic ulcer was 23,574.(1) It was officially stated in May, 1942 that 17 per cent. of the total discharges for all diseases from the Army and Royal Air Force and 13·8 per cent. from the Royal Navy were on account of digestive disorders.(3) The majority of these men were suffering from peptic ulcer and 90 per cent. of the ulcers had given rise to symptoms in civil life, before the man joined the Services.(4) In war-time industry men broke down with peptic ulcer under the strain of long hours or changing shifts. It has been calculated that in England and Wales there are about 1½ million living people who have suffered from peptic ulcer and that nearly 200,000 men develop peptic ulcer each year.(5) No such phenomenon was noted in the 1914–18 War, either in the Armed Forces or in industry and the explanation lies in a very considerable increase in the incidence of peptic ulcer in the years between the two wars. Nor is the increase confined to this country, as is shown by the provision of special dietetic facilities for workers with peptic ulcer in Russian factories and the foundation of special units for German troops suffering from digestive disorders. In the years 1929–38 there were 43,200 deaths from peptic ulceration in England and Wales, of which 20,700 occurred in 1929–33, 22,500 in 1934–8, showing a definite rise in the death-rate.(6) Tidy(7) has shown that for Great Britain there was little or no rise in the death-rate from peptic ulcer between 1912 and 1920, a rapid rise from 1921 to 1928, a slower increase to 1934 and then a rapid rise again to 1938. Coincidentally, as might be expected and giving further proof of this general increase, the incidence of perforation more than trebled between 1924 and 1941.

THE FIRST YEAR

These facts were not appreciated in 1939 and the large number of admissions to hospital of men diagnosed as suffering from peptic ulcer attracted attention as early as October, 1939. Inquiries addressed to the consulting physician in the B.E.F. elicited the information that large numbers of men were reporting sick with indigestion, about one-third of whom were considered to have peptic ulcers and were evacuated to the United Kingdom, the remaining two-thirds being treated for indigestion at Base hospitals in France and returned to their units. It soon became clear that military and civil hospitals in the United Kingdom were also receiving large numbers of cases of dyspepsia and peptic ulcer from the Army at home. This high incidence was quite unexpected, and took by surprise the Army Medical Services and the civilian medical profession. For the first two years of the war digestive disturbances constituted a problem of considerable difficulty and confusion. It was suggested that the cases diagnosed as peptic ulcers were not in fact ulcers and that the prevalence of dyspepsia was due to poor cooking in the Army. At Tidy's instigation Newman and Payne[9] working under a grant from the Royal College of Physicians established two facts: first, that the cases so diagnosed were in general definitely ulcers, and secondly, that nearly 90 per cent. of the cases, both ulcer and non-ulcer, had a long history of similar symptoms in civilian life. They were of the opinion that Army cooking and especially the greasiness of the food, was a factor in causing the early breakdown and recurrence of symptoms in the Army. Loss of weight was very considerable (an average of 12·1 lb. on an initial weight of 148 lb., in the men from the B.E.F.),[1] and it was remarkable that vomiting was a common symptom in men with duodenal ulcers. A large proportion of the Army at that period consisted of reservists, many of whom had been several years in civilian life and it was anticipated that, as these were weeded out, the incidence of dyspepsia and of ulcer in particular, would fall. As time passed, the number of reservists became a small fraction of the Army, which came to consist largely of conscripts. Nevertheless, the high incidence of dyspepsia continued. The trend was forecast by Hinds-Howell[12] who reviewed 804 cases seen during the first year of war. Peptic ulceration was present in 52—7 per cent. of all cases—and was spread equally between reservists and the Army classes but was rare in regulars. Duration of symptoms of dyspepsia was between two and five years, only 10 per cent. of patients developing symptoms while in the Army. Malingering, in the early stages of the war, was extremely rare.[9] [18] [20]

A similar state of affairs existed in the Royal Navy, though the total number involved was not so great. The growing frequency of peptic ulceration among sailors had been noted as far back as 1931.[13] The expansion of the Service with the outbreak of war involved a rise in the number of sailors and marines reporting sick with indigestion. In the first year or two of hostilities one often heard the view expressed that gastro-duodenal disorders were more common in small ships, viz. trawlers, destroyers, escort vessels, etc., than in capital ships or in shore establishments. That this may have been so is suggested by the recommendation made in 1941 by the Medical Department of the Admiralty (M.D.G. 22928/41) that, to avoid wastage, medical officers should recommend wherever possible fully trained and highly skilled ratings with peptic ulcer for 'shore and harbour duties'. Allison and Thomas,[14] however, dealing with a series of cases observed in the first year of the war, found that all the usual classes of naval ratings were represented among their patients and that there was nothing to suggest that dyspepsia was more prevalent in one branch of the Service than in another. A high proportion of the dyspeptics came from destroyers and small auxiliary craft but it was thought the reason for this was that many of these ships, which were in reserve at the outbreak of war, were manned by pensioners and reservists. An interesting point in this connexion is that peptic ulcer and dyspepsia in general appear to have been remarkably infrequent in the crews of submarines.

Most authors describing their experience of Service dyspepsia, and especially peptic ulcer, have commented on the long history which the patients usually gave on their admission to hospital. This is an important point for, recognising the intractability of an established dyspepsia under active Service conditions, those entrusted with the selection of new entries should pay particular attention to such complaints and defer all doubtful cases for further investigation. In about half the cases which were seen in the first year of the war indigestion had been present for 5 years or more and in 1, aged 50, the dyspepsia went back as far as 10 to 20 years. In only 7 of the 100 cases investigated by Allison and Thomas was the history under 1 year. About 1 patient in 3 described a preliminary phase of atypical dyspepsia which had been noticed during adolescence. The early symptoms were either recurring 'hungry' feelings with heartburn or flatulence, severe attacks of abdominal colic or 'frequent' bilious attacks. All the 93 patients who had had dyspepsia in peace-time considered that it had become worse since the outbreak of war. In the first year 16 had complications: 6 perforation, 5 melaena, 3 haematemesis, 1 pyloric stenosis, 1 gastro-colic-jejunal fistula, but the rarity of complications in the Army was noticeable. In the great majority pain recurred more frequently, lasted longer and was unrelieved by alkaline powder. Three other symptoms were very prevalent: loss of weight, vomiting and aerophagy. The first-named was almost invariable in cases of gastric and duodenal ulcer for, being unable to get a suitable diet, the subjects either vomited the food they ate or did without regular meals, relying for sustenance on snacks of bread and butter, tea, pudding, or a dose of alkaline powder. This was almost invariably the statement made and there seems no reason to disbelieve it. Aerophagy was remarkably prevalent and was easily recognised clinically. Its occurrence, though usually associated with concurrent affective disturbances, afforded no proof of a functional origin of the dyspepsia for it was as commonly seen in patients with radiological evidence of ulcer as it was in those without any such evidence.

Meanwhile, in the civilian population in London, subjected to heavy and continuous night bombing attacks during the autumn of 1940 and the early months of 1941, there occurred a very great increase of perforated peptic ulcers.(10) (11) Within a few days in September, 1940, seven patients with perforated ulcers were admitted to Charing Cross Hospital, which normally admitted one a month. Figures from 16 London hospitals showed an average number of perforations per month for the years 1937–40 and 1941–2, ranging from 16·5 to 25·5. During the Blitz the figure rose to 35·11. Similar findings were reported from Germany.(41)

THE MIDDLE PERIOD (1941–3)

With a large army building up at home, there was ample opportunity during this phase of the war to investigate the problem of dyspepsia, since, as already indicated, the incidence had not fallen, rather had it steadily increased. Dyspeptics were passed by civilian recruiting boards in the early days because of the suspicion that simulation was so easy and the boards were largely staffed by doctors whose last experience of war had been during the war-weary, malingering days of 1918, and later because the Service attitude was that the Services knew best what they could make of men, and that the simplest plan was to recruit a doubtful case and decide about his fitness afterwards.(15) This may have led to efficiency, but it was very expensive to the country, and not without hardship to the men. The aetiology of the dyspepsia was, however, changing(16) as the composition of the Army changed, the older Reservists being weeded out and diluted as the younger conscripts were called to the Colours. At a military hospital where 8,702 medical cases were seen in 1940, 14·6 per cent. were suffering from dyspepsia: in 1941 5,606 cases were seen and of these 17·4 per cent. were dyspeptic.Only 10 per cent. of these had developed symptoms for the first time after joining the Army.

The increase of 2·8 per cent. in 1941 in the number of dyspepsia cases was found to be due to a rise in the neurotic dyspepsias from 5·6 per cent. in 1940 to 18 per cent. in 1941. The percentage of peptic ulceration had fallen from 55 to 43. Duodenal ulcer was twice as common as gastric ulcer. During 1941 it was noted that the incidence of peptic ulceration in the Forces was what would be expected from the civilian pre-war figures[17] and that the incidence was similar to that obtaining in civil hospital practice at that time (1941).[18] The falling percentage of peptic ulcer and the rising incidence of dyspepsia was also noted in the Royal Navy.[19] Figures from a Royal Naval Hospital showed a total admission of 628 dyspeptics for the fourth quarter of 1939 of whom 62 per cent. had ulcers, whereas in the third quarter of 1941, 1,598 dyspeptics were admitted, of whom 50 per cent. had ulcers.

By 1942 the percentage of ulcers had fallen still further. Three series of cases published during the first six months of that year gave the following figures:—(*a*) of a total of 931 dyspeptics, the percentage of ulcer cases dwindled from 46 per cent. of those investigated during the first six-monthly period to 35 per cent. of those investigated during the last six-monthly period;[20] (*b*) of 429 cases examined by barium meal 35·4 per cent. had a demonstrable gastric or duodenal ulcer;[21] (*c*) of 217 patients examined by X-ray and gastroscopy 28·5 per cent. showed peptic ulceration.[22]

By December 31, 1941, 23,875 cases of peptic ulcer had been discharged from the Army. It was evident that although the dyspeptic soldier continued to be a bugbear to his unit M.O., nevertheless the proportion of these having an undoubted ulcer, and whose disposal was a simple matter of invaliding, was steadily shrinking. There remained the increasing proportion in whom no organic lesion was easily found. It was agreed that some of these had gastritis but two problems remained (1) How many ?, and (2) What should be their disposal ? In the Swiss Army at this time, the same difficulties arose[23] and it seemed to be accepted that gastritis accounted for a high proportion of the non-ulcer dyspepsias—Demole found 40 to 50 per cent., Michand emphasised its frequency, and Hammerli diagnosed only 15 per cent. of his cases as functional non-gastritis dyspepsia.

It was accepted[24] that of the various criteria necessary for the diagnosis of gastritis, the appearances found at gastroscopy were of supreme importance, and there can be little doubt that most gastroscopists, both at home and abroad, were, at this date, greatly influenced by the views of Schindler,[25] whose vast experience was unequalled anywhere and who, early in the war had emphasised the importance of the gastroscope in the diagnosis of gastric diseases in the Army.[26] Shortly before the outbreak of hostilities Bulmer[27] using the Wolf-Schindler flexible gastroscope, in civilian hospital practice, had diagnosed chronic gastritis in 40 per cent. of dyspeptics with negative radiological findings: in 6 per cent. there was a gastric ulcer. Gill[28] in 1943, using the Hermon Taylor gastroscope, found that one-third of his Service patients with negative X-ray findings had gastritis and 3 per cent. a gastric ulcer. Edwards[29] in the same year commented that the gastroscope is an invaluable aid in the diagnosis of dyspepsia.

The most important cause of dyspepsia in the Services was, it is generally agreed, peptic ulceration. The nature of the other causes is more obscure, and little information was published by those junior medical officers who alone had the opportunity of observing it in all its forms.

The presenting symptoms of dyspepsia in war-time differed little from those seen among civilians in peace-time. Most men complained of upper abdominal discomfort or epigastric pain, occurring either immediately or at an interval after food, and sometimes being relieved by alkalis or food. Vomiting, heartburn and flatulence were frequent accompaniments.

A WORKING CLASSIFICATION

The following classification is an arbitrary one and no doubt open to criticism, but it was found useful in deciding the treatment and disposal of Service dyspeptics:—

(1) *Acclimatisation dyspepsia.* A mild type of dyspepsia frequently developed in new recruits before they were acclimatised to Army routine. This was specially common in the early stages of the war, possibly before the training centres had settled down and the medical officers had gained experience of the work. This form can and should be dealt with in the unit. The experienced medical officer reassures the man, explains the cause to him and gives him a bottle of medicine. After two or three weeks nothing more is heard of him. The procedure commonly followed in the earlier months of the war of sending such men to hospital to be investigated or to see a medical specialist was apt to convert a transient into a chronic dyspeptic and finally into a useless soldier. The symptoms would respond readily to hospital treatment and the man be sent back 'cured' to the training centre, but although the symptoms had been removed the man had not been acclimatised, and the cycle started over again and resulted in admission to hospital for a second time. A recruit admitted twice to hospital within a short time for the same complaint was unlikely subsequently to get rid of his symptoms. When it became recognised that such cases should not be admitted to hospital they ceased to cause appreciable trouble.

(2) *Bolting of food* appeared to be a common cause of minor dyspepsia.

(3) *Defective teeth* was a common cause, in older ratings, of inadequate mastication, for the artificial teeth often did not fit properly or they caused discomfort during the act of chewing.

(4) *Air swallowing* was remarkably common, the patient being seen to swallow his saliva frequently and belch noisily. Under examination with X-rays a large bubble of air could be seen filling the fundus of the stomach and pressing upwards on the diaphragm, and it was this action which probably accounted for the unpleasant feeling of fullness. Taking powder and causing more gas to be evolved often relieved the discomfort temporarily by inducing belching. As already remarked, however, the occurrence of the symptom was in itself no guarantee that organic

disease might not be present, but when other suggestive symptoms were lacking, treatment by simple explanation and directing the patient to hold a matchstick between his teeth usually sufficed.

(5) *Tobacco and alcohol* were frequently blamed for causing dyspepsia and in this connexion naval ratings were no exception, for most of them smoked to excess and many drank unwisely when the opportunity offered. The low incidence of dyspepsia among submarine ratings has already been referred to and it will be noted that their opportunities for smoking were limited and their times of taking meals irregular. Of the two irritants, tobacco appeared to be the greater offender, though an acute alcoholic debauch was often responsible for an acute dyspepsia.

(6) *Reflex dyspepsia: subacute appendicitis, cholecystitis and gall stones, renal calculus, intestinal parasites, constipation, seasickness, etc.* The number of cases of chronic dyspepsia which could be attributed to one or more of these causes was relatively small. Occasionally constipation was at fault, especially when stomach powders or aperients were being taken regularly. Examination of the abdomen in these cases usually showed a hard elongated tumour-like mass in the left iliac fossa and on rectal examination hard faecal masses. Treatment by aperients was useless; the best results followed an enema or removal of the scybala from the rectum by the finger.

(7) *Migrainous dyspepsia.* Migraine accounted for a definite proportion of the dyspeptics admitted to hospital. The diagnosis was frequently overlooked because the patient dwelt exclusively on the abdominal aspect of his complaint. A tendency to seasickness was often associated, but seasickness by itself appeared to play little part in the genesis of the chronic dyspepsia. Occasionally migraine and peptic ulcer were found to co-exist in the same patient, though more often one found a history of classical migraine earlier in life which had been replaced in more recent times by the symptoms of peptic ulcer. The points used to distinguish migrainous dyspepsia from other forms were as follows:—

(*a*) Pain, though epigastric, not relieved by food. Absence of night pain. Relief after vomiting. Recurrence of pain rarely more than 2–3 days at a time and often related to known factors, viz. overeating, irregular meals, seasickness, worry or excitement.

(*b*) Concomitant anorexia, nausea and vomiting with headache, unilateral or bilateral. Careful inquiry usually established the fact that the headache and dyspepsia were closely correlated, the one rarely occurring without the other.

(*c*) Occurrence of visual disturbances, scotoma, hemianopsia.

(*d*) Corroborative evidence of a migrainous diathesis in a family tendency to the complaint, a history of 'bilious' attacks in childhood, car or train sickness, seasickness or idiosyncrasy to certain foodstuffs.

(8) *Psychogenic dyspepsia.* This group comprised the cases in which the symptoms were determined by psychological causes, and in which

there was no suggestion, either from history-taking or from examination, of any gross dysfunction of the digestive system. The group included for the most part patients with anxiety and depressive states, some backward subjects and psychopaths, and some patients activated by hysterical motives. A study of the psychiatric material provided at the Royal Naval Auxiliary Hospital, Barrow Gurney, did not suggest that digestive disturbances were more common among such cases than among other types. Confusion was most likely to arise in dealing with patients who presented a mixed clinical picture, i.e. some evidence of an emotional disturbance, with other symptoms suggestive of peptic ulcer, though radiological examination was negative.

(9) *Emotional dyspepsia.* (*Gastro-duodenal dyspepsia without ulcer.*) Though the effect of conscious mental processes in upsetting digestion is well recognised, it is possible that less attention has been paid to the occurrence of the same effects originating at a lower level in the nervous system and disturbing digestion. Right from the beginning of the war it was obvious, however, that there was a large number of dyspeptics with symptoms more or less typical of peptic ulcer in whom repeated X-rays were often negative. Conscious psychological factors appeared to play little or no part in the genesis of their symptoms, nor could it be said that they were careless with regard to food or drink. On the contrary, many of these patients were highly conscientious, hard-working types, and many undoubtedly had been submitted to considerable mental stress, either as a result of enemy action or through prolonged worry, mostly concerned with their dependants at home. The conclusion was inescapable that in these cases the dyspepsia was due largely to the effect of unconscious emotional stimuli acting upon an unstable vegetative nervous system. Hyperchlorhydria was usually present and, though positive evidence of an ulcer was lacking, radiological study of the movements of the stomach and bowel often showed the same kind of neuro-muscular disorder as one sees in peptic ulcer, viz. hypertonus, hyperperistalsis and rapid emptying of the stomach. It would often happen that a man would be admitted to hospital with such symptoms, be X-rayed with inconclusive results, lose his pain with rest in bed and return to duty only to relapse and require further hospital treatment. In the majority an ulcer was ultimately found by X-rays though, in a few, more dramatic evidence was later forthcoming in the way of perforation or haematemesis. A difficulty with these cases was that they were often confused with psychogenic dyspepsia, for the fact that their pain recurred and that no tangible cause could be found for it often led to their developing superimposed symptoms of anxiety or depression. The difficulty in diagnosis was increased still further when vomiting or the excessive consumption of alkalis led to the development of an alkalosis.

(10) *Gastritis.* The idea of chronic gastritis as a relatively common disease had originated as a result of Schindler's observations[25] with

the flexible gastroscope and there is no doubt that, owing to his vast experience, his views had dominated the scene for several years, both before and during the war. Towards the end of the war, however, during which time several British gastroscopists had gained considerable experience (although still not to be compared with Schindler's) grave doubts began to arise as to whether mucosal changes described by Schindler as being due to chronic inflammation were not in fact physiological variations and not pathological at all. The publication, by Wolf and Wolff[33] of their classical experiments on Tom and his gastric fistula, was sufficient to stimulate the British investigators and encourage them to believe that their views were correct.

The position was crystallised at an important meeting at the Royal Society of Medicine in the autumn of 1944.[34] Izod Bennett, in opening the discussion, reminded the meeting of the many articles appearing during the war in which it had been written that gastritis was a common cause of dyspepsia in the Services; nevertheless, he himself had not once succeeded in definitely establishing a diagnosis of gastritis in any member of the Services suffering from dyspepsia; the gastroscopic diagnosis of gastritis should be accepted with reserve. Avery Jones emphasised the great variability of the normal gastric mucosa, capable of simulating inflammation, and noted that gastric atrophy need not necessarily be inflammatory, since it can arise as a result of trophic changes.[35] [36] [37] [38] He considered that gastritis was not a common condition. Mather Cordiner, describing the radiological appearances of gastritis, stated that there are no characteristic findings which enable the radiologist to diagnose atrophic gastritis. Thompson Hancock thought that atrophic gastritis had a recognisable syndrome, but, since this type of gastritis is relatively rare, gastritis is rarely diagnosable as a clinical syndrome and there is a tendency for gastroscopists to diagnose gastritis too frequently owing to insufficient allowance being made for the great variations that normally occur in the gastric mucosa. Morton Gill suggested that certain conclusions could be drawn from a combination of gastroscopic and secretory studies. Using histamine and insulin,[40] a summation of chemical and nervous gastric secretion could be obtained and measured, while the mucosa could be inspected with the gastroscope at the height of secretion. In subjects showing the gastroscopic appearances labelled hypertrophic gastritis, the highest concentration of free HCl and highest rate or secretion was seen, and, since inflammation is not associated with enhanced function, these observations suggested that some cases at least of so-called hypertrophic gastritis are in reality merely a physiological mucosal hyperactivity. Sir Henry Tidy considered that there was agreement among experienced gastroscopists that the appearances of the gastric mucosa could change with rapidity, and that this was an advance on earlier views, held earlier in the war, that variations from what was considered normal were permanent.

(11) *Duodenitis.* There was a tendency in some quarters to attribute atypical duodenal syndromes to duodenitis, but the concept was not generally accepted.

INVESTIGATION AND DISPOSAL OF DYSPEPTICS

In the early part of the war the investigation and disposal of the Service dyspeptic were somewhat haphazard. The investigations carried out were sometimes limited to a fractional test-meal done on an out-patient. In other cases a careful and thorough in-patient investigation was performed, but sufficient care was not taken to see that the results were attached to the man's medical record, with the result that, if a man was posted to a different unit, coming under a new medical officer, he might find himself admitted to another hospital and undergoing the same procedures all over again. The writer came across one such individual who had had no fewer than eight barium meals in the space of two years. In yet other cases, so thorough and so prolonged was the in-patient investigation, that a mild and transient functional case of indigestion became transformed into a chronic introspective dyspeptic, hopelessly unsuited for any form of soldiering.

In May, 1941, the military authorities decided to organise the investigations of dyspeptics in special units, the whole process being carried out within a week.[22] [23] [30] [31] It was found that large numbers of cases of dyspepsia could be quickly passed through hospital, without sacrifice of accuracy, if there were separate wards for investigation, treatment and disposal, all under the control of one sister. No attempt was made to investigate cases of dyspepsia as out-patients, it being considered that investigation should either be thorough or not attempted at all, since an inconclusive result would be of no value. Liaison between the various members of the medical staff was close, each case being reviewed, after investigation was complete, by the clinicians and radiologist in consultation. In the course of not more than seven days a positive diagnosis and decision as to disposal were reached, as a result of procedures which included the following: detailed history, clinical examination; psychological assessment; behaviour and response of patient to ordinary hospital diet without drugs; examination of stools for occult blood; gastric secretion tests, mostly using the standard gruel meal, but in selected cases histamine and insulin; barium meal, using the mucosal relief technique of Berg, no ulcer being diagnosed unless a niche was shown on the film; gastroscopy, using the Hermon Taylor model. Disposal was aided by the fact that a medical board sat at the hospital once a week, so that cases selected for invaliding (with few exceptions, those with chronic peptic ulcers) could be brought before the Board without delay. In every case thus selected, it was found that time was well repaid by a sufficiently long stay in the treatment ward to ensure healing, and in fact less than 1 per cent. of ulcers failed to heal under medical treatment. Before discharge from hospital and a return to civilian life, steps were taken to ensure that a suitable job should be available, and the man was given a diet-sheet, and a letter to his private practitioner, detailing the investigations performed, treatment given and results obtained.

Those patients not boarded and not treated, were returned to their units within seven days of admission to hospital, and their unit medical officers informed in detail of the investigations carried out and conclusions reached, in the hope, often unfulfilled, that these results would be recorded in the soldier's medical history sheet and thus re-admission to hospital avoided for the same complaint at some future date. Over 50 per cent. of cases admitted to the E.M.S. Dyspepsia Unit had previously been investigated at other hospitals. Although the soldier's medical history sheet was not allowed to be sent to an E.M.S. hospital with him, a photostat copy could be obtained, but this procedure did not work well in practice.

A further point in regard to disposal of ulcer cases was made by Rook[32] who followed up R.A.F. patients with ulcer, allowed to return to duty. The subsequent history of these cases suggested that disposal was to some extent related to rank, for the higher the rank the better was the patient able to carry on in the Service. In the R.A.F. and in the Navy men were so anxious to continue in the Service that a much greater number of dyspeptics were retained, but the Army failed to arouse a corresponding enthusiasm.

In the Navy in 1943, when the retention of skilled men was especially desirable, the Admiralty sanctioned the provision of special dietetic arrangements and conditions of service at certain naval bases whither suitable men with proved peptic ulcer were drafted. This scheme was under the direction of Allison. It never attained more than experimental status but a few points of interest emerged from the experience gained. (Rae. M.D. Thesis, University of Edinburgh, 1947.) Some seventy men in all were selected and employed on harbour and dockyard duties as engine room artificers, electricians, seamen, stokers, signal ratings and cooks. One party was accommodated in a partly disabled frigate which was moored in Belfast Dockyard (H.M.S. *Goodson*). Here they had their own messing arrangements and lived as a unit with executive officers and a medical officer in charge. The other party lived in the R.N. Barracks, Londonderry, again as a corporate unit and subject to all the rules of naval life except that (1) they were static and excused work involving special hardship or fatigue, (2) they had regular meals and snacks between meals and extras in the way of milk and eggs, the cost of which amounted approximately to 1s. a day. In initial selection care had been taken to pick only men of especial value to the Service and of good morale. This probably accounted for the fact that though they all had unequivocal evidence of peptic ulcer at selection and were employed for a year the percentage of their total working days spent off duty sick with dyspepsia was only 8·78 per cent., a figure which contrasted favourably with the 16·52 per cent. given for the insured population of Scotland in 1936–7. Nevertheless, while 73 per cent. of the men under these favourable conditions were sick only for a week or less, 14 per cent. were off sick for appreciable periods which made their retention uneconomic. At the conclusion of the experiment, which coincided with the end of hostilities with Germany, all the men were reinvestigated. Only 21 out of the 70 were then found to be free of symptoms and to show no radiological evidence of gastro-duodenal abnormality. In 25 men not only were symptoms present but X-rays still showed evidence of active chronic ulceration. Contrasting these cases with the others in which improvement or recovery had been effected, little significance seemed to attach to the previous duration of symptoms, occurrence of complications, or age. In the chronic active group, however, there was a high proportion of men with unstable temperament, lack of co-operation or insight, and with immoderate habits in regard to the use of tobacco and alcohol. Psychogenic factors as such appeared to play little or no part and had in fact been largely excluded.

The Royal Air Force tried to arrange a 'dyspeptic unit' very much like the Navy's, but there were many disadvantages from the executive point of view and the plan never matured. The medical branch of the R.A.F. found that the only satisfactory way to keep the good type of man fit after his treatment was to post him to a unit near his home so that he could live out. The posting branch was very helpful over this, and as a result, a large number of most useful non-commissioned officers were able to continue in the Service; but 'home posting' could not be adopted for R.A.F. officers (and W.A.A.F. officers) and eventually it was laid down that if an officer's symptoms recurred while living in mess he had to be invalided. In fact, most officers with peptic ulcer could stand up to mess conditions if they took care of their diet and led a reasonable life, particularly as regards smoking and drinking, but too many refused to conform.

THE FINAL YEARS

These years were marked in general by the turn of the tide and approach of victory and in particular by the tremendous depletion in numbers of Service personnel, especially in the Army, in this country, as more and more went oversea. There was thus a rapidly improving morale and a rapidly diminishing Service population and the problem of dyspepsia faded into comparative insignificance.

The Germans also found that dyspepsia was a product of static warfare, and that during active warfare it faded away.(9) (18) (42) There remained to try and understand the reasons for the existence of the problem and to learn as much as possible therefrom.

It was clear that with peptic ulcer there had developed, almost unsuspected, a large ulcer population between the wars and that when these individuals were taken away from their accustomed occupation, put into uniform and deprived of their careful diet, so many developed recurrences as to form a problem of the first magnitude for the Service authorities. Attempts to retain such men in the Armed Forces resulted in relapses and repeated hospital treatment, and it was found early on that in practice it was better, as a general rule, to invalid the majority of these men as soon as diagnosed, to treat them, until healed, in E.M.S. hospitals and then to ensure, through the machinery of the Ministry of Labour, that they returned to occupations in civilian life, which, while suitable to their condition, would also be of use to the country.

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CHAPTER III

CARDIOLOGY

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Casualties from cardiovascular causes, organic and functional, in the War of 1939–45 were only a very small fraction, approximately one-fiftieth, of the large numbers in the War of 1914–18. This simple but remarkable fact invites consideration of the reasons for such an improvement.

In 1914 the pioneer work of Mackenzie was but little appreciated. His discoveries had not gained general acceptance and there was practically no teaching of the fundamental principles which he had established. This ignorance of the profession at that time resulted in the mass evacuations from the Expeditionary Forces of casualties diagnosed as disordered action of the heart (D.A.H.) or valvular disease of the heart (V.D.H.). These were noticeably absent from the casualty lists of the second war.

There were several reasons:

(1) The better examination of all recruits by a medical board of three registered medical practitioners who could refer cases of difficulty or doubt for special investigation and report by a cardiologist.

(2) The better education of the medical profession in diseases of the heart between the wars, so that all medical officers, from the front line to the home hospitals, had been trained as part of their general medical education to understand and apply the advances in cardiology which had progressively taken place over some three decades.

(3) The appointment to the Services as consulting physicians or graded physicians of many of the best cardiologists in the country, and their distribution in all theatres of war, ensured that full advantage was taken of the relatively new knowledge to aid in maintaining the medical efficiency of active service units, and prevent unnecessary invaliding to the United Kingdom, or from the Services altogether when once the men had been so returned.

A cross-section of the special cardiac examinations can be obtained by the result of 1,000 cases examined by one of the civilian cardiologists at the request of the chairmen of some fifteen boards within reach of London. The 1,000 individuals were in every case examined personally by him by appointment. A medical history, clinical examination, X-ray film of chest, and three leads of an electrocardiogram were always obtained and the relevant features of each investigation recorded in the report. Of the 1,000 cases 560 were placed in Grade I and 190 in Grade

II; that is, three-quarters of the referred cases were fit for training and for the Services. One-quarter were placed in Grades III and IV and not deemed likely to be medically fit for training. Those in Grade IV were quite unfit for the Services, however great the need for man-power. A small point of clinical interest emerges from this comprehensive report on all the recruits. It was found that 2 per cent. of the 1,000 recruits had heart block of the first degree with a PR interval of at least 6/25ths second or more. The block was regarded by the examiner as a functional delay in conductivity in juveniles, just as sinus arrhythmia has been proved to be a normal functional irregularity of the heart, and likely to change to the normal conductivity of 1/5th second or less in adults. The few cases invalided from the Services in the recent war diagnosed as heart block might well contain some of this type.

The better training of all medical officers in their student days by the cardiologist and his colleagues removed the fear of a mistake in diagnosis from the commissioned medical officers who were thus able to keep many men on full duty, who, in the previous war, would have been evacuated for similar signs, say a systolic murmur or a simple tachycardia. The confidence of the medical officers gave confidence to the various ranks reporting on sick parades as to their fitness for duty, and fear of heart disease was correspondingly less.

Many of the leading cardiologists of the day were called up for commissioned rank. Their duties inevitably were largely of a general medical nature, but their experience in their special subject was frequently valuable and to the benefit of all ranks in the Services. Any tendency to be unduly lenient in preparing invaliding lists could be investigated on the spot in an authoritative manner. Almost all the cardiologists remaining in civilian life were employed part-time in special investigations of recruits for medical boards or in treating the Services casualties in the Emergency Medical Hospitals. There was no lack of expert cardiological knowledge and experience. These were available for the benefit of the recruit and all ranks in all the Services, before, during and after his or her service.

A special instruction to the medical boards necessitated their rejection of every recruit found to have a congenital malformation of the heart. This order materially reduced the risk of subacute bacterial endocarditis in the mobilised forces. At the same time, it could be held that minor cases of malformation, such as those which show a systolic murmur but no radiological, no electrocardiographic, nor other abnormal sign might well be physically fit for the Services and should be considered for enlistment when man-power is a pressing necessity.

Official figures supplied to the Editor-in-Chief of the Medical History of the War fortify the claims above made. The first set of figures relate to men examined under the National Service Act and were taken for two periods. The figures were representative of all regions and related to

30,000 men in each case, the ages being from 18 upwards. The percentage of recruits rejected for organic heart disease for the period 1939–41 was 2·66 per cent. and in October, 1942 was 2·18 per cent.

The causes of discharge from the Army for heart disease in other ranks were as follows;—

Diseases of valves	1943	1944	1945
Mitral stenosis	436	338	229
Mitral incompetence	82	73	27
Aortic stenosis	13	5	13
Aortic incompetence	159	129	78
Combined mitral and aortic lesions	37	41	28
V.D.H. unqualified	40	38	101
TOTAL	767	624	476

Disordered action of heart	1943	1944	1945
Tachycardia	21	22	27
Heart block	14	13	6
Auricular fibrillation	22	33	18
Auricular flutter	1	4	2
Syncope	3	8	6
Sinus arrhythmia	1	—	—
Premature contractions	1	3	2
Others	1	3	1
TOTAL	64	86	62

The most striking figures are those given by the Ministry of Pensions. In the War of 1914–18 pensions for functional diseases of the heart were awarded to 44,855 persons. So far for the War of 1939–45 the total number pensioned for functional diseases of the heart, both male and female, is 938.* When allowance is made for the total number of men and women in all the Services in each of the wars, there is justification for the statement made at the beginning of this article that casualties from cardiovascular causes, organic and functional, in the Second World War were approximately one-fiftieth of the numbers in the First.

Cardiovascular degeneration, chiefly atheroma and hyperpiesis with their respective development and dangers, was more clearly appreciated as a result of the increase of knowledge of these conditions between the wars. In the War of 1914–18 for instance it was rare for a hospital to have as part of its equipment an instrument for recording the blood-pressure. The capillary tube was an unsatisfactory instrument whereas soon after 1918 the present standardised and serviceable instrument was

* The 938 cases mentioned here were those pensioned for 'Effort Syndrome', and their diagnosis was on a much more critical and accurate basis than the 1914–18 War group of functional cardiac disorders. See 'Medicine in the Emergency Medical Services' in this Volume, Chapter I.

developed and the general use of it followed. Further, the knowledge that coronary thrombosis might be consistent with survival was not appreciated until a few years after the War of 1914–18. There is no evidence that cardiovascular degeneration has any greater incidence in the Services than in civilians of the same age. The truth appears to be that atheroma is an inborn condition with very variable rates of progress, but is always present in its earliest stages by the age of 30 years, and in some at an earlier age. Stress and strain as aggravating cardiovascular degeneration have never been defined, and in fact cannot be separated from life itself whether in the Services or civilian life, in the physically active or in the lethargic, in the mentally alert or the dull. Of those who survive to 30 years of age and are then passed as medically fit, it has been estimated that at least one in ten of them will die of some form of cardiovascular degeneration before the age of 65. A larger number will show clinical evidence of these degenerations by the same age.

Gunshot wounds of the heart were treated with greater boldness and success in the War of 1939–45 than in previous wars owing to the development in the preceding two decades of a special branch of surgery. Surgical thoracic units were organised in the Services and in the Emergency Medical Hospitals at home where the new principles that had evolved in the operative treatment of diseases and wounds of the chest were applicable to wounds of the heart through the team-work of the whole staff of these special hospitals. Tamponade of the heart or haemorrhage called for emergency treatment, but otherwise foreign bodies could well be left until the patient was received into a surgical chest-unit. There the removal of foreign bodies could be effected whether adjacent to the pericardium, in the heart muscle, or, very rarely, in the auricle or ventricle. This subject will be found described in the volume on Surgery in this series.

CHAPTER IV

RHEUMATIC DISEASES

(i)

Acute Rheumatism

BY J. ALISON GLOVER
C.B.E., M.D., F.R.C.P.

DAMP, chill and exposure have always been regarded so highly as prime factors in rheumatic fever that the conditions of modern war—the trench or fox-hole filled with water, icy exposure, sleeping in wet clothing, and the crowded dug-out or shelter—might well seem to make an environment very favourable to rheumatic fever, and one might expect it to be outstanding among those diseases which crowd in the train of war. Yet it found no place in Hurst's *Diseases of War*, and the various Bulletins of War Medicine hardly noticed it. Even in times when the disease in civil practice was far more common and severe than to-day, its incidence in war was much below expectation. 'Certain it is', says Lehlbach[1], in 1863, 'that we often see regiments exposed to damp, wet, cold, sudden and violent changes of temperature, and obliged to sleep on wet ground with but scant protection and no cases of acute rheumatism.' Then it was, as it still is, a disease of recruits, occurring in training establishments (in war always overcrowded) rather than a scourge of armies in the field or fleets at sea. Even in peace-time, as early as 1859, depot battalions in England had a much higher incidence of acute rheumatism (39·3 per 1,000) than trained infantry (28·7). In the American Civil War[1] we find: 'Acute rheumatism shows in its monthly rates a greater prevalence in that period of the war during which new levies were sent to the field than later when the levies have become inured to the hardships of active service.' This preferential incidence on recruits and training establishments often assumes the form of 'barrack epidemics' referred to in a later section. But rheumatic fever, if not outstanding as a war disease, is important, for it causes no small proportion alike of medical casualties (who require long treatment in bed) and of permanent rejections from the Services. Table I epitomises the experience of rheumatic fever in recent wars.

THE DECLINE OF RHEUMATIC FEVER

For long now, rheumatic fever has shown the features of obsolescence, its incidence, and, still more, its severity steadily declining. In previous military history this trend can be seen. In civil life no longer is it 'not only one of the most prevalent, but one of the most fatal maladies

TABLE I

Rheumatic Fever in Recent Wars

War	Date	Average annual admission rate per 1,000 strength	Average annual death-rate per 1,000 strength	Case mortality per 1,000 strength	Rheumatic fever admissions as a percentage of total admissions for all diseases and non-battle injuries	Observations
American Civil War (1)	1861–5	65	0·20	0·2	—	Although the admissions are classified as 'acute rheumatism' the author of the American History considers a large proportion to have been myalgia or of other conditions than rheumatism.
South African War (2)	1899–1902	44	0·04	0·1	6·05	Fine climate, much severe marching, often short rations, dust, much enteric fever and dysentery.
B.E.F., France (3)	1915	35	0·03	0·1	3·9	Mud, wet trenches, trench feet, trench fever, excellent rations, some rest periods.
Dardanelles (3)	1915	56	0·15	0·26	4·5	General discomfort and exposure to both great heat and severe weather, rations probably inferior to (3) but superior to (2), no real rest periods, much dysentery.
U.S. Army, 1st World War (4)	1.4.1917 to 31.12.1919		0·01	0·18		Severe overcrowding in training camps and transports: conditions in France somewhat better than (3).

incident to our precarious climate' (Macleod, 1837). No longer are more than a tenth (11·5 per cent., Ormerod, 1852) of all admissions in general hospitals those of patients with rheumatic fever, so acute as to be readily diagnosable by high pyrexia and characteristic odour. Since 1870 their numbers and the proportion to total admissions in civil hospitals have fallen to a tenth of what they were, and, in peace-time, there have been similar reductions in the Service hospitals. The severest of its clinical features, such as hyperpyrexia, pericarditis and nodes, are nowadays rarities, the age incidence has shifted from the younger adult age-groups to that between 5 and 15 years, while its social incidence is now almost exclusively on the children of the poor, especially those of great cities.(7)

The standardised all-ages *death-rate* for males, 89 per million in the decade 1891–1900, had fallen to less than a quarter—22 per million in 1937. In the military age-groups the reductions in death-rates were even greater. Occasional exacerbations occurred; such as one (1915) during, and one (1920) just after the First World War, the latter perhaps an aftermath of the high level of haemolytic streptococcal infection from the great influenza waves of 1918–19. Minor peaks occurred in 1925 and 1934, but in spite of them the great decline in rheumatic-fever mortality still went on.

The inter-war years 1919–39 were noteworthy in rheumatic fever history for three things: first, the acceleration of the decline; secondly, the inception of systematic preventive effort, especially in London, Birmingham and Bristol; and thirdly the strengthening of the theory (not yet conclusively proved) that infection by the *Streptococcus pyogenes* is the cause of the disease.

THE RÔLE OF STREPTOCOCCUS PYOGENES

Bacteriologically. During the inter-war years new light was thrown on the rôle played by this organism, in all the diseases wholly or partially due to its infection, by the differentiation of its serological types by F. Griffith (himself a war casualty) and by the work of Lancefield, Todd, Coburn and many others. (See Chapter XXIX.)

Epidemiologically. The general trend and oscillations of rheumatic fever mortality so closely correspond to those of scarlet fever mortality as to support the view that both derive from the same infection, in the latter case undoubtedly *S. pyogenes.* The investigation of '*barrack epidemics*' and similar outbreaks in residential schools in these inter-war years also supported the streptococcal theory. Such epidemics have certain characteristics. They occur in overcrowded communities with a high proportion of newcomers—freshly recruited adolescents. They have a regular cycle: overcrowding, a precursor epidemic of acute tonsillitis, an interval (representing the latent period in the individual) and then the occurrence of cases of rheumatic fever, usually less than one-tenth of the cases of tonsillitis. If, during the precursor tonsillitis epidemic, sample throat swabbings of the healthy members of the community be investigated, a high carrier-rate (say 30 to 50 per cent.) of a single type of *S. pyogenes* will be found, and the same type will be grown from swabs from the throats of the tonsillitis patients. Such 'barrack epidemics' of rheumatic fever obviously resemble those of cerebro-spinal fever, save the meningococcus itself produces no throat or catarrhal symptoms and so only a 'silent' or 'carrier' precursor epidemic. Recruits, in both cases, are particularly vulnerable in their first weeks of training, when the strain of unaccustomed exercises and environment lower resistance to the infection by a fresh strain of haemolytic streptococcus, of which the virulence has probably been enhanced by rapid transference.

The possibility of a virus being the primary cause, and the *S. pyogenes* playing but a secondary part was explored by many, but no convincing evidence has yet emerged to support the virus theory of causation of acute rheumatism. Nor has any *specific deficiency* (vitamin or other) been incriminated, though a sufficient and properly balanced diet, including plenty of milk, is probably of much protective value for children and adolescents against acute rheumatism.

THE WAR OF 1939–45

This war involved civilians to an extent unparalleled in this country since the Anglo-Saxon invasion, and on the Continent since the Thirty Years War. Civil experience is therefore of great significance, especially as the war in this country began with evacuation, the unprecedented mass movement from great industrial cities of three-quarters of a million of the schoolchildren, the most susceptible section of all the community to acute rheumatic infection. Evacuation was fortunately carried out in ideal weather, and though an epidemic of tonsillitis was noticeable (though, of course, not notifiable) in the autumn of 1939, the great decline, described in a previous section, continued through the years 1940 and 1941, and brought acute rheumatism to its nadir in 1942, in which year the crude *all-age death-rate* sank to 12·1 per million, scarcely half of what it was in 1939[(23)] and only 56 per cent. of the previous low record of 1937 (21·5).

Of actual *deaths under* 15, only 157 from rheumatic fever occurred in 1942, compared with 300 in 1937, and from heart disease (at least nine-tenths rheumatic in origin) only 330 (contrasted with 590 in 1937). Scarlet fever mortality showed corresponding and even greater reductions up to 1942.

Since its nadir in 1942, rheumatic fever has increased a little, the crude death-rate rising to 17 in 1943, and 18 in the first half of 1944; deaths under 15 rose to 233 in 1943, all figures still much below the best pre-war records of 21·5 and 300 respectively in 1937. Scarlet fever showed a corresponding trend in incidence.

The decline of acute rheumatic mortality in children is shown in Table II.

TABLE II

Death-rates Per Million at Ages under 15 during the War Years[5]

For comparison	Rheumatic fever	Heart disease
1901–10 . . .	55	147
1911–15 . . .	55	137
1916–20 . . .	50	115
1926–30 . . .	55	88
1938 (last year of peace) .	44	68
1939	34	56
1940	30	49
1941	22	45
1942	18	39
1943	27	40
1944	28	42
1945	26	34
1946	18	26

Evacuation of children and hospitals, together with the closure of many rheumatic supervisory clinics, renders impossible any comparison between pre-war and war incidence on London children, but Bristol, though later suffering severely from air raids, was not originally an evacuation area, and Professor C. Bruce Perry has kindly provided the following information:—

Cases at the Bristol Cardio-Rheumatic Clinic showing Evidence of Active Infection

	1933–4	1937–8	1941–2
Average number of children on elementary school registers .	55,130	50,800	42,545
Total cases with active infection (including chorea) . .	199	201	63

Patients with arthritis dropped from 114 in 1933–4 to 28 in 1941–2. Patients with rheumatic nodules in 1941–2 numbered 5 compared with 20 in 1937–8, showing a decline in severity. In Cardiff, hospital admissions dropped from 121 in 1937 to 89 in 1941–2. In Leicester, the patients attending the rheumatic clinic declined from 179 (nine months only) to 102. At Great Ormond Street Children's Hospital, the percentage of rheumatic patients to total admissions in 1933–4 was 2·24; in 1937–8, 1·20; and in 1941–2, 0·83. In the Glasgow Royal Hospital for Sick Children, admissions for acute rheumatism in 1941–2 numbered 70 and formed 3·3 per cent. of the total admissions; in 1931 there were 150 and they formed 10·1 per cent. of the total admitted.

MILITARY EXPERIENCE

The original British Expeditionary Force of 1939–40 which evacuated from Dunkirk had but few cases of rheumatic fever. Copeman[6] records that during the first four months of this campaign admissions to Base Hospitals No. 2 and No. 3 for 'rheumatic' conditions were about 15 per cent. of total admissions and 26 per cent. of all admissions in the medical division. Only 15 per cent. of these patients with 'rheumatic conditions' (judging by the first 100 cases admitted to a special 'rheumatism' ward) suffered from either acute or subacute rheumatic fever; the great majority—70 per cent.—suffered from fibrositis, 6 per cent. from rheumatoid arthritis, and 9 per cent. from osteoarthritis (mostly traumatic in origin). Rheumatic fever therefore seems to have accounted for some 2·25 per cent. of total admissions to hospital. Copeman's finding that only 15 per cent. of military patients of the original British Expeditionary Force who were admitted for 'rheumatic conditions' suffered from either acute or subacute rheumatic fever, may be compared, after allowing for differences in terminology, with those of earlier military records. The latter, however, generally put the proportion of true rheumatic fever even lower (e.g. 7·9 in 1916–17–18 and 5·2 in Italy 1917–18) and may also be compared with those for insured males[7] of corresponding age (16–35) in civil life in England and Wales in 1922, which are: acute rheumatic fever 9·2 (subacute 20·4), rheumatoid 2·9, osteoarthritis 3·8, muscular rheumatism (including lumbago) 63·6. Later experience in the Middle East tempted Copeman further to modify rheumatic classification by describing three types of rheumatic fever: first, the 'classical' type; secondly a 'benign' type for which he suggests the title 'acute febrile myalgia' and which though not uncommon is non-epidemic, of short duration, and without cardiac or other sequelae; and thirdly a type, which, while 'classical' in attack and in the occurrence of carditis, does not resolve but merges into chronic fibrositis.

Royal Air Force

H. S. Barber[8] gave the incidence of rheumatic fever in 1940 in the R.A.F. as a whole as 2·1 per thousand, whereas among the boy entrants and apprentices it was 10·4 per thousand for the same year. The subsequent incidence is shown in Table III.

Experience in the American Forces

D. D. Rutstein[9] has stated that, from January, 1941, to August, 1945, approximately 17,000 cases of rheumatic fever occurred in the United States Army, and from the onset of war to January 1, 1945, 14,344 cases of rheumatic fever occurred in the United States Navy.

Admission to E.M.S. Hospitals from the Services

Judging by the one-fifth samples taken by the E.M.S. Statistical Branch. Ministry of Pensions, Norcross, and multiplying them by five,

TABLE III

Incidence of Acute Rheumatism in the Royal Air Force during the Years 1941–1945

(*Males only*)

	Total force		Force at home		Force abroad	
	No. of cases	Rate per 1,000 per annum	No. of cases	Rate per 1,000 per annum	No. of cases	Rate per 1,000 per annum
1941	1,091	1·6	952	1·6	139	1·8
1942	1,026	1·2	649	1·0	377	1·9
1943	802	0·8	413	0·6	389	1·3
1944	1,229	1·2	724	1·1	505	1·6
1945	443	0·5	268	0·4	175	0·6

the numbers of patients from the Forces admitted to the E.M.S. hospitals in this country with acute rheumatic fever in 1942 and 1943 are shown in Table IV.

TABLE IV

Approximate number of Admissions of Male Service Patients to E.M.S. Hospitals (a) with Rheumatic Fever, (b) with 'Rheumatism', Arthritis and Fibrositis. Estimated from One-fifth Samples by P. Stocks and E. M. Brooke

Period (1)	Cases in age-groups (no case over 45) (2)			Total rheumatic fever (3)	Total 'rheumatism', arthritis and fibrositis (4)	Proportion of rheumatic fever, i.e. percentage which 3 is of 4 (5)	Percentage which rheumatic fever forms of admissions for all diseases (6)
	18–	25–	35–44				
1942 1st half	220 (85)	175 (5)	45 (5)	440 (95)	3,435 (285)	12·8 (33·3)	0·51 (1·2)
2nd half	120 (80)	170 (15)	70 (5)	360 (100)	3,105 (440)	11·6 (18·1)	0·46 (1·0)
1943 1st half	270 (65)	165 (15)	65 (10)	500 (90)	2,935 (485)	16·3 (13·4)	(0·7)
2nd half	120 (90)	110 (20)	35 —	265 (110)	— —	— —	— —

Figures for females in parenthesis.

As it is not possible to state the populations at risk these figures cannot give us the incidence, but it is apparent that the incidence was low and that it was heavier in the first than in the second half of each year, and that the proportion which rheumatic fever bears to the rheumatic group as a whole is not unlike that found in France by Copeman. The figures for female patients from the Services are much smaller and much more confined to the 18–24 group and the percentage of rheumatic fever in the whole rheumatic group is as might be expected considerably higher.

Stocks and Brooke[10] found that rheumatic affections, comprising rheumatic fever, fibrositis and all forms of rheumatic arthritis, accounted for a remarkably constant proportion of all non-infective and non-respiratory illnesses causing admission to E.M.S. hospitals, the proportion being about 50 per thousand for each sex.

INVALIDING

Acute rheumatism is now fortunately a much less frequent cause of invaliding than it was in previous wars. In the American Civil War the ratio was 25·1 per 1,000; in the South African War 7·75; in the War of 1914–18 I estimate the figure at 8·2 per 1,000, but I do not think that this estimate relates so accurately to acute rheumatism as does the South African War figure; it probably includes other forms than acute. It is yet too early for estimates for the Army in the War of 1939–45. Acute rheumatism nevertheless still often causes a Service patient to be invalided out. G. C. Ferguson[11] described an increased prevalence of acute rheumatism in military hospitals of Canada in the spring of 1942: 534 cases were admitted in the year ended July, 1942, and of these 331 were admitted in the four months February–May. He showed that 50 per cent. of the patients were invalided out, including 35 per cent. with valvular disease and 7 per cent. with rheumatoid arthritis; of the 50 per cent. who returned to duty 20 per cent. were subsequently invalided out.

Surgeon Commander C. A. Green has furnished Table V.

TABLE V

Royal Navy. Final Invalidings due to Acute Rheumatism and Allied Conditions

Rates per 1,000 Strength per Annum (Officers Excluded)
(F = Women's Royal Naval Service)

Age	Rheumatic fever or subacute rheumatism, with or without acute or chronic cardiac lesions		Mitral stenosis or incompetence, aortic stenosis or incompetence, subacute endocarditis		Unspecified organic heart disease		Total of all three groups	
	M.	F.	M.	F.	M.	F.	M.	F.
Under 20 .	0·50	0·73	0·11	0·08	—	—	0·61	0·81
20–24 . .	0·24	0·41	0·08	0·06	—	—	0·32	0·47
25–29 . .	0·23	0·59	0·05	0·17	0·02	—	0·30	0·76
30–34 . .	0·15	0·55	0·11	—	—	—	0·26	0·55
35–39 . .	0·11	0·36	0·02	—	0·02	—	0·15	0·36
Over 39 .	0·02	—	0·05	—	0·11	—	0·18	—
All ages .	0·26	0·49	0·08	0·08	0·01	—	0·36	0·57

PROPHYLAXIS

Prophylaxis against rheumatic fever is at present identical with that against acute streptococcal tonsillitis or scarlet fever. Good ventilation and avoidance of overcrowding are still the paramount considerations, though the importance of dust suppression grows ever clearer, and dampness in houses, barracks, huts or between decks is a factor. Chemo-prophylaxis was tried extensively in American camps and was in certain cases regarded as effective. R. Cruickshank[12] wrote of these measures of control:—

'Mass chemoprophylaxis with sulphonamides was tried in a number of these outbreaks. Unfortunately this prophylactic measure was sometimes not instituted until the epidemic had reached its peak so that a sharp fall in incidence following its introduction was difficult to interpret. None the less, the combined evidence suggested that sulphadiazine in doses of 0·5 g. twice daily for periods of one to four weeks helped to control the epidemic spread of streptococcal throat infections. There was, however, an unhappy sequel. In the winter of 1944–5 (the large-scale prophylactic use of sulphonamide was introduced in 1943–4) a number of outbreaks of scarlet fever and streptococcal tonsillitis occurred due to sulphonamide-resistant strains of the same types (principally types 17 and 19) as were prevalent the previous winter, and there seems little doubt that these resistant strains derived their origin from the small doses of sulphonamides used to control the earlier outbreaks of streptococcal infection.

'Experience with the chemoprophylaxis of streptococcal infection in this country has been largely negative.

'Recent work by Hamburger and his colleagues (1945) has suggested that the nasal carrier may be more important than the throat carrier as a reservoir and source of streptococcal infections.'

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(ii)
Chronic Rheumatism

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Although comparatively little reference to chronic rheumatic diseases is to be found in the available reports of the consultants in medicine, their nuisance value was in the aggregate considerable and at times produced a mild man-power problem in certain regions, while the hospital bed situation was adversely affected owing to the length of the average stay in hospital. For information concerning this aspect it is necessary to consult the quarterly reports of the officers in charge of medical divisions of general hospitals and these have been summarised in a separate section.

The difficulties inherent in the lack of a standardised nomenclature, and the fact that interest in rheumatic diseases varies widely among medical men, make it difficult to give an exact picture of the incidence of the different forms, but the samples given for the various theatres of war are believed to be generally representative. The difficulty is increased by the fact that a number of cases were admitted to surgical divisions and retained there, more especially if orthopaedic facilities were available.

The cases sent to the spa hospitals for physiotherapy under the Emergency Medical Service of the Ministry of Health depended largely on the views of the medical and surgical staffs of the Service hospitals and depots at which the cases were first received for treatment, and it follows that many cases were received from some, and few or none from others. While this depended in some degree upon the availability of physiotherapeutic treatment in the various hospitals, it was also affected by the experience of rheumatic diseases and the effective methods of treatment possessed by the medical officers and medical boards concerned. Unfortunately patients undergoing treatment by heat and massage were often detained in general hospitals for many weeks; they would have recovered more quickly in a hospital specially equipped for physiotherapy, where they would not have been confined to bed and where systematic exercises adapted to the case would also have been a feature of the treatment. These factors make it impossible to correlate the numbers treated with the numbers at risk.

The number received for treatment at the two E.M.S. hospitals upon which this report is based, from the beginning of 1940 to the end of

1945, was 1,497 of whom 226 were of commissioned ranks and the remainder 'other ranks'; there were 52 from the Women's Services. During the latter half of this time, half the beds previously reserved for rheumatic cases were taken over for the treatment of peripheral nerve injuries by reason of the facilities available for physiotherapy. These cases are not taken into account in this survey. The cases came from all branches of the Forces and were treated in two hospitals, one being reserved for officers; cases were also received from the W.R.N.S., thc A.T.S., the W.A.A.F., and from the Nursing Services.

DISEASES TREATED: CAUSES AND CONTRIBUTORY FACTORS

The types of disease treated were chiefly those of the non-articular group classified under various headings, but subacute rheumatism, arthritis, both of the rheumatoid type and the traumatic and degenerative forms, and spondylitis are also included. A marked increase in the incidence of spondylitis of the ankylosing variety was noted in comparison with civilian experience. A similar increase has been reported in the American Armies (Boland and Present, 1945), and it has been stated that German writers noted an increased frequency of the disease among soldiers in the 1914–18 War (Miller, 1934).

Classification of Admissions: Percentage

	Officers	Other ranks
Sub-acute rheumatism	4	4·5
Fibrositis	35	52·5
Lumbago	—	4·5
Sciatica	15	12·3
Rheumatoid arthritis	19	19·0
Osteo-arthritis	6	1·3
Spondylitis	9	1·1
Synovitis	—	2·0
Pes planus	—	1·5
Gout	5	0·4
Other diseases	7	0·9

The consensus of opinion from the theatres of war has been that the precipitating factors have been febrile illness, trauma, and severe climatic exposure, cold appearing to be the major element.

Cold, Damp, and Changes in Weather

The majority of the men at risk were conditioned by long training to withstand a degree of exposure not normally encountered in civil life. Those who attributed their symptoms directly to exposure described such conditions as night patrols in the snow; sleeping on concrete floors or in slit trenches; lying in mud wrapped only in a blanket; spending days at a time in wet clothes after crossing rivers; continual exposure to the fierce damp draught which concentrates on the driver's seat in a Sherman tank; dispatch riding in all weathers; or wading ashore from landing craft in bad weather. The common factor in all these experiences was cold with insufficient protection to a degree approaching or exceeding the limit of individual tolerance, either alone or in conjunction with over-exertion, fatigue or mental strain.

Another significant factor appeared to be the variability of the conditions to which forward troops had to adjust themselves. Periods of relatively good living alternated with periods of full exposure to the weather. Sudden changes of weather bringing low temperature, wind, rain, or snow exerted their full effect on soldiers living in the open without cover. The protection afforded by clothing is lost when the clothes become wet and in these circumstances even in relatively warm weather a man is subjected to considerable stress. However well conditioned a man may be, there are periods in such an existence when he is reduced to a state of shivering misery which is tempered only by his occupation with the job in hand.

An attempt to correlate recent physiological observations with the onset of rheumatism precipitated by such conditions was made by Copeman and Pugh in B.L.A. (113 General Hospital), and the effect of such climatic conditions on intracellular tension was shown. They were able to demonstrate that these changes are reversible by means of dehydration. It seems possible that some therapeutic advance is foreshadowed by this work. (Copeman and Pugh, 1945.)

Infection

Focal infection met with little support as an aetiological factor in rheumatic conditions in the Army. In a group of young men so carefully selected as were the forward fighting troops, it was a comparatively simple matter to exclude it.

E.M.S. HOSPITAL EXPERIENCE

This in the main supported the observations above recorded from the actual war theatres. Fibrositis accounted for the largest proportion of the cases sent for treatment, a somewhat loose designation including conditions differing both in aetiology and pathology and having in common only the symptoms of pain and stiffness and the localisation of the trouble in the fibrous tissues. The results of treatment were influenced in some measure by the fact that among 'other ranks' more particularly there were two categories which tended to reduce the general average of recovery: men from the reserve, many of whom had served in the 1914–18 War and were at an age when their capacity to stand up to prolonged physical strain was deficient; and a fairly large number who had been passed by recruiting boards but from various causes had broken down in training, some having gone 'sick' within a week or two of being called up, and others having been in and out of hospital for months, in a few cases for more than a year, generally with very indefinite complaints. The truth of the saying that malingering is rare but exaggeration is common was frequently illustrated and it cannot be denied that the disease which was once described by an eminent surgeon as 'miles antiquus' was not unknown. A good many cases of these types were sent for out-patient treatment from a depot of Pioneers in the district and were mainly men of low category complaining of stiff and painful backs and shoulders, flat foot, etc. often with a history of old injuries in civil life with little or nothing in the way of objective evidence to explain their symptoms; these were very unsatisfactory cases to treat. It appeared likely that some were psychosomatic or psychoneurotic in nature but a psychotherapist was not available to investigate them from this standpoint. Cases of the kind, described by J. L. Halliday and by R. G. Gordon, were not numerous, though a psychological element leading to exaggeration of symptoms was often encountered, especially in cases where long continued strain and exposure had reduced the general powers of resistance; they usually proved amenable to physical measures and rest.

The tendency of recruiting boards to regard chronic backache as merely neurotic or a shirker's complaint led to many men being taken into the Services who were a liability from the first, but this was perhaps inevitable. Cases with a clear history of serious accident to the back in previous years and a few cases of well-marked adolescent kyphosis were met with. Cases of pain in the lumbar and sacral regions frequently presented a difficult problem in diagnosis, since on clinical examination there might be no objective evidence beyond some limitation of forward bending or a flattening of the normal lumbar curve with perhaps spasm of the erector spinae which could be corrected with the man in a supine position without eliciting pain. In such cases it might be only a matter of habitual defective posture, and physical training so far from being inadvisable might prove of permanent benefit to the recruit.

In the majority of cases of fibrositis sent to these hospitals the cause appeared to be a physical strain or exposure or a combination of both; in a smaller number there was a definite history of some infection though the causal relation was not always clear. A great variety of infections was noted, the most common being a history of subacute rheumatism, tonsillitis, otitis media and dysentery; among the others were chronic appendicitis, colon bacilluria, amoebiasis and non-specific urethritis. In some cases with a history of strain X-ray examination revealed congenital defects, most commonly sacralisation of the fifth lumbar vertebra which appears to be a factor predisposing to strain especially when unilateral, though in view of the frequency with which this abnormality is met with in radiography of the vertebral column for other purposes its causal relation cannot be regarded as certain.

It is probable that troops serving abroad were in much harder condition and better fitted to stand exposure in the later stages of this war than in 1914–18. The impression was formed that there were more cases of fibrositis among men who had never been abroad during their training than in those returning from foreign service, but this observation remains to be tested later when records are complete.

Trauma

Strains and other forms of injury due largely to the increased mechanisation of the Army played an important part in the production of many of the cases classified as fibrositis. Strain from lifting was the most common cause of low back pain in the nursing services. Periarthritis of the shoulder, often called brachial neuritis, has been included with fibrositis and was usually associated with strain.

Fibrositis due to exposure was usually effectively treated by heat and massage which was available in most military hospitals, only the more obstinate cases in which there was usually some other aetiological factor being transferred to the physiotherapy centres, so that any statistical conclusions as to the relative proportion between the different aetiological factors cannot be drawn from the admissions to these hospitals. The researches of Copeman and Ackerman (1944) and of Mylechreest (1945) have thrown a good deal of light on this difficult subject and it is likely that many cases were in consequence treated by their methods in the Service hospitals which would otherwise have been sent to the centres for physiotherapy. These reasons may explain the fact that exposure was less often attributed as a cause of fibrositis and other rheumatic conditions than in the 1914–18 War and strain was more frequently deemed responsible.

Morbid Anatomy

The researches of Copeman and Ackerman referred to above demonstrated by means of biopsy that in many cases the nodules in fibrositis consisted of a local non-inflammatory oedema of the fibro-fatty tissues in certain regions, which sometimes resulted in herniation of fat lobules through their fibrous investment where this was deficient.

Elliott noticing that certain fibrositic nodules disappeared as a result of treatment, produced myographic evidence to confirm his view that these lesions were in fact local collections of muscle fibres in spasm.

Pugh and Christie (1945) examined 500 healthy soldiers in B.L.A. and found that non-tender nodules could be detected in many; equally in rheumatic and non-rheumatic subjects. Tender nodules and trigger points were found in only 3 per cent. of men who did not give a clear history of fibrositis as compared with 30 per cent. in those who did. Thus it seemed that non-tender nodules can be considered to be of no importance whilst tender nodules must definitely be correlated with a rheumatic 'diathesis'.

The observation was made by Copeman (1940) during an epidemic of influenza, that the pain in the back of which these patients complained was referred to trigger points similar in every way to those characteristic of fibrositis. He observed moreover, that although in a majority of patients these points disappear during their convalescence, in others they remain, unknown to the patient, until they are reactivated by any subsequent febrile illness or exposure. It seemed that in this way they may prove to be the basis for subsequent chronic fibrositis.

Aetiological Factors in Fibrositis admitted to E.M.S. Hospitals: Percentages, Officers only

Exposure		30·0
Traumatic causes	27·5	33·0
Trauma plus congenital defects	5·5	
Infective		26·4
Psychoneurosis		4·6
Unclassified		5·5

Sciatica

There were many cases of sciatic pain among the admissions to the E.M.S. hospitals, and of these 30 per cent. showed definite evidence of prolapse of an intervertebral disk and in about an equal number there were grounds for suspecting that this might be the cause. Of the remainder the majority were due to fibrositis of the lumbo-sacral ligaments and gluteal muscles, and in about one-third of these X-rays showed the presence of some congenital abnormality as described in the section on fibrositis. The cases in which there was evidence of a disk lesion were transferred to orthopaedic or neurological centres, the remainder were generally treated effectively by physiotherapeutic methods to be described later. It is probable that many cases due to a prolapsed disk were recognised in the general hospitals and transferred to special hospitals directly so that the percentages given above may be misleading.

A considerable amount of work was carried out, largely at the Military Hospital for Head Injuries at Oxford, on the subject of sciatica caused by prolapsed intervertebral disks. It seems to be the general opinion among officers in charge of medical divisions that about 70 per cent. of patients with sciatica seen in their hospitals were suffering from this lesion, though neurologists are inclined to claim 90–95 per cent. A questionnaire on this point circulated privately appeared to indicate that very few soldiers affected in this way reverted to useful employment in the Army.

Elliott and Kremer (1945) showed that a lesion of the cervical intervertebral disks could be demonstrated in certain cases of brachial neuritis.

SUBACUTE RHEUMATISM AND RHEUMATOID ARTHRITIS

A small number of cases were admitted to the E.M.S. hospitals for treatment of stiffness of joints left after subacute rheumatism, but there were in addition a few cases of pain and swelling in the joints moving from one joint to another over a period of several weeks or months.

There was a history of moderate fever at the onset and an accelerated sedimentation rate, salicylates had little effect beyond relieving pain and in several cases sulphanilamides had been given in general hospitals also without benefit; remissions and recurrences with the same symptoms occurred and the condition gradually became chronic, settling in the proximal phalangeal joints and sometimes the wrists, knees or other joints, presenting the picture of true rheumatoid arthritis. By this time the sedimentation rate had generally become normal and the joints though thickened showed no sign of breaking down or of ankylosis, but from contraction of the capsular ligaments there was generally some restriction of movement as in closing the fist, otherwise recovery tended to become complete and so far as could be traced no further development occurred. While such cases might be regarded as true rheumatoid arthritis they differed clinically from the usual type; there was no cardiac involvement in most cases. The writers had met with similar cases in civil hospital practice before the war, chiefly in young male adults, and the late Professor Noah Morris stated (in a personal communication) that he had met with several cases of the same kind and had come also to the same conclusion that they represented a link between rheumatic fever and rheumatoid arthritis; no infective foci were identified.

There were many patients with rheumatoid arthritis of the usual type; in some instances the condition was slight and the patient was able to return to duty in a lower category, but there were other more severe cases which resulted in crippling. Gonorrhoeal arthritis was rarely seen in the E.M.S. physiotherapy centres, probably because of its early recognition and treatment in special hospitals. In a few cases there was a history of gonorrhoeal infection some years earlier but it seemed doubtful whether the arthritis was gonococcal; in two cases there was a history of non-specific urethritis. Dysenteric arthritis was less common than in the 1914–18 War; there was a history of malaria in several cases but it did not appear to have any relation to the arthritis. Vaccines were not used and gold only in a few of the more severe cases, the effect of rest in favourable conditions and physiotherapy often being sufficient.

Spondylitis

The incidence of ankylosing spondylitis, as already mentioned, showed a marked increase compared with civilian practice before the war. It was not usually of the adolescent type so far as age of onset was concerned, and probably for this reason was less acute and less rapidly progressive; there were no cases among women. There was frequently a history of jarring of the spine but this must have been a very frequent experience in war conditions without any sequel, and its aetiological significance was doubtful. X-rays frequently showed the maximum bony change in the upper lumbar and lower dorsal vertebrae; the sacro-iliac joints were affected but to a less pronounced degree than in the more acute form of adolescence, and osteoporosis was less pronounced. In the later stages of the war many patients were sent for physiotherapy after a course of deep X-ray treatment and did well. Many cases recovered sufficiently to remain in the Service though usually in a lower category; in a few instances in the R.A.F. recovery was sufficient to permit of flying again.

Osteo-arthritis

Osteo-arthritis as a late effect of chronic strain, synovitis, and fibrositis of the ligaments, especially of the spine, was a frequent cause of disability calling for treatment mainly among the older men. The presence of small osteophytes on the vertebrae detected in X-ray examination in men complaining of painful backs appeared frequently to have been regarded as pathological and a form of spondylitis ; the fact that they may almost be regarded as normal in men of middle age who have followed occupations demanding much muscular effort appeared to be generally unknown. The symptoms in such cases probably had no relation to the X-ray appearances and were due to strain and fibrositis. Treatment by the usual physiotherapeutic methods led generally to disappearance of the pain and return to duty, but in some cases where the man had become aware of the result of the X-ray examination there was a disposition on the part of the patient to regard himself as permanently disabled and to behave accordingly.

Gout

Gout accounted for a small percentage of the total admissions and appeared to be relatively more common in the Navy than in other branches of the Forces. It presented no unusual characters and complete recovery was the rule.

Other Diseases

Among the other conditions treated in the E.M.S. physiotherapy centres, sacro-iliac and lumbo-sacral strain, chronic synovitis, flat foot and metatarsalgia were the most common and do not call for special description; they formed only a small proportion of the whole number.

METHODS OF TREATMENT IN THE SPA HOSPITALS

As a routine measure in all suitable cases warm immersion baths with hot underwater douches were used for the treatment of painful and stiffened joints and stiffness due to fibrositis. They were preceded in some cases by general vapour baths and in a large proportion by the application of hot peat packs to the affected joints. A development of the simple deep immersion bath was the deep pool in which an operator entered a large pool of warm water with the patient and carried out passive movements with local hot douching, encouraging such active movements as the patient was capable of and which he could more easily carry out when the limbs were supported by water; this method was especially useful for stiffness of the larger joints and for ankylosing spondylitis; very crippled patients could be lowered into the water by a crane. In suitable cases this was followed, as the patient improved, by his immersion in a warm swimming bath.

Massage under water in a shallow bath also proved an effective and popular method of treatment for chronic fibrositis, lumbago and strained backs. Local whirlpool baths, often alternating with one or other of the methods mentioned above, were used for painful and stiffened joints, and also for disorders of the peripheral circulation, trench foot, Raynaud's disease, and chronic oedema from various causes; in these the water at a temperature of 100 to 110 was kept in a state of violent agitation by mechanical means, producing a massaging effect and strongly stimulating the peripheral circulation. General effervescing baths of a similar but milder character were used at a lower temperature as a general stimulant and tonic to the peripheral circulation.

Massage was widely used and all forms of electrotherapy except X-rays were available; the existence of a large massage school in connexion with the hospital provided an ample staff for these measures.

A feature of the treatment in these hospitals was systematic physical exercises adapted to the patient's condition; they were arranged in grades commencing with the milder exercises and progressing to more active work as the patient improved. This included regular walks with an orderly, games, both indoor and outdoor, and towards the end of the war occupational therapy on a large scale was introduced. Recreation was regarded as an essential feature of treatment. The results were good and in some cases remarkable.

GEOGRAPHICAL INCIDENCE

BRITISH EXPEDITIONARY FORCE (TO FRANCE)

When war began, a large number of reservists were recalled to the colours, a number of them being middle-aged men who were not very fit. As the result of the rather primitive conditions in some regions at the outset, a fair number broke down. Dyspepsia seemed to be the principal evidence of this, although 'rheumatism' accounted for 15 per cent. of all admissions and 26 per cent. of all medical admissions into Nos. 2 and 3 General Hospitals during the first four months.

The Medical Society of Dieppe Medical Base area, under the chairmanship of Major General R. Priest, invited Copeman in March, 1940, to discuss this matter. He showed that of the first 100 cases of 'rheumatism' admitted to No. 3 General Hospital, rheumatic fever accounted for 15 per cent. (acute and sub-acute), chronic polyarticular rheumatism (? infective) for 6 per cent., osteo-arthritis—9 per cent. and fibrositis—mostly first attacks attributed to exposure or trauma—for 70 per cent. He demonstrated a primitive but effective field treatment centre in which all the apparatus had been improvised from salvage material. The experiment of grouping all rheumatic patients into special tents adjoining this centre was tried (Lt. Col. F. Holmes) and, in spite of adverse factors such as leaking tents and the coldest winter for many years, the results of therapy at once improved. This was attributed to the active co-operation of the patients, obtained as the result of the increased interest and activity which this system produced in the nursing and medical staff concerned.

Stott and Copeman (1940) described 27 cases which had mostly been thought to be rheumatism. They were able to show conclusively that these were actually suffering from chronic meningococcal septicaemia and further that such cases of mistaken diagnosis are in fact not uncommon.

The high admission rate for rheumatism was beginning to fall during the two months (April, May) which preceded the Army's evacuation of France in 1940.

MIDDLE EAST FORCE

The consulting physician to this Force (Brig. W. D. D. Small), discussing the subject of 'rheumatism' in his report for the quarter ending September 30, 1940, stated that rheumatism, following rheumatic fever, was 'of a more chronic type than that seen in civilian practice at home. Small joints were more frequently affected, whilst cardiac complications were thought to be fewer, especially with first attacks. It did not respond to salicylates'. In April, 1942, he held a conference in Cairo to which all officers in command of divisions and many medical specialists were summoned. In opening this he stated that rheumatism in the Middle East needed discussion since the general conclusion reached by his predecessors was that, while it was probable that the types of rheumatism seen in Egypt were essentially the same as those seen at home, there were certain local variations in their clinical features or course. Rheumatism, in the wider sense, was, he said, the cause of a great deal of illness requiring admission to hospital, and the acute forms did not in Egypt respond well to salicylates.

Lt.-Col. I. W. G. Hill had formed the impression that rheumatism of all forms was commoner in Palestine than in Egypt, and that it accounted for a considerable wastage in man-power; the high incidence of these diseases was acknowledged by the civilian authorities in Jerusalem. Captain J. H. L. Easton emphasised the frequency of sciatica and fibrositis amongst Libyan prisoners-of-war.

Lt.-Col. J. C. Hawksley agreed that clinical types might be expected to vary in different localities, as did certain factors which might be expected to influence them. In the Suez area the incidence was low—out of 12,500 admissions in the year ending March 31, 1942, only 1·33 per cent. were rheumatic. These cases averaged 25 days in hospital. He pointed out that if the figures for cases treated at M.I. rooms and O.P. Department were included it would be seen that 'these minor cases formed a big problem of their own'. He pointed out that many were probably admitted to surgical divisions and were retained, more particularly those cases of sciatica in association with the typical fibrositic syndrome which had occurred rather frequently among certain types of worker, especially railwaymen and lorry drivers.

At this conference the syndrome was first reported which eventually became so well known in this theatre of operations: the triad of arthritis, conjunctivitis and non-venereal urethritis—a late result of bacillary dysentery. It was stated that these cases generally recovered, but that they might progress to chronic arthritis. One case, which had developed florid rheumatoid arthritic deformities, was described. Lipscomb and Sydney Smith stated that they had never previously seen this syndrome during long service in India.

Major M. Sarwar, I.M.S., reported that although rheumatism of all forms was relatively uncommon in India, 'it had been a great problem amongst the Indian troops in the Middle East during the last year'. Lt. Col. C. G. McDonald commented on 'the large problem of chronic rheumatism and fibrositis amongst Australian troops' which caused a serious wastage. He regarded an anxiety neurosis as a frequent aetiological factor and it was in his view encouraged 'by indulgent orthopaedists and physicians'. Lt. Col. E. Bulmer stated that, of 1,750 medical patients admitted during the previous quarter to No. 2 British General Hospital, 101 were for fibrositis. Many had developed the condition for the first time after lying in damp forward surroundings. He also found it excessively commonly complained of among Cypriot labour battalions.

After the report of this conference no further reference to the rheumatic diseases is to be found in the reports of the consulting physician.

With a view to estimating the incidence of these diseases, subsequently, the quarterly reports of the officers in command of divisions have been perused and an abstract is appended from the two in which most information is to be found, i.e. No. 19 General Hospital and No. 2 General Hospital, when they moved to Tripoli in 1943.

The impression gained from reading the reports mentioned is that treatment in this disease-group was seldom adequate, for the following reasons: the hurried examination and often inaccurate diagnosis given by the first medical officer to see the case—this was often an R.M.O. in a forward area; the lack of interest in these cases, as opposed to acute or rarer forms of disease; the frequent need to transfer cases from one hospital to another on account of the military situation; and finally, in some cases, the absence of suitable physio-therapeutic apparatus.

MIDDLE EAST

No. 19 *General Hospital, Tripoli.* (Lt. Col. J. G. Scadding.)

1943
April—June:

Total medical admissions—2,800

- Arthritis, acute—6
- ,, subacute—11
- ,, monarticular—13
- Fibrositis—29
- Sciatica—8

Total p.o.w. admissions—928; 'rheumatic'—10.
Of 143 Medical Boards, 11 were on account of 'Rheumatism'.
Of 120 O.P.'s seen, 13 were 'rheumatic' diseases.

July—September:

Total medical admissions—2,600

- Polyarthritis, acute—11
- ,, subacute—20
- Arthritis, monarticular—6
- Fibrositis (mostly lumbago)—21
- Sciatica—7
- Spondylitis, ankylosing—1

Of 99 medical boards, 8 were on account of rheumatic diseases.
Of 59 O.P.'s seen, 4 were 'rheumatic diseases'.

October—December:

Total medical admissions—2,839

- Polyarthritis, acute—11
- ,, subacute—2
- Arthritis, monarticular—5
- Fibrositis (lumbago)—33
- Sciatica—5

In addition, 6 p.o.w.'s admitted with 'rheumatism'.
Of 142 medical boards, 6 were on account of rheumatic diseases.
Of 68 O.P.'s seen, 5 were 'rheumatic diseases'.

1944
January—March:

Total Medical Admissions—1,900

- Polyarthritis, acute—14
- ,, subacute—7
- Arthritis, monarticular—8
- Fibrositis and lumbago—39
- Sciatica—8
- Synovitis, acute—3
- Spondylitis, ankylosing—1

April—June:

Total medical admissions—1,588

- Polyarthritis, acute—16
- ,, subacute—5
- Arthritis, monarticular—6
- ,, q.c.—1
- Fibrositis (and lumbago)—29
- Sciatica—3
- Synovitis—1

In addition, acute rheumatism was seen in two West African native soldiers and fibrositis in one.

July—September:

Total medical admissions—3,770

- Acute rheumatism—8
- Subacute ,, —10
- Fibrositis, lumbago, etc.—22
- Osteo-arthritis—5
- Sciatica—4
- Spondylitis—2

October—December:

Total medical admissions—2,700

- Acute rheumatism—15
- Subacute ,, —6
- Fibrositis—21
- Osteo-arthritis—6
- Rheumatoid arthritis—3
- Sciatica—13
- Synovitis—1

'As can be seen, the group has not been a very large problem on account of size, but has made up for this on account of refractoriness to treatment. Only one group of cases might be noted. This was one of 33 cases of polyarthritis occurring between July and October, 1943. All these men came from the desert and had been living in tents. Usually knees, ankles, wrists and elbows were affected, but not infrequently the small joints of the hands were attacked as well. Pain was a more noticeable factor than swelling. The cyclical involvement of acute rheumatism was not noticeable, but the arthritis, nearly always multiple, persisted for some time and responded poorly to salicylates. Pyrexia tended to be slight but persistent, and tachycardia was moderate. No case of carditis was seen and there was no enlargement of lymph nodes. Search for focal sepsis was unproductive. A past history of acute rheumatism was rarely obtained, but previous joint pains had been fairly frequent. Those affected were rarely discharged from hospital in less than six weeks. The E.S.R. was considered to be the most useful guide to progress.'

No. 2 General Hospital, Tripoli. (Lt. Col. H. R. Donald.)

1943

April—June:

Total medical admissions—4,300

- Rheumatic diseases, subacute and chronic, excluding neuritis—143
- Acute rheumatic fever—8

July—September:

Total medical admissions—5,000

- Rheumatic diseases, subacute and chronic—98
- Acute rheumatic fever—10

October: 1—25

Rheumatic diseases, subacute and chronic—21.

Acute rheumatic fever—10.

An appendix to one of the reports of the adviser in physical medicine to M.E. (Lt. Col. G. Kersley) is worth quoting for the total figures included for the various countries comprised in this Command:—

Rheumatic Diseases in the Middle East, 1943–4

A review of all available statistics on 'rheumatic' cases from military hospitals in M.E. covering the period of eighteen months has been carried out. In considering the findings, the following factors must be borne in mind: (*a*) the movement of troops and convoys of wounded from one locality to another; (*b*) inexactitude in terminology in many cases; (*c*) the Palestinian temperament; (*d*) climatic conditions.

Among the cases of acute rheumatism are probably included many cases of acute non-traumatic synovitis of doubtful aetiology seen so frequently in the hot weather and which resemble rheumatic fever except for the absence of cardiac sequelae. Under arthritis, unless specifically noted, are included cases of rheumatoid, infective and osteo-arthritis, and also the syndrome of non-specific urethritis, conjunctivitis and arthritis.

Incidence of rheumatic diseases admitted to hospital, including fibrositis and sciatica, in comparison to the total medical admissions:—

Egypt	637 cases out of 28,670, i.e. 2·2 per cent.	
Palestine and Syria	389 " " " 13,000, " 2·9 " "	
Tripolitania and Malta	262 " " " 10,170, " 2·6 " "	
Total	1,288 " " " 51,840, " 2·5 " "	

Seasonal Incidence:—

January—March (inclusive)	189 cases out of 3,670, i.e. 5·1 per cent.
April—June	537 " " " 16,470, " 3·2 " "
July—September	267 " " " 13,800, " 1·9 " "
October—December	119 " " " 4,520, " 2·6 " "

Types of rheumatic disease:—

Acute rheumatism	250
Arthritis	164
Fibrositis	253
Sciatica	108

Of 199 cases grouped as arthritis, 18 per cent. were classed as osteo-arthritis.

CENTRAL MEDITERRANEAN FORCE

No reference to the chronic rheumatic diseases is to be found in the available reports of the Consulting Physician.

No. 33 *General Hospital, Sicily.* (Lt. Col. W. S. C. Copeman.)

1944
January—March:

Total medical admissions—2,662	Fibrositis (gluteal, 60; lumbar, 38) —105
	Subacromial bursitis—1
	Sciatica—13
	Polyarthritis, acute—14
	,, infective—2
	Synovitis—3
	Spondylitis, ankylosing—3
	Osteo-arthritis—3
	Rheumatoid arthritis—2
	Arthritis, gonococcal—3

Extracts from accompanying report:—At this period the Eighth Army were crossing the Straits of Messina after a campaign through Sicily entailing great hardship and exposure. Large convoys were received from C.C.S.'s and F.A.'s in forward areas; and the hospital itself functioned as a C.C.S. for half this period. In more normal circumstances, some of these cases might not have been evacuated to a base hospital.

In view of the urgent need to free beds, the non-articular cases were treated energetically from the first by means of procaine injection and manipulation, with the result that the number who could not be returned to full duty within twelve days was very small.

Some cases of typical fibrositis were observed to develop pain in the distribution of the sciatic nerve, and this was considered to be a more common cause in this series of sciatica than prolapse of an intervertebral disk.

(Lt. Col. W. L. Ackerman.)

April—July:

Total medical admissions—2,094	Fibrositis	lumbar—39
		gluteal—9
		shoulder girdle—1
		intercostal—7
		miscellaneous—8
	Gluteal plus sciatic pain—8	
	Lumbar ,, ,, ,, —1	
	Sciatica	fibrositic—6
		disk—2
	Arthritis	acute polyarticular—11
		infective ,, —5
		serum—1
		osteo-arthritis—4
		rheumatoid—1
		spondylitis, ankylosing —4

July—September:

Total medical admissions—2,078

- Fibrositis
  - lumbar—19
  - gluteal—4
  - miscellaneous—4
- Fibrositis with sciatic pain reference—24
- Synovitis—5
- Polyarthritis, acute—11
- Osteo-arthritis—4
- Old Perthes' hip—1
- Spondylitis, ankylosing—1
- Postural pain—3

Extracts from accompanying report:—

'Fibrositis and mild referred sciatic pain has ousted dyspepsia, diarrhoea and headache as the chief cause of frequent and prolonged hospitalisation. Most of these patients have been in several hospitals—average two months —and by the time we see them the residual pain and intensity is difficult to estimate owing to the impaired functional background. The man at this stage is often reconciled to being a chronic case. It is suggested that more efficient results would be obtained if these 'rheumatic' patients could be referred to one hospital for all investigation and treatment, and if mild pain persisted after a certain time, a decision other than to transfer him to another hospital might be agreed upon, if necessary the medical category being lowered temporarily.'

No. 45 *General Hospital, Malta.* (Lt. Col. R. E. Tunbridge and Major W. A. Dewer.)

1943
July—September:

Total medical admissions—1,488

- 'Arthritis'—1
- Fibrositis and lumbago—14
- Sciatica—4
- Neuritis—4
- 'Rheumatism'—8

O.P. Dept., Total 308

- Osteo-arthritis—3
- Sciatica—5
- 'Rheumatism'—4
- Fibrositis and lumbago—13
- Neuritis—4

(Lt. Col. J. Halliday Croom.)

October—December:

Total medical admissions—1,117

- Acute rheumatism—7
- Fibrositis—23
- Infective polyarthritis—6
- Osteo-arthritis—2

Of 11 medical boards, 2 were on cases of rheumatic disease.
Of 7 cases evacuated to the United Kingdom, 1 was for fibrositis. In addition there was 1 naval patient with severe sciatica.

1944
January 1—*February* 23:

Total medical admissions—131
- Acute rheumatism—1
- Subacute „ —4
- Lumbago—3
- Synovitis (ac.)—2

O.P. Dept., Total—56
- Subacute rheumatism—3
- Fibrositis and lumbago—11
- Osteo-arthritis (spine)—2

Of 10 medical boards, 3 were on cases of rheumatic disease.
No cases were evacuated to the United Kingdom for this cause.

April—June (In Italy):
Total medical admissions—879 (379 Jugoslavs)

'rheumatism'
- British—16
- Jugoslavs—17

Gibraltar

Precise figures were not available, but an unofficial report from Lt. Col. L. Howells (Officer commanding medical division Military Hospital, Gibraltar, 1941–3) may be quoted as being his subsequent impression of the problem presented by the chronic rheumatic diseases:—

'We certainly found fibro-myositis a problem at Gibraltar. My recollection is that we found it a common and a difficult complaint to treat and we had to evacuate a large number of such cases. We attributed this to the humid atmosphere of the Rock, especially during the periods when the 'Levanta' enshrouded the Rock. Old 'rheumatic' subjects who had kept their symptoms in abeyance for years found that they relapsed soon after arriving in Gibraltar and that they soon improved after leaving. Chronic arthritic manifestations and acute rheumatic fever were not common. Apart from the climatic factor, I have little doubt that the mental stress consequent upon the peculiar conditions associated with service in wartime Gibraltar, and a consequent desire to get away, played some part in the relative frequency of fibro-myositis. In other words, in some it was a psychosomatic manifestation.'

BRITISH LIBERATION ARMY (N.W. EUROPE)

10 *C.C.S.* (Major J. Ranking.)

1944–5
September—April:

Total medical admissions—3,096
- Chronic muscular rheumatism—157
- Sciatica—38
- Rheumatoid arthritis—2
- Osteo-arthritis—2

Note by Major Ranking: 'Soldiers of good temperament appeared to recover fairly quickly under adequate treatment, but in a large number of cases downgrading to a lower medical category appeared to be the only solution'.

No. 101 *General Hospital, Louvain.* (Lt. Col. G. Mitchell-Heggs.)

1944 *August—September:* Total medical admissions—665	Rheumatoid arthritis—1 Osteo-arthritis—1 Non-articular fibrositis—15 Other types—3 Acute and subacute rheumatism—2
October—December: Total medical admissions—1,214	Rheumatoid arthritis—1 Osteo-arthritis—1 Spondylitis—4 Unclassified—4 Fibrositis—44 Prolapsed disk—17 Other types—2 Acute and subacute rheumatism—4
1945 *January—March:* Total medical admissions—1,910	Rheumatoid arthritis—8 Osteo-arthritis—10 Spondylitis—3 Unclassified—4 Fibrositis—68 Sciatica—9 Prolapsed disk—6 Other types—2 Acute and subacute rheumatism—8
April—June: Total medical admissions—1,846	Infective and rheumatoid arthritis —22 Osteo-arthritis—8 Fibrositis—68 Sciatica (disk)—31 Acute and subacute rheumatism —17

Note by Lt. Col. Mitchell-Heggs: 'Fibrositis became a very common complaint in the autumn in Normandy, and increased throughout the winter of 1944–5. The incidence of sciatica seemed to me to be particularly large in this theatre as compared to the Middle East and Italy, although I have no figures to prove this'.

No. 8 *General Hospital, Brussels.* (Lt. Col.J. Osborne.)

The consolidated figures for three quarters were available. Of 10,144 medical cases admitted, 484 were on account of chronic rheumatic diseases and were divided as follows:—

Muscular rheumatism—265	Osteo-arthritis—34
Sciatica—118	Spondylitis—7
Infective arthritis—60	

PERSIA AND IRAQ FORCE—LATER P.A.I. COMMAND

In the consulting physician's report for January–June, 1944 (Brig. F. M. Lipscomb) there is a paragraph under the heading of Fibrositis:— 'The group consisting of fibrositis, myalgia and allied conditions is remarkably small, with an incidence of only 1·7 per cent. of all hospital admissions for the half year. These figures are in marked contrast to those seen in the United Kingdom and are interesting in view of the extreme climatic changes in this Command, where cases of frost-bite and heat stroke may both be seen during the same half year, and a daily temperature swing of over 40° F. is not uncommon. The rainfall, however, is as a whole low.'

In the subsequent report for July–December, 1944 (Brig. T. C. Hunt) the admission rate for this group is given as 0·5 per 1,000 per month. He comments on the number of cases of neuritis which had been seen in this half year. These cases were characterised by an acute onset with severe pain, followed in 2–3 weeks by weakness and wasting, usually in the shoulders. Sensory loss was variable, but generally slight, and it was the supra-scapular and serratus muscles which were generally most involved. Indian troops appeared to be more frequently affected than European troops. He pointed out with regard to the fibrositic group of cases that these had increased in the late summer and autumn and were reported equally among Indian troops.

This Command was not popular as a place of residence for the troops and the question of a psychosomatic basis for some of these cases became of importance. Major St. John Brooks at the Lahore Conference in May, 1944, speaking on 'Neurosis in Iraq' indeed stated that all psychosomatic complaints increased rapidly after the first year of residence in the country, and instanced 'fibrositis' and 'sciatica' as examples amongst British soldiers. Lt. Col. Bhalla, speaking of Indian 'other ranks', mentioned the common occurrence among them of 'such manifestations of hysteria as backache or sciatica, the part affected being usually the one which will make the individual unfit for his job if he is dissatisfied with it'.

The only analysed record from a General Hospital concerning this group is for the quarter January–June, 1943 :—

No. 33 *General Hospital, Mussaiyib.* (Lt. Col. W. S. C. Copeman.)

1943 *January—June:* Total medical admissions—781	Fibrositis—36 Osteo-arthritis—3 Spondylitis, ankylosing—2 Rheumatoid and infective arthritis —3

A note appended to these figures records the observation that many of these cases of fibrositis appeared to have had their origin in acute illnesses of various kinds. Their average stay in hospital was twenty-five days with active treatment.

EAST AFRICAN COMMAND

Chronic rheumatic diseases were not common in this Command, although the consulting physician (Brig. E. Cullinan) stated that a large number of the native troops suffered with pains of unknown aetiology (often thought—with no evidence—to be due to a yaws infection) for which they were, however, seldom admitted to hospital. The following figures of admissions in chronic rheumatic group are from his official reports.

Rates of admission per 1,000 total strength:—

Bones, Joints, Fasciae, etc.

1944	Europeans	Non-Europeans	All races
January—April	3·12	2·0	2·12
May—July	2·81	1·64	1·76
July—September	2·44	1·39	1·49
September—December	3·50	1·31	1·54

He records a syndrome which was commonly observed among African troops. The onset was with high fever lasting for only a few days and was associated with pain in one or both sides of the neck and remarkable rigidity of the posterior cervical muscles, which were extremely tender. Occasionally there were some enlarged glands in the posterior triangle of the neck; but there was no evidence of superficial thrombosis. This syndrome often gave rise to chronic cervical pain for many months. Of troops boarded to category B or C, diseases of the bones and joints represented 13·3 per cent. in Europeans and 2·5 per cent. in African natives.

INDIA AND S.E.A.C.

The chronic rheumatic diseases were not much trouble in these Commands, according to the consulting physician, Brig. H. L. Marriott.

He wrote (personal communication) 'Perhaps I should put the position more accurately if I said that the main tropical diseases—malaria, dysentery, sprue, etc.—bulked so largely that all other problems seemed small by comparison'. The figures from the two annual reports of the Standing Medical Review Board at Poona issued by Brig. J. D. S. Cameron confirm this on the whole, though since these figures refer only to cases evacuated back to the United Kingdom via India from these two Commands, it would seem that the reservoir from which they were drawn may have contained a considerable total number of cases suffering from this group of diseases. It is interesting to find that Brig. Cameron specifically mentions that dysenteric arthritis was no problem in this war, for he states 'its very low incidence was one of the rather unexpected findings of tropical disease in the India Command, contrary to what the book said'. The figures referred to above have been extracted from his reports for the years 1944 and 1945 and are as follows:—

Standing Medical Review Board

1944 Total cases 3,261

Fibrositis and bursitis	10
Neuritis	12
Sciatica	9
Arthritis	52
Spondylitis (deformans and adolescent)	15
,, ankylopoietica	12
Gout	1
Total	111

The total number of rejections during this year on account of chronic 'rheumatic' complaints was 29 out of a total 262.

1945 Total cases 8,812

Fibrositis and bursitis	20
Polyneuritis	9
Neuritis	19
Sciatica	28
Rheumatism	9
Arthritis—Polyarthritis	8
,, Infective	23
,, Osteo-	57
,, Osteochondritis	7
,, Rheumatoid	37
,, Sacro-iliac	7
Spondylitis deformans	19
,, ankylopoietica	21
Total	264

PSYCHOLOGICAL BASIS OF SOME RHEUMATIC PAINS

Group Captain C. A. Rumball adds the following note: 'This combined contribution on chronic rheumatic disease in the Services enters fully into the matter and corresponds very closely to what was found in the Royal Air Force. But the psychogenic basis of so-called rheumatic pains which was the subject of work by J. Flind and H. Stuart-Barber at the R.A.F. Rheumatic Centre in 1940–1 may be worthy of mention, because the centre soon recognised that it was receiving many cases of so-called stubborn rheumatism, which had been treated unsuccessfully for weeks or months at R.A.F. General Hospitals, where they had been labelled fibrositis, generalised rheumatism, etc. and in none had the psychogenic origin of such pains been worked out or seriously considered. Flind and Stuart-Barber's work was published in the *Quarterly Journal of Medicine*, April, 1945, and its chief value in my opinion was to arouse doubt upon the organic nature of intractable rheumatism described in terms of 'pain in every joint of the body' or 'pains all over the body' or 'continuous pains in the arms, legs and shoulders' especially when all investigations had proved essentially negative in discovering organic pathology. They found in a sample of 42 such patients that 17 were regarded as fundamentally hysterical, 22 were suffering from an anxiety state, and 3 from a depressive state. Their observations on the psychological basis of some forms of rheumatic pains must have been amply confirmed throughout the three Services, and they certainly agreed with my experiences as a Divisional Officer in a General Hospital oversea.

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CHAPTER V

TECHNICAL DEVELOPMENTS IN THE MANAGEMENT OF VENEREAL DISEASES

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(i)
Syphilis

DIAGNOSIS

Difficulties in the maintaining of a sufficient supply of guinea-pigs to furnish complement-serum in complement-fixation tests for syphilis and gonorrhoea led to the elaboration, by Dr. G. M. Richardson, in the Ministry of Health's special laboratory for syphilitic serum tests, of methods of preserving the complementing power of serum without drying it. He showed that the preservation of liquid complement at room temperature depends on sterility, hypertonicity, a correct *p*H, and absence of specific destructive effects. The *p*H is particularly important, the stability rapidly deteriorating at a *p*H above 7, and 6·0 being the best for preservation at room temperature. Sterility was ensured by the adding of sodium azide which does not damage any ingredient in a complement-fixation test. For hypertonicity sodium chloride was used, and for the *p*H, buffer acids with *p*K values between 6 and 7 were chosen. On these principles, two methods were proposed. In the first, for use in ordinary clinical laboratories, three solutions were made: (A) Boracic acid, 1·55 g. dissolved in and made up to 100 ml. with saturated NaCl solution; (B) Sorbitol, 9·55 g., and sodium azide, 0·81 g. dissolved in and made up to 100 ml. with saturated NaCl; (C) Sodium azide, 0·81 g., dissolved in and made up to 100 ml. with saturated NaCl. Eight volumes of serum were mixed with one of solution A and one of a mixture of B and C, the ratio of B to C usually being about 1 : 1, depending on the source of the complement. The *p*H should be 6 to 6·5. In the second method, suitable for research laboratories, eight volumes of serum were mixed with one of solution C made as above and one of a saturated solution of NaCl; the serum was then stored in an atmosphere of CO_2 in a closed container.

Large amounts of preserved complement made according to the first of the above methods were supplied to civilian and Service centres during the war and were found completely satisfactory. A great advantage of supplying complement-serum from a central source is that it can be made of a pool derived from 100 or more male guinea-pigs each of a weight not less than 600 g. (each component having been tested before being added to the pool, for suitability of titre and absence of undue auto-haemolytic activity) thereby contributing materially to uniformity of results in different laboratories using the same methods.

TREATMENT

In the civilian treatment centres working under the Public Health (Venereal Diseases) Regulations 1916, the plan of treatment that was commonly followed until 1945, when penicillin became available for general use, was founded on that known as the 'Plan of Intermittent Treatment' recommended by a Committee of Experts on Syphilis and Cognate Subjects which was convened by the Health Organisation of the League of Nations in 1928 and reported in 1935 as the outcome of an inquiry into the actual results of treatment by various methods in five countries. Briefly stated, this plan provided for the administration, to adults with early syphilis, of a minimum of four courses each consisting of eight injections of neoarsphenamine concurrently with the same number of bismuth, with the addition of two more bismuth injections. The treatment centres chiefly modified this by giving ten injections of neoarsphenamine concurrently with the same number of bismuth ones, and by limiting the dose of neoarsphenamine to 0·6 g. The scheme of treatment was intended to be completed in about a year.

An important modification was made, by agreement, in the recommendations for the treatment of merchant seamen based on ports in the United Kingdom. The great variety of schemes of treatment employed by medical officers of different nations caring for merchant seamen working for the Allies caused great inconvenience to those responsible for the administration of the merchant service and, by request of the Ministry of War Transport, a conference of medical officers of the following nations was called at the Ministry of Health on November 18, 1942: Belgium, Great Britain, Greece, Holland, Norway, Poland and Jugoslavia.

After recommendations on the prevention of venereal diseases in ports and on the sulphonamide treatment of gonorrhoea, the conference suggested, for men ashore who would return to deep-sea service in ships not carrying surgeons and for men on coastwise service for whom a weekly injection was impracticable, twelve injections of 0·45 g. neoarsphenamine concurrently with the same number of bismuth each containing 0·15 g., the whole course being completed in 39 days. After this the interval was to be three to six months during which the seaman was at sea, and the course was to be repeated with the exception that, if the blood was found to be negative at the beginning of the course, only nine injections of each type of remedy were to be given. For men on deep-sea service in ships carrying surgeons the first course was to be as above, the patients remaining ashore, but subsequent treatment was to be carried out at sea. For men on coastwise service permitting of one injection a week ashore, the treatment recommended was the same as for landsmen. These recommendations were embodied in a circular letter by the Deputy Chief Medical Officer of the Ministry of Health to all concerned, which was dated March 23, 1943, and (as a supplement to the *Ship Captain's Medical Guide*), in a Notice No. M237 to Masters which was issued by the Ministry of War Transport in March, 1943.

The treatments practised in the Services at the beginning of the war were as shown in the Appendix to a circular letter, dated October 24, 1940, sent by the Chief Medical Officer of the Ministry of Health to medical officers of treatment centres on the treatment of men of the Fighting Services when it was found convenient to have this carried out in the civilian centres; the aim in this was to secure reasonable uniformity of treatment within the individual Services notwithstanding the fact of the treatment being carried out in civilian centres. (See Appendix.)

A notable change in the plan of treatment practised in the Royal Navy was made when the Medical Director-General (1943) ordered the substitution of oxophenarsine (in the form of 'Mapharside') for neoarsphenamine. This change was provoked by a high incidence of jaundice in men treated for syphilis and the belief that oxophenarsine was less icterogenic than neoarsphenamine, a view which was fostered by an article by Davies (1943) purporting to show that at the V.D. Treatment Centre at St. Thomas's Hospital the incidence of jaundice had been greatly reduced since oxophenarsine had been substituted for neoarsphenamine. The question of jaundice in subjects treated with anti-syphilitic injections is discussed more fully below, but meantime it may be said that later investigations showed conclusively that the important aetiological factor in jaundice affecting such persons is probably a virus passed from person to person through the medium of imperfectly sterilised syringes.

Surgeon Captain T. R. Lloyd-Jones and Surgeon Lieut. Commander F. G. Maitland (1945) reported on an intensive form of treatment which they had practised since 1943. It was based on the American plans of intensive treatment but had regard to the stage of the disease when the treatment started. They divided their primary cases into three categories: 'early primary' in which a quantitative complement-fixation test performed daily remained consistently negative; 'middle primary' in which a similar test showed a negative reaction followed by a positive phase lasting a few days; and 'late primary', in which the test showed a high titre of reagin which persisted for some time. To the first group were given 15 daily injections of 0·04 to 0·06 g. mapharside; to the second, 20 such injections; and to the third, 30 of 20 mg. per kg. bodyweight supplemented by an injection containing 0·2 g. bismuth every third day.

The results when read with regard to changes in the schemes of treatment which were described in the paper (the above-mentioned were the final ones) showed 2 relapses in 70 cases of early primary syphilis but both had had only 10 injections each; 1 relapse in 37 middle primary, and 2 in 62 cases of late primary that had been treated with the full amount of mapharside and bismuth mentioned above. The periods of observation ranged from 9 to 24 months, and the toxic effects were: 3 encephalopathy, all of which survived; 3 agranulocytosis; and 2 dermatitis, both of them mild.

The discussion following the reading of the above paper before the Medical Society for the Study of Venereal Diseases disclosed that intensive forms of treatment had been practised in the other two Services and in some civilian centres. Sq. Leader Jean Morton, R.A.F. and Major Betty Walker, R.A.M.C. treating members of the W.R.A.F. and of the A.T.S. respectively, had used an 8–9 day treatment with mapharside, with apparently satisfactory results, and Sq. Leader Moynahan had used the three-injections-a-week scheme of Eagle and Hogan. Other speakers did not appear to be enthusiastic about the intensive arsenical and bismuth treatment of early syphilis which has been so extensively used in the U.S.A.

Major F. L. Lydon (1944) Area Venereologist Middle East Forces, reported having used a modified five-injections-a-day, five-day course of treatment—in later cases the number of injections a day had been reduced to 4 and the number of days of treatment increased to 6—in early cases that were considered suitable from the point of view of general health. The paper mostly discussed encephalopathy which had occurred in 5 out of 53 patients who had been treated on this plan.

The plan of treatment which seemed eventually to be favoured in the U.S. Army before the introduction of penicillin was described by Pillsbury *et al.* (1944) at a meeting of the Medical Society for the Study of Venereal Diseases; it was copied largely in the British Army until displaced by penicillin. It provided for the injection of 20–30 mg. per kg. bodyweight of oxophenarsine in 20 days with coincident bismuth (8 injections of 0·2 g. bismuth salicylate), the daily dose of the arsenical remedy being given by 1 injection. The authors reported on over 3,000 cases that had been treated on this plan. The incidence of positive spinal fluid in 236 patients examined in this way six or more months after the treatment had been less than 1 per cent. In 435 cases tested four or five months after treatment the number of positive serum reactions had been 13 and the doubtful ones, 8. According to Pillsbury (1945), the plan of treatment just mentioned was succeeded in the U.S. Army on June 26, 1944, by the routine use of penicillin. This change followed on the demonstration by Mahoney *et al.* (1943) of the anti-syphilitic power of penicillin and the investigations carried out in a large number of clinics in the U.S.A. under the aegis of the American National Research Council's Sub-Committee on Venereal Diseases. Pillsbury (1945) reporting on the results of treatment with 2·4 mega units over a period of 7½ days in a minimum of 5,000 cases and a maximum of 8,000 that had been observed for one to ten months after treatment, disclosed 71 relapses, but others had less favourable results.

Penicillin became generally available for the treatment of syphilis in civilians in the United Kingdom in March, 1945. At first the recommendations of the Ministry of Health followed the plan of dosage of penicillin then accepted in the U.S.A., viz. 2·4 mega units in 7½ days, but reliance on penicillin alone was not recommended; instead, it was suggested that the penicillin course be supplemented by one of arsenic and bismuth on the lines of the 'Plan of Intermittent Treatment' recommended by the Committee of Experts of the League of Nations mentioned above. It was felt that besides the fact that the ultimate results of penicillin treatment could not be known for many years, those immediately available, showing a relapse rate of about 15 per cent. in cases treated with 2·4 mega units, were not good enough. At the same time evidence from a number of quarters indicated a very high rate of success from one of the four League of Nations' courses, and it seemed safe to trust the combination of one penicillin and one League of Nations' course to give a good result in over 90 per cent. of cases.

As mentioned in the section on gonorrhoea, the practical difficulties attending three-hourly injections for patients with syphilis stimulated a search for a method of administration which would delay the absorption of penicillin sufficiently to allow of the daily dose being given in one or two injections and of the patient attending for it instead of his having to enter a hospital. As also mentioned, suspensions of penicillin in oil-wax began to be issued in the early part of 1946.

Jaundice

The incidence of jaundice in patients under treatment for syphilis aroused great concern in the different Services. As mentioned above, it caused the D.G., Royal Naval Medical Service, to change the arsenical component of the treatment to oxophenarsine, and it was the subject for discussion at various conferences and meetings.

So far as the experience at the civilian treatment centres was concerned, a questionnaire issued by the Adviser in Venereal Diseases, Ministry of Health, to the directors of venereal diseases treatment centres elicited that in 26,293 cases of syphilis treated with arsenical remedies, the incidence of jaundice had been 3·22 per cent. No details of the numbers of injections were given in the answers, and the only point of any importance in regard to the culpability of any particular remedy was that the incidence in cases treated with oxophenarsine was certainly not less than in cases treated with other arsenical preparations. A more detailed questionnaire was issued late in 1943 asking for information respecting jaundice in patients treated at civilian centres in the year ending September 30, 1943. The replies, shown in three tables which are reproduced in an appendix, showed generally that the incidence of jaundice in cases treated with intravenous injections of arsenical remedies, whether considered in the light of numbers of injections or of cases, was decidedly higher than that in cases treated with intramuscular injections. Between the incidence in cases treated with, respectively, the three trivalent remedies, neoarsphenamine, arsphenamine diglucoside (stabilarsan) and oxophenarsine (administered in the form of mapharside), there were only slight differences, the rates being 3·5 per cent. of 25,050 cases treated with neoarsphenamine, 4·6 per cent. of 3,772 treated with arsphenamine diglucoside (stabilarsan), and 4·9 per cent. of 1,283 treated with oxophenarsine (mapharside). Considered from the point of view of injections, the rates were, 0·51 per cent. of 179,709 neoarsphenamine, 0·40 per cent. of 38,593 stabilarsan, and 0·52 per cent. of 21,697 mapharside. In all categories there was a decidedly higher incidence in males than in females. Remarks accompanying the answers to the questionnaire in a number of cases showed that the incidence in Service patients attending the civilian centres was decidedly higher than in the civilians; thus in four centres the directors remarked that they had seen 16 cases in 741 civilians but 21 in 85 Service men. This impression was supported by the experience in Service centres. Surg. Rear Admiral Sir Sheldon Dudley (1943) mentioned, as a reason for the substitution of oxophenarsine, that in some groups of naval ratings treated for syphilis the incidence had been as high as 30–40 per cent. Major J. Marshall (1943) gave an average incidence of 29 per cent. in three military hospitals, and Lieut. Col. D. J. Campbell (1943) at the same discussion in which Marshall gave his figures said the incidence in his cases had been 15 per cent.

In the discussion on jaundice in syphilitics at which the above figures were given the possible causes advanced by different speakers were: (*a*) dietetic deficiencies such as sulphur-containing amino-acids, advanced principally by Professor Beattie; (*b*) transmission of a virus through the medium of syringes; (*c*) the action of a virus aggravated by the hepatotropic action of arsphenamine compounds. In voicing the possibility of the infective agent being transmitted through imperfectly sterilised syringes, MacCallum (1943), at the above-mentioned discussion, suggested that minute amounts of blood left in syringes might convey the virus from carriers to healthy patients. Further evidence that the cause of what had been commonly called 'post-arsphenamine jaundice' was due to an agent other than the arsphenamine was afforded by Dible and McMichael (1943) in a paper on 'The Pathology of Arseno-Therapy Jaundice' in which they concluded that 'The histological appearances do not support the suggestion that either syphilitic lesions of the liver or arsenobenzol poisoning play any part. The appearances are more compatible with damage by an agent similar to that causing serum jaundice or epidemic hepatitis'.

MacCallum's view that the agent was transmitted in imperfectly sterilised syringes received substantial support in experiments by Bigger (1943) which showed that the methods of 'sterilising' syringes between injections that were practised in many centres were very inefficient. Salaman, King, Williams and Nicol (1944) and Laird (1946) showed that 'arsphenamine jaundice' could be prevented by rigid methods of syringe sterilisation, and the conclusion of a memorandum by Medical Officers of the Ministry of Health (1945) on 'The Rôle of Syringes in the Transmission of Jaundice' which appeared as a special article in *The Lancet* included the following:—

> '. . . late hepatitis following arsphenamine, gold and other therapies is an expression of "homologous serum jaundice" communicated by traces of blood transferred on syringes and needles from patient to patient . . . the resistance of icterogenic agents to disinfection, and the impossibility of removing all traces of blood from syringes by the methods generally used, are factors calling for revision of existing injection techniques.'

It is interesting that in the War of 1914–18 the Salvarsan Committee of the Medical Research Committee (now Council), which was formed on account of some outbreaks of severe jaundice in military V.D. hospitals, should have come rather close to the solution of the problem of 'post-arsphenamine jaundice'. Among the outbreaks which they investigated was one of malignant malaria which was proved to have been transmitted through the medium of the last portion of the tubing used in giving '606'. This might have given them the clue if it had been supplemented by examples of syringe-transmitted jaundice such as occurred in the War of 1939–45 in soldiers inoculated against yellow fever and in persons who had received injections of serum derived from patients convalescing from mumps. The Salvarsan Committee did consider the possibility of an infective agent being partly, at least, responsible, saying in their Report:—

> '2. The hypothesis that the outbreak (at the Cherry Hinton Military Hospital) might have been due to some infective factor, possibly supplemented by the anti-syphilitic treatment, is supported to some extent by (*a*) the explosive character and curve of the outbreak, (*b*) the hutment incidence. . . . This theory of an intercurrent infection, not necessarily of itself producing jaundice but increasing the liability to toxic effects of persons under arsenobenzol treatment, is attractive, but no solid facts beyond (*a*) and (*b*) above can be adduced in its support.'

There was, of course, the further fact that infection (with malaria) could be transmitted by the injection apparatus, but there was nothing to suggest that jaundice might be due in some cases to a virus. Even a small outbreak of jaundice following injections of some remedy other than an arsphenamine compound would have given the clue and have saved a very great amount of disability from jaundice in the years between the two wars as well as in that of 1939–45.

TABLE I

Cases of Jaundice in Males and Females treated with u/m Arsenical Compounds in Year ending September 30, 1943

Compounds	Cases		Injections		Jaundice		Percentage of cases			Percentage of injections		
	M.	F.	M.	F.	M.	F.	M.	F.	T.	M.	F.	T.
Neoarsph.	12,852	8,693	83,711	72,717	466	266	3·6	3·0	3·3	0·55	0·36	0·46
Stabilars.	2,149	1,623	20,817	16,236	128	48	5·9	2·9	4·6	0·61	0·29	0·47
Tryparsum	414	249	5,253	3,568	14	6	3·3	2·4	3·0	0·26	0·16	0·22
Acetylarsan	409	702	5,073	7,856	6	2	1·4	0·2	0·7	0·11	0·02	0·06
Sulpharsp.	231	369	2,176	4,360	1	1	0·4	0·2	0·3	0·04	0·02	0·03
Mapharside	810	473	6,915	5,331	54	9	6·6	1·9	4·9	0·78	0·16	0·51
	16,865	12,109	123,945	110,068	669	332						
			234,013		1,001							

TABLE II

As Table I but without Distinction of Sexes and with Addition of Cases not so Classified in the Reports

	Cases	Injections	Jaundice	Percentage of cases	Percentage of injections
Neoarsph.	25,050	174,536	900	3·5	0·51
Stabilars.	3,772	37,053	176	4·6	0·47
Tryparsum	831	10,890	31	3·7	0·28
Acetylarsan	1,131	13,186	8	0·7	0·06
Sulpharsp.	668	8,222	3	0·4	0·03
Mapharside	1,283	12,246	63	4·9	0·51
	32,735	256,133	1,181	3·6	0·46

TABLE III

Jaundice and Injections as in Table II with Addition of Figures from Centres not Stating Cases of Syphilis Treated

	Injections	Jaundice	Percentage of injections
Neoarsph. . . .	179,709	928	0·51
Stabilars. . . .	38,593	176	0·40
Tryparsum . . .	13,374	36	0·26
Acetylarsan . . .	16,206	10	0·06
Sulpharsp. . . .	9,586	4	0·04
Mapharside . . .	21,697	113	0·52
	279,165	1,267	0·45

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APPENDIX

TREATMENT AND TESTS OF CURE OF VENEREAL DISEASE IN THE ARMED FORCES

(For the information and guidance of Directors of Civilian V.D. Treatment Centres in dealing with members of the different Forces. October, 1940.)

ROYAL NAVY

In a number of cases naval personnel are referred to civilian centres for diagnosis and treatment from the first, and in such cases it is very important that the diagnosis be supported by laboratory tests. The treatment and tests of cure employed in the Royal Navy are left to the discretion of the specialist medical officers employed on this work. Generally it can be assumed that it is on lines similar to those employed in the Army and the R.A.F. which are detailed below, or as practised at the R.N. Hospital, Chatham. In the latter, *for syphilis*, the unit course of treatment consists of 14 × 0·45 g. neoarsphenamine and 7 × 2 c.cm. 'Bicreol' in seven weeks. For sero-negative cases four courses are given, and for sero-positive, six. The interval between the first and second courses is one month, and between subsequent ones, two months. *For gonorrhoea* the treatment is 3 g. sulphapyridine daily for 14 days. Apart from these differences the routine, including tests of cure, is on lines similar to those in the Army and R.A.F.

As it is desirable that, subject to limitations imposed by patients' idiosyncrasies the treatment, etc. given to naval personnel in civilian centres should be on uniform lines, it is recommended that either the schedule of the R.N. Hospital, Chatham, or one of those set out below be followed. It is difficult to say which would give the best results but any can be regarded as satisfactory.

ARMY

Syphilis

In most cases Army personnel attending civilian treatment centres for syphilis have received initial treatment in military hospitals, and only continuation treatment and tests according to the schedule below are necessary. The treatment consists of a minimum of four 'courses' of injections for sero-negative primary cases, and three after that which ended with negative serum reaction for all cases which were sero-positive at the beginning of the treatment. Each 'course' consists of 1 × 0·45 g. and 9 × 0·6 g. neoarsphenamine given intravenously at weekly intervals concurrently with ten injections of an insoluble bismuth preparation each dose of which should contain 0·25 g. bismuth metal. This can be calculated from the following:—

Injectio Bismuthi B.P. contains 0·2 g. Bi. per c.cm.
" " Oxychloride B.P. contains 0·08 g. Bi. per c.cm.
" " Salicylate B.P. " 0·064 g. " " "

It is assumed that each patient is examined for signs of intolerance (albuminuria, stomatitis, jaundice, rashes, etc.) before each injection. Any case of intolerance should be reported to the medical officer of the patient's unit. The interval between the first and second course is 4 weeks; that between the second and third is 5 weeks; that between the third and fourth is 5 weeks. A serum test is carried out at the end of each course. After completion of treatment the blood is examined every three months for one year and every six months during the second year. The cerebro-spinal fluid is tested during the last six months of the observation period. The patient is considered cured if all tests following suspension of treatment have proved negative.

Gonorrhoea

The routine treatment of gonorrhoea, generally administered in a military hospital, consists of the administration of sulphapyridine, either at the rate of 4 g. a day for 5 to 7 days or 19 to 20 g. in 3 days. After disappearance of all signs the patient remains in hospital under observation for 7 days. If then prostatic and vesicular secretions are normal and the passage of a curved sound provokes no return of signs, the patient is discharged to attend once weekly for 3 weeks and finally at the end of 3 months. The examination at each of the first 3 attendances is as follows:—Specimens are taken for microscopical examination of any discharge at the meatus or in urinary threads. A curved sound is passed, the prostate and vesicles are massaged, and a specimen of the secretions is examined microscopically. At the last visit, at the end of 3 months, all the above tests are repeated, the anterior urethra is examined with the urethroscope and a specimen of blood is taken for the Wassermann (or Kahn) and in special cases the gonococcal complement-fixation tests. If all tests have proved negative, the patient is discharged. If gonococci or any considerable number of pus cells are found at any examination, the patient is referred to the medical officer in charge of his unit with a view to his readmission to a military hospital.

ROYAL AIR FORCE

Syphilis

As in the case of military patients, R.A.F. personnel have already received initial treatment before their first attendance at a civilian centre. Cases of sero-negative primary syphilis receive three 'courses' as detailed below. Cases which have become sero-positive before treatment is started receive two courses after that which ends with a negative Wassermann reaction. Cases of secondary syphilis receive a minimum of four 'courses'. If the Wassermann reaction remains positive after the second course, the case should be referred to the medical officer in charge of the patient's unit with a view to disposal by the R.A.F. specialist. Each course is as follows:—

Day	Neoarsphenamine grammes	Bismuth metal* grammes
1st	0·3	0·2
8th	0·45	0·2
15th	0·6	0·2
22nd	0·6	0·2
29th	0·6	0·2
36th	0·6	0·2
43rd	0·6	0·2
50th	0·6	0·2
57th	0·6	0·2
64th	0·6	0·2

* For guidance on bismuth content of different preparations see under Army.

The interval between any two courses is four weeks. It is assumed that, as in military cases, the patient and his urine are examined before every injection, and any case showing definite signs of intolerance should be reported to the medical officer in charge of the patient's unit. After suspension of treatment the blood is tested every three months for one year and twice in the second year. A full examination of the cerebro-spinal fluid is carried out before final discharge.

Gonorrhoea

All active treatment will normally have been carried out before discharge from hospital, and attendance at a civilian centre will be for observation and tests of cure only. These are carried out at least eight weeks after the patient's discharge from hospital, and are as follows:—

(1) Examination of the patient for signs of primary syphilis.
(2) Examination of the urine for 'threads' or haziness due to pus.
(3) Examination of the prostate and vesicles, and their secretions for pus cells and organisms.
(4) Palpation of the urethra on a curved sound passed into the bladder.
(5) Provocative injection of gonococcus vaccine (500 millions).
(6) Anterior urethroscopy in doubtful cases.
(7) Blood Wassermann reaction or Kahn test.

Patients are instructed to report for three days after these tests to their medical officer, who examines them for signs of relapse. He reports to the centre for final examination after a further month, when, if his condition is satisfactory, he is discharged. Any patient showing signs of relapse should be referred to the medical officer of his unit with a view to his readmission to hospital.

ALL SERVICES

As regards the transmission of information respecting Service patients, the position is analogous to that when a civilian patient is referred to a centre by a practitioner, and no breach of confidence is involved in giving full information respecting any case to the medical officer of the patient's unit or to the medical officer of the Service concerned who is the specialist in venereal diseases for the area in which the patient is stationed. Each patient carries a card analogous to the transfer card Form V.15 (revised) or V.44 (revised) on which it is important that all particulars of treatment and progress be legibly entered at each visit. It is important also that, in cases in which for any reason it is not considered advisable to carry out the treatment or/and tests of cure outlined above, the fact be notified to the medical officer of the patient's unit so that the Service's specialist can be informed.

(ii)

Gonorrhoea

DIAGNOSIS

Apart from a modification of the Pappenheim stain by Barritt (1943) there was no particular improvement in methods of staining the gonococcus. The Barritt stain, when properly made, has proved to be a good counterstain when used in Gram's method, but it cannot be relied upon as a substitute for the latter.

Evidence continued to accumulate that culture of the gonococcus is a far more reliable method of diagnosis than is examination of stained films of the discharges, though the two methods used simultaneously are better than either alone. During the war most of the work in this field was done in the U.S.A., where a bewildering number of formulae for culture media were published as superior to all others for the diagnosis of gonorrhoea. The rival claims of a number of them may prove to have been settled by a comparison of three well-known ones with a method which had been evolved in the Venereal Disease Research Laboratory, Staten Island, New York. This comparison was completed in 1942 but has only recently been published by Thayer, Schubert and Bucca (1947), publication having been delayed by the war. The Research Laboratory's medium appears to have proved superior; it was described as a modification of McLeod's (1934) but appears to have embodied what the authors thought were the best features of not only McLeod's medium but Peizer's and Gardner's. It was made of lean ground beef, 600 g.; proteose peptone No. 3 (Difco) 10 g.; disodium phosphate, 2·0 g.; and distilled water, 1,000 ml. The mixture was properly sterilised and had its *p*H adjusted to 7·2 before it was made up into a stock nutrient agar which was autoclaved at 10 lb. for 10 minutes. When required for plates, this agar was melted and then cooled to 60° C. before having added to it an enriching medium made as described by Peizer and Steffen (1942); it contained Nile Blue A as recommended by Gardner (1940). The media which were compared with that just described were: Difco chocolate blood agar made with Bacto-proteose peptone No. 3 and Bactohaemoglobin; Peizer's horse-plasma-haemoglobin agar; and the Mueller-Hinton starch agar. The V.D. medium, as Thayer and colleagues called theirs, grew more and larger colonies of the gonococcus than did any of the others. Among the total specimens examined (115 of cervical secretion) the V.D. medium demonstrated gonococci in 9 per cent. more than the Peizer, in 17 per cent. more than the Difco, and in 32 per cent. more than the Mueller.

Much research continued to be devoted in the U.S.A. to the finding of a medium in which discharges suspected of containing gonococci could be transported to the laboratory for culture when the transportation involved a journey of several hours. No method appears to have proved completely satisfactory as all seem to have resulted in a mortality of about 50 per cent. by the end of 24 hours. Brigadier T. E. Osmond (1945a) commenting on a method of transportation described by Hirschberg (1944), suggested that a plan likely to be more successful than implantation of the material on a special transportation medium, with exposure to room temperature conditions, would be to sow the secretion on a suitable medium, incubate at once and transport the culture to the central laboratory at the end of 48 hours. This presupposes (*a*) an incubator, though not necessarily a trained pathologist, close to the patient and (*b*) training of the clinician to sow suspected material on the medium, a relatively simple matter.

In gonococcal complement-fixation tests, Messer and McLachlan (1942) published evidence supporting the view of Brandt (1935) and of Fischer and Gunsberger (1935) that a lipoid such as olive oil or castor oil added to a gonococcus antigen enhances its complement-fixing power with a gonococcal serum. Their results showed, however, that the addition increased the number of non-specific reactions. They also presented evidence supporting the view that Wassermann reagin in a serum strengthens the reaction with gonococcus antigen.

CHEMICAL PROPHYLAXIS

No experimental work on the chemical prophylaxis of gonorrhoea seems to have been carried out in Great Britain during the war but a very considerable amount was done in the U.S.A. Joses (1942), Kline and Ryan (1942), and Loveless and Denton (1943) were among the earliest to publish evidence that gonorrhoea can be prevented after exposure to infection if the person concerned takes sulphathiazole as soon as possible on the same day and throughout the next. Kaufmann and Litterer (1944 and 1945) found, in 10,000 treatments, that the application of an ointment containing 16 per cent. sulphathiazole and 33 per cent. calomel prevented gonorrhoea in all but 10 cases. Their work was based on the experiments of Stedman (1943) which showed that the instillation of sulphathiazole in microcrystalline form (5 per cent. suspension in water) into the urethra and sealing it there prevented gonorrhoea in all but 2 of 297 persons. Keet (1944) found a decided advantage in supplementing the ordinary prophylactic ointment with sulphathiazole by mouth. Of 1,802 exposures in which sulphathiazole was taken with or without the use of a condom and/or calomel ointment, 15 resulted in gonorrhoea (incidentally, none in chancroid). Of 498 exposures in which condoms and/or prophylactic ointment were used but no sulphonamide was taken, 12 resulted in gonorrhoea and 5 in chancroid. The free issue of sulphonamides to non-medical persons raises the question whether many men in the Forces to whom the tablets were given may have used them for self-treatment of gonorrhoea and, by under-dosage, have often contributed to the development of sulphonamide-resistance by strains of gonococci that had hitherto been sensitive to these drugs. Such a question could not be settled.

TREATMENT WITH SULPHONAMIDES

During the period of the war improvements in sulphonamide remedies for gonorrhoea culminated in sulphathiazole and sulphadiazine with which at one time over 90 per cent. of success was claimed from one short course of treatment. Unfortunately this rate was not maintained, and in many countries, including Great Britain, a disconcerting drop in the percentage of success became evident. Experience in this respect varied in the different fields, perhaps the most unfavourable being that reported by Lieut. Col. D. J. Campbell (1944) and later by Major H. J. Bell (1945), in Italy. Campbell found that in spite of care over dosage, not more than 50 per cent. of cases responded ultimately to this form of treatment, and both he and Bell reported that not more than 25 per cent. responded well to the first course. Campbell's experience in Italy contrasted with that in North Africa just previously, when 70–75 per cent. of his cases had been cured with a single course of 10 g. sulphathiazole given in two days. The decline in the success of sulphonamides was analysed in Switzerland by Miescher (1944) who reported on the experience in his clinic in Zurich by half-yearly periods from January, 1941 to the end of 1945. The percentages cured by a single course of sulphathiazole in these periods were, successively, 95·7, 96·0, 92·9, 86·0, 72·5, 55·5. Similar results were reported by Wiederkehr (1944). The decline in the success of sulphonamide treatment was attributed to the development of resistant strains of the gonococcus, though in some cases a course of sulphonamides weakened the partially resistant organisms, which were finished off by a second course. A similar falling off in the success of sulphonamide treatment was found in the case of sulphathiazole by Seeberg (1945) in Sweden. In a total of 2,500 male cases, this author found that the relapses rose from 15 per cent. at the beginning of 1941 to 70 to 80 per cent. at the end of 1943.

In different countries much laboratory work showed a parallelism between sulphonamide-resistance *in vitro* and the same *in vivo*. Among workers on this problem in England may be mentioned Surg. Lieut. Commander J. Petro (1943), who found, in 44 strains isolated from cases of gonorrhoea, 5 that were resistant *in vitro*, and a corresponding resistance to treatment of the subjects from whom the strains had been isolated; in the remaining 39 cases there was no resistance either *in vitro* or *in vivo*. Petro quoted, as supporting the parallelism between resistance *in vitro* and *in vivo*, the Danish workers Schmith and Reymann (1940), who classified 80 recently isolated strains of gonococci according to the degrees of their sensitivity to sulphapyridine *in vitro*, 0 being the least sensitive and 8 the most. Of 48 patients whose gonococci were classed as having sensitivities from 6 to 8, practically all responded to treatment with sulphapyridine, but in the remainder with degrees of sensitivity ranging from 5 to 0 the corresponding infections showed a resistance to sulphapyridine treatment that varied inversely with the degree of sensitivity *in vitro* of their infecting organisms. As a complement to their work on recently isolated strains of the gonococcus, they tested 50 strains that had been isolated in the pre-sulphonamide era, and in which, therefore, there could not be any question of resistance having been acquired by previous contact with sulphonamides, and they found in them much the same degrees of sensitivity as they had found in their recently isolated strains. So far as their experience went, there was not then any evidence of an increase in the percentage of sulphonamide-resistant gonococci, but evidence of such an increase was provided later by the work, in the U.S.A., of Carpenter, Ackerman, Winchester and Whittle (1944) who tested out 214 strains isolated between May 1, 1942 and August 1, 1943 and found that the proportion of resistant strains had risen from 15·4 per cent. of those isolated in the first six months of the period to 59·3 per cent. of those isolated in the last three months.

A question of decided interest is whether the growth of resistance of gonorrhoea to sulphonamide treatment was hastened by the war. Assuming that there existed at the beginning of the sulphonamide era strains of gonococci that were naturally resistant to sulphonamides, as is suggested by the investigations of Schmith and Reymann, it is reasonable to expect that as the sensitive strains were eliminated, the percentage of resistant ones must have increased. Further, the very greatly increased sexual promiscuity which prevailed in this and other countries during the war must have distributed the resistant strains far more rapidly than would have been the case in times of peace. Another factor that may have contributed to the increase in sulphonamide-resistance was the free distribution of sulphonamides among the men of the Allied Forces other than British, as also among merchant seamen. Before the war the sulphonamides had been scheduled as poisons in Great Britain, a measure that must have ensured that a large proportion of those who took sulphonamides did so under medical supervision and in adequate doses; the indiscriminate distribution that prevailed in this country after its invasion by the Allies must have resulted in large numbers of British girls and women under-dosing themselves with these remedies. Whether or not this resulted in the acquisition of sulphonamide-resistance by many previously sensitive strains of the gonococcus is uncertain but the fact that it is a comparatively simple matter to train a strain of the gonococcus to acquire a high degree of this resistance suggests strongly the possibility of this having occurred naturally.

An exception to the rule in Great Britain, providing that sulphonamides should be obtained only on prescription by a registered medical practitioner, was made in 1943 for merchant seamen in ships carrying no ship's surgeon. The recommendation was made as the result of a conference convened at the Ministry of Health in November, 1943, to decide on uniform schemes of treatment of venereal diseases in men of the Merchant Navy. At this conference, which was attended by medical representatives of seven of the Allied Forces, it was agreed that on ships not carrying surgeons, ship's officers could be empowered to dispense to men suffering from gonorrhoea supplies of sulphonamide compounds according to certain directions as to dosage. The recommendations, which were embodied in a circular letter by the Deputy Chief Medical Officer Ministry of Health, to all concerned on March 23, 1943, included instructions relating to tests of cure and tests for syphilis which should be carried out when the men so treated reached port.

The increasing percentage of failure in the sulphonamide treatment of gonorrhoea, before the problem was largely solved by penicillin becoming generally available, stimulated the development of methods of supplementing sulphonamides by artificially-induced fever, by protein-shock therapy, and by gonococcal vaccines.

In the field of pyrexia, very valuable work was done at the Royal Victoria Hospital, Netley, and later at the Westbury Military Hospital by Lieut. Col. A. J. King, in collaboration with Majors D. I. Williams and C. S. Nicol (1943), and later by these workers in collaboration with Major J. Loudon (1946) with the Kettering hypertherm and with the induction of fever by the intravenous injection of vaccines. In civilian work, Batchelor, Thomson and Huggan (1942) made a valuable contribution on the treatment of gonorrhoea by pyrexia induced by the inductotherm. In both centres, although the treatment was mostly applied to sulphonamide-resistant cases, it was found advantageous to supplement the fever with some form of sulphonamide therapy. With this aid, it was found by King *et al.* that the induced temperature need not exceed 106·2° F. (as compared with 106·8° to 107° F. in earlier work), with corresponding reduction of risk to the patient. The modification was made in the military hospital on the advice of Dr. H. W. Kendell (U.S.A.), who, with Simpson and Rose, was a pioneer in the use of the Kettering hypertherm for the induction of fever and its use in the treatment of gonorrhoea and syphilis. The papers by British workers support those published in the U.S.A. in showing that hyper-pyrexia to such degrees as those mentioned is a form of treatment to be practised only by well-trained staff on patients who, apart from their venereal disease, are physically sound. The nursing technique was well described by Nursing-Officer Edith Pegg, Q.A.I.M.N.S.R. (1943) and the physiological and biochemical changes in the patients undergoing hyper-pyrexia by Captains Wallace and Bushby (1943), whose findings, particularly in regard to the development of anoxia and bilirubinaemia underline the need for care both in selection of patients for this form of treatment and in carrying it out. In suitable cases of resistant gonococcal and non-gonococcal urethritis (more so in the former than in the latter) the treatment appears to have been valuable.

King *et al.* also reported favourably on fever induced by intravenous injection of T.A.B. Vaccine, which they found effective in early cases of arthritis, if carried out vigorously; for later cases they preferred the hypertherm. For the vaccine method they preferred the technique first recommended by Nelson, in which a relatively small dose of the vaccine is followed in a few hours by a second.

Lt. Col. E. Cronin (1944) practised with success a combination of sulphonamide treatment with fever induced by T.A.B. Vaccine administered intravenously by the drip method. The scheme was to administer 4 g. sulphapyridine or sulphathiazole on the evening before induction of the fever and 2 g. the following morning at the same time as 0·2 c.cm. of the standard T.A.B. Vaccine was given intravenously. Two hours later the intravenous drip began, the suspension being 4 c.cm. of the standard vaccine in 600 c.cm. of glucose-saline, and the initial rate of flow a drop a second. The goal was a temperature over 103° F., and the fever was governed by the rate of the drip. The fever was maintained for five hours. The principle of using a comparatively low temperature in conjunction with sulphonamide treatment was inspired by the work of Ballenger (1937 and 1939) which suggested that a successful response to sulphonamide remedies could be achieved by a temperature well below the death point of the gonococcus.

Wawersig (1944) claimed success from the intramuscular injection of 'olobintin' (a turpentine preparation) followed the next day by sulphathiazole, 5 g., which was repeated on the two following days. Harkness (1944) classified the causes of failure of sulphonamides under three headings: '(1) failure of the drug to reach the gonococci; (2) resistance to the drug of the defence mechanism of the host (drug tolerance); (3) resistance to the drug of the gonococci (drug-fastness)'. In support of (2) he gave instances of multiple infections from the same source in which some, but not all, of the infected were resistant to this form of treatment, and in a later part of his paper he advanced the hypothesis that the sulphonamides in these cases interfered with the defence mechanism of the body. He recommended that in cases where the disease had not been cured by one course of the selected sulphonamide compound, urethro-vesical irrigations should be given daily, and every five days some form of protein-shock therapy. He regarded it as useless to continue with the same drug if gonococci were still present after the fourth day but stated that a change from sulphathiazole to sulphadiazine was often effective. If these measures failed, he recommended treatment by artificially-induced fever: substantially the same recommendations were made in the second edition of the Medical Research Council's Memorandum on 'The Medical Use of the Sulphonamides' (1945).

An interesting consequence of the increasing failure of the sulphonamides to cure gonorrhoea was a revival of the view (common before the introduction of sulphonamides that proved more efficient than the older sulphanilamide, uleron and albucid) that it is advantageous and even necessary to ensure the aid of anti-gonococcal immunity. Prior to the introduction of sulphapyridine, many workers such as Felke (1938) had recommended that in acute cases one should wait two or more weeks before starting treatment as this would give the tissues time to develop an anti-gonococcal resistance. The principle had been developed further by Keefer and Rantz (1938), who showed that sulphanilamide does not interfere with the defence mechanism, if this can be judged by the complement-fixation test; their recognition of the importance of immunity was expressed in the following:—

> 'These observations naturally raise the question as to the significance of the increased bactericidal action of the blood and synovial fluid in patients with gonococcal infections. It can be assumed that the presence of sulfanilamide in the blood and synovial fluid will aid materially in the destruction of organisms in the joints, and also aid in preventing the spread of organisms from a local focus of infection. It will not, however, cause complete sterilisation of a local focus in the genital tract in every case. For this reason it is well to remember that the defense mechanism of the body must increase or maintain the capacity to destroy organisms in the local focus before complete recovery can take place. It also serves to emphasise the importance of continuing the drug until the immune bodies have developed, since withdrawal of the drug too soon is often followed by exacerbations or recurrences of the infection with reinvasion of the tissues.'

As mentioned, the brilliant initial success of sulphapyridine in 1938, and later that of sulphathiazole thrust into the background the rôle of immunity in elimination of gonococcal infections, but the revival of recognition of the importance of this factor may be seen in recommendations to employ protein-shock therapy in resistant cases, or to give gonococcal vaccines, as is shown quite specifically in a paper by Cohn and Kornblith (1944). These authors tried vaccines made from sulphonamide-resistant and from sulphonamide-sensitive organisms but were unable to decide whether either of these was superior to the other.

The history of the sulphonamide treatment of gonorrhoea during the war years has made it clear that, if this class of remedy had remained our only means of chemotherapy, we should before long have reverted to the conditions of the pre-sulphonamide era, when gonorrhoea was one of the most difficult diseases to eliminate.

TREATMENT WITH PENICILLIN

Fortunately, it was soon discovered that the gonococcus is one of the micro-organisms that are eminently susceptible to attack by penicillin. Supplies of this remedy became available for treatment of civilians in Great Britain suffering from venereal disease in March, 1945, and by then we had for guidance the results of considerable pioneer work which had been done in the U.S.A. These suggested that a high percentage of cures would follow the administration of 100,000 units in five doses, at intervals of two or three hours, but as penicillin was then becoming more abundant and it was desirable in the interests of the public health to secure the highest possible percentage of cures out of hand, a total dose of 150,000 units in five doses of 30,000 at two-hour intervals was recommended in a circular issued by the Ministry of Health in March,

1945. This method afforded excellent results, but it has the important disadvantage that it requires the patient's attendance at a treatment centre over a period of eight hours, with all the inconvenience to patient and clinic staff which this entails, besides the risk of the patient's default before completion of treatment. This and the need for devising a treatment which would entail only one attendance a day by syphilitic patients stimulated a search for one which would have the effect of keeping the penicillin in the circulation for twenty-four hours after a single injection. Under the inspiration of results published by Romansky and Rittman (1944), which showed that after injection of a suspension of calcium penicillin in a mixture of arachis oil and beeswax, the penicillin was retained in the circulation in detectable amounts for several hours, an investigation was started in 1945 by the Ministry of Health to discover if possible the best formula for such a suspension, the aim being to find one which would be relatively easy to administer and would result in retention of the penicillin in the blood in detectable amounts for twenty-four hours or longer. Alternatively, it was thought that a suspension which when administered in a single dose of 200,000 units would cure over 90 per cent. of cases of gonorrhoea would be reasonably satisfactory. With the collaboration of more than twenty treatment centres a number of combinations containing different amounts of penicillin per unit volume of oil and wax, the latter in different proportions, had been tried out between August, 1945, and the end of May, 1946, when the free issue of penicillin ceased. The directors of the collaborating centres were asked to report on the clinical effect of a single dose of 200,000 units when administered in the different suspensions, and by January, 1946, the reports so far received seemed to justify the issue, to all V.D. treatment centres, of a suspension containing 50,000 units per c.cm. of arachis oil and beeswax. Later a trial of ethyl oleate in place of arachis oil seemed to give satisfactory retention and the suspension was easier to manage. With increasing purity of the penicillin made in this country it became possible to increase the concentration of penicillin in the suspension, and the last free issue was one containing 125,000 per c.cm. of ethyl oleate with 4 per cent. beeswax. It was unfortunately not possible to arrange at first for estimations of penicillin in blood serum and urine to be carried out in the laboratories associated with the collaborating clinics, and most of this work was done until the end of April, 1946, by Col. L. W. Harrison. The examinations of the blood serum after single doses of 200,000 units in ethyl oleate and wax, given subcutaneously, as recommended by Leifer, Martin and Kirby (1945) showed generally that most specimens contained penicillin in detectable amounts at the end of sixteen hours but not so many at the end of twenty-four hours. In the urine, on the other hand, it was common to find penicillin at the end of seventy-two hours and sometimes at the end of ninety-six. In October, 1946, systematic investigations on similar lines commenced under the aegis of the Ministry of Health, the collaborators being Dr. G. L. M. McElligott on the clinical side and Dr. J. R. May on the laboratory.

Later note: The problem of combining delay in absorption with ease of administration of the suspension appears now to have been satisfactorily solved by Brindle, Fairbrother and Jackson (1947) who found that the delaying factor was not the wax in an oil-wax mixture but the oil, and that the rôle of the wax was to ensure even distribution of the penicillin in the suspension. This was found to be satisfactorily accomplished by as little as 1 per cent. wax. Further, by using practically pure non-hygroscopic sodium penicillin, the sodium salt could be used in place of the calcium which had been found necessary in the oil-wax mixtures hitherto employed. In this way a suspension which remained perfectly fluid at room temperature and could be injected through a No. 2 serum needle was made in a concentration of 300,000 units per c.cm.

Of other methods of prolonging the action of a single dose of penicillin may be mentioned that of Surg. Capt. T. F. Lloyd-Jones, Surg. Lt. Cmdr. E. M. Donaldson and Surg. Lt. Cmdr. S. J. Allen (1946) who gave 200,000 to 300,000 units of a mixture made up by suspending 3 mega units of penicillin in 10 c.cm. arachis oil and 5 g. magnesium sulphate. In the U.S.A., Cohn *et al.* (1946) reported well on an emulsion made on the spot by dissolving 200,000 units in 1·4 c.cm. saline and adding to it 3·1 c.cm. of a mixture of arachis oil, 20 parts, with 'falba' (a cholesterolised lanolin), 11 parts. In the light of the later work of Brindle, Fairbrother and Jackson (1947), it seems probable that any success achieved by these suspensions was attributable to the oil rather than to the other constituents of the mixture.

In the other Services, the treatment of gonorrhoea with penicillin appears to have been on the same lines as in the civilian centres.

The fact that penicillin was powerfully anti-syphilitic, though the curative dose here was considerably higher than that for gonorrhoea, very quickly raised the question whether its administration to a patient who was in the incubation stage of syphilis would either delay or prevent the appearance of the primary sore without preventing the infection. Brigadier T. E. Osmond (1945b) reported a case in which 100,000 units given for an attack of gonorrhoea appeared to have lengthened the incubation of an apparently concurrent syphilitic infection to at least 64 days and possibly 84. Lt. Col. E. Cronin (1946) reported a number of cases in which a sub-curative dose of penicillin given in early syphilis which had been diagnosed as something else, had altered the syphilitic picture. Majors F. L. Lydon and W. R. S. Cowe (1945) jointly and Major Cowe (1945) also drew attention to the need for particular care in looking out for syphilis in patients who had been treated for gonorrhoea with penicillin. The possibility of syphilis being masked by such treatment led to the practice of prolonging to six months the routine tests for syphilis which had been practised for many years in all good venereal disease treatment centres after the cure of gonorrhoea. Some workers considered it advisable to restrict the use of penicillin in gonorrhoea to those cases that had proved resistant to treatment with sulphonamides, and this is particularly worth consideration in pregnancy, where it is very important that the fact of a concurrent syphilitic infection should be known as soon as possible.

Whether or not penicillin will prove to have solved the problem of gonorrhoea is for the future to decide. At the time of writing, long after the war, an efficient method of administering penicillin by mouth opens the way for serious under-dosage by forgetful patients and thereby the possible development of penicillin-resistant strains of the gonococcus. A further disturbing thought is the suggestion by Major M. H. Salaman (1946) that possibly the L organisms, which will be discussed in more detail in the section on non-gonococcal urethritis, are a stage in the life-cycle of the gonococcus; they are penicillin-resistant.

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(iii)

Non-Gonococcal Urethritis

Venereal diseases encountered in the War of 1939–45 differed remarkably from those in the War of 1914–18 in the high proportion of the cases of urethritis which were classed as non-specific, or more correctly as non-gonococcal. This was not peculiar to the European and North African theatres as its prevalence in the Pacific theatre provoked articles by Australian writers. Thus Willis (1942) working in a special hospital for the Royal Australian Air Force found that in 50 cases of acute urethritis, only 19 were gonococcal. From another military hospital he obtained statistics which showed that only 35·6 per cent. of their cases of urethritis were gonococcal.

At the time of writing, the proportion of Service cases of non-gonococcal urethritis in the European and North African theatres is known to have been considerable. In civilian centres in this country separate figures were not kept, these cases being grouped in the category, 'Conditions other than Venereal', a classification which was not correct from the aetiological point of view but was in accordance with the definition of 'Venereal Disease' in the Public Health (Venereal Diseases) Regulations, 1916, which recognise only three; syphilis, gonorrhoea and soft chancre. It was well known, however, that during the war the proportion of cases of urethritis that were non-gonococcal increased in males very greatly, and some directors of treatment centres estimated it at not less than one-half of their male cases of urethritis.

The cause was not settled and only the lines on which the aetiology—or probably more correctly, the aetiologies—must be sought, can be mentioned here. Harrison and Worms (1939) published a critical review on 'The Relation between some Forms of Non-gonococcal Urethritis, Lymphogranuloma inguinale, Trachoma and Inclusion Blenorrhoea'. At the outset it stated that the writing of the review had been stimulated by, *inter alia*, '(1) the finding, by some workers, that an antigen made from the urethral discharge of patients with "Waelsch urethritis" acts like Frei antigen in cases of lymphogranuloma inguinale. (2) The discovery by Gay-Prieto, Miyagawa and others of the bodies now believed to be the virus of lymphogranuloma inguinale. (3) The previous discovery, by many workers, of similar bodies in cases of Waelsch urethritis, inclusion blennorrhoea, trachoma and some other diseases'. The intention of the review was to suggest to those dealing with non-gonococcal urethritis that a search for a virus might not be unfruitful. Another suggestion that some cases of urethritis might be explained by trichomonad infestation was advanced by Liston and Lees (1940) who reviewed the literature dating from 1894 on this subject and stated that they had found trichomonad infestation in approximately 4 per cent. of 400 consecutive male cases of urethritis, other than syphilitic, dealt with in the V.D. Department of the Royal Infirmary, Edinburgh. Among American workers who believe this infestation more common in males and more important than is commonly thought may be mentioned Allison (1943), Roth (1944), and Feo (1944). Allison suggested the use of Seller's Negri stain (a combination of basic fuchsin and methylene blue in alcohol), for the demonstration of *T. vaginalis*, and Liston and Lees recommended Leishman's stain, but the absence of confirmatory reports suggests that either the method requires special skill not possessed by the majority of workers in this field, or trichomonad infestation accounts for only a small proportion of the cases of non-gonococcal urethritis that are encountered in venereal disease treatment centres, whether Service or civilian.

In Australia, Beveridge (1943), in agreement with Dienes (1940) and with Dienes and Smith (1942), found the L organisms of the pleuropneumonia group described by Klieneberger (1935), in a number of his cases of urethritis in Australian soldiers. In this country, Salaman (1946) examined the question of the relationship of the organisms of the pleuropneumonia group to urethritis more deeply than appeared to have been done by other workers. After finding that L organisms could be grown on ordinary chocolate-blood agar, such as is used for growing the gonococcus, he searched for these organisms in the genito-urinary discharges of a number of male and female patients of the V.D. Department of the Royal Victoria Hospital, Netley. The method of demonstrating the colonies of the L bodies was that of Klieneberger and Smiles (1942) with modifications by C. Robinow as described by Salaman *et al.* (1946), and by it he found them in males as follows: 12 of 23 cases of gonorrhoea; 3 of 45 cases of non-gonococcal urethritis; 2 of 34 cases of urethritis following gonorrhoea; 3 of 38 cases of prostatitis; and 4 of 28 cases from the Skin Department (24 with no sign of genito-urinary disease and 4 with slight pyuria). In female discharges he found them in 11 of 18 cases of gonorrhoea; 38 of 63 cases of trichomonad infestation; 8 of 18 cases of non-specific cervicitis; all 20 cases of gonorrhoea with trichomonad infestation; 1 of 17 clinically normal women. The frequent association of L bodies with gonorrhoea stimulated further research; they occurred sometimes in separate colonies and sometimes the vesicles were found closely mingled with the gonococcal colonies. On plates containing in one spot a blob of penicillin cream, the cultures in which the two types of organisms were intermingled showed this feature well removed from the penicillin, but close to the latter were only the L vesicles containing the minute granules which are a feature of this growth. In testing a strain of gonococci for sensitivity to penicillin, because it had been isolated from a patient who had not responded to penicillin treatment, he found that the gonococci were sensitive but that close to the penicillin again were the vesicles of the L bodies; these were not evident in cultures of the strain on plates not containing any penicillin. This led to the testing, as a matter of routine, of all gonococcal strains on penicillin-treated plates, with the surprising result that at the time of writing the L bodies had been found in 80 consecutive cultures of the gonococcus. The author discussed possible explanations of the phenomenon and gave reasons against the L bodies being involution forms of the gonococcus, but left for solution in the future three alternative explanations of his findings: '(1) that L organisms invariably contaminate gonococcal strains of genital origin; (2) that gonococci and L organisms live in obligate symbiosis; (3) that the L-like structures observed are stages in a complex life cycle of the gonococcus'. In the discussion following the paper by Salaman, it appeared that so far no attempt had been made to cultivate the L organisms from discharges found in extra-genital gonococcal infections, but Harkness (1945), in a paper on 'The Cutaneous Manifestations of Gonorrhoea' mentioned that in five recent cases of the syndrome of urethritis, arthritis and conjunctivitis known as Reiter's disease, inclusion bodies had been found in both the conjunctival and the urethral secretions. Similar bodies had been found in a parakeratotic nodule which he had excised from the foot in a case of Reiter's disease under the care of Lt. Col. A. J. King, R.A.M.C., and subsequently he had found them in three cases of keratodermia blennorrhagica. He consequently believed, with Naegeli (1937), that keratodermia blennorrhagica is a manifestation of Reiter's disease.

Thus at the close of the war, probably most venereologists would have agreed to a classification of non-gonococcal urethritis under five headings: (1) Those due to ordinary mixed organisms (staphylococci, streptococci, diphtheroids) and yielding fairly readily to irrigation with antiseptic lotions; (2) those due to trichomonad infestation; (3) those associated with Reiter's disease; (4) the type called sago-grain or Waelsch urethritis with a glairy discharge and sago-grain-like nodules in the mucous membrane of the urethra; (5) a large group which does not fit into any of the preceding four and may be due to pleuropneumonia-like organisms, or to the same organisms as are responsible for inclusion blennorrhoea and perhaps for trachoma, and may be related to the respective organisms responsible for Waelsch urethritis and lymphogranuloma inguinale. Considerably more work will be necessary before the classification is clarified.

The importance of these cases of non-gonococcal urethritis will grow according to their resistance or otherwise to chemotherapy. In the papers already mentioned neither Salaman nor Harkness offered much hope from penicillin in cases in which the pleuropneumonia-like organisms were found, but Harrison (unpublished) cleared up a classical case of Reiter's disease with three injections of penicillin in oil-wax at daily intervals, the doses being 375,000 units for the first and 500,000 each for the second and third. This patient had been seen first in 1936 with urethritis, arthritis and conjunctivitis, in 1938 with urethritis of the Waelsch type and arthritis; and finally in 1946. At no time was any organism at all resembling the gonococcus seen in or cultured from his urethral discharge, and his gonococcal complement-fixation reaction was completely negative on the many occasions when his blood was tested. The urethral discharge had been frequently examined for inclusion bodies but none found. The attack in 1938 resisted sulphonamides of various kinds in heavy doses, and both this and the preceding attack had been very persistent; when seen in 1946 the trouble had been simmering for five years, having started while he was in the R.A.F. with dysentery, urethritis, arthritis and conjunctivitis. The response to relatively heavy doses of penicillin suggests that here may at least be a partial solution of the problem presented by many cases of non-gonococcal urethritis.

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CHAPTER VI

CEREBRO-SPINAL FEVER

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MENINGOCOCCAL disease, at its lowest seasonal ebb when war broke out, was one of the least anxieties of that grave hour, for although the havoc it had wrought in the First World War still lingered in the memory, the great strides lately made in treatment by sulphonamide drugs had largely robbed it of its terrors. Towards the close of 1939, however, the aggregations of recruits, the mass movements of population, the season, the weather and the 'black-out', with its difficulties of ventilation, all provided a setting which had never been more favourable for a serious outbreak. The ominous rise in incidence in the last two weeks of the year was of unmistakable import. It was in these circumstances that, on January 6, 1940,[1] *The Lancet* published a timely survey of existing knowledge of the control of the disease, and this was followed within a few weeks by a War Office memorandum[2] for the guidance of Service medical officers, and a little later by a Ministry of Health memorandum[3] for the guidance of civilians.

Important principles in epidemiology and treatment had been established during and since the First World War, but few had had the opportunity to become acquainted with this knowledge because the disease had not greatly prevailed in the inter-war period. The organisation of the Services was such that the knowledge was easily and rapidly conveyed to the medical officers concerned, but the civilian profession was much slower to learn. There was a definite lag in the civil hospitals in the realisation of the significance of sulphonamide treatment of the disease and in the acquisition of an adequate technique. This was reflected in the superior results of treatment of Service cases in Service hospitals as compared with civil hospitals during the first year of the outbreak (1940) and particularly in the early months of that year as shown in Table VI.

EPIDEMIOLOGICAL PRINCIPLES ESTABLISHED AT THE OUTBREAK OF WAR

The chief principles which had been established were:—

(1) The value of lateral bed-spacing of at least three feet between beds in the sleeping quarters of recruiting depots, as shown by Glover in 1917.[4]

(2) The importance of preventing overcrowding in public halls, canteens and places of entertainment and recreation used by troops.[4]

(3) The ill effects of lack of ventilation along with overcrowding in public recreation rooms as well as in the small houses of the poorer quarters of cities.[4]

(4) The importance of concomitant upper respiratory catarrhs and colds in aiding the transmission of meningococci from throat to throat by means of coughing and sneezing.[4] [5]

(5) The special susceptibility of recruits in the training depots, as compared with seasoned troops and more or less stabilised populations.[5] [6] [8] This was related to the well-known studies of Topley, Greenwood, Dudley and others,[6] [8] on herd infection and immunity, and particularly on the aggravation of epidemics by repeated introduction of non-immunes into the herd.

The question whether carrier surveys were worth while among the contacts of clinical cases had not been finally determined. The practice was falling into discredit.[7] [9] The relatively enormous number of carriers found both in contacts and non-contacts of clinical cases during epidemic prevalence made the problem of segregation virtually insoluble. Besides, it had become recognised that its utility was doubtful since there was no practicable routine test to determine the virulence of meningococci isolated from the naso-pharynx. But no official lead on this subject was given until the Ministry of Health memorandum of March, 1940,[3] 'discouraged as a routine practice the search for carriers', and the Army memorandum of October, 1940, stated that 'routine post-nasal swabbing of contacts will no longer be carried out'. The bacteriological work on contacts which had proceeded in some laboratories from the start of the epidemic was virtually stopped in this country from the date of these pronouncements.

THERAPEUTIC PRINCIPLES ESTABLISHED AT THE OUTBREAK OF WAR

Fortunately, the main principles of sulphonamide treatment of meningococcal meningitis had been worked out just before the war, though many doctors had not yet become familiar with them. The story is exceedingly well told by Brinton[10] and needs only brief mention here. By 1938, it had been shown by various workers,[11] [12] [13] that sulphanilamide and sulphapyridine were both highly effective drugs in the treatment of both Group I and Group II meningococcal infections. In 1939, combined treatment by serum and sulphonamides was widely favoured by clinicians, both on theoretical grounds and as the result of promptings from animal experiments. In July, 1939, at the British Medical Association Meeting, it was shown, however, that sulphonamides alone in adequate dosage yielded even better results than sulphonamides combined with serum.[14] This somewhat surprising result was not fully accepted by the profession when war broke out, though it was later amply confirmed.[15] [16] [17] [18] [19] Hence combined serum and drug treatment was employed in the early months of the war in military hospitals and for a considerably longer period in some civil hospitals.

START OF THE EPIDEMIC

Up to the middle of December, 1939, the numbers of notified civilian and military cases in England and Wales, though slightly increased, approximated to those of 1938. At that point the 1939 curve swung definitely upwards. In January, 1940, this rise became phenomenal—from 52 cases in the first weeks to 190 in the last. In Scotland there was a similar rise of notifications from 18 in the first week of January, 1940, to 46 in the last week of that month.

Since the peak of the seasonal rise of meningococcal infections generally occurs in March or April, it was evident in January, 1940, that a considerable epidemic was on the way. Practical means available for its control were, however, very limited. On general preventive measures the advice offered in the War Office memorandum of January, 1940, contained little more than one item of practical significance, namely that of bed spacing in sleeping quarters. 'It is absolutely essential to ensure that a minimum distance of 2½ feet is maintained between the beds. If the distance is less than 3½ feet every alternate bed should be turned round so that each man sleeps with his head opposite his neighbour's feet. Extra space can also be obtained by pulling some of the beds into the middle of the room.' The Ministry of Health memorandum of March, 1940, could but repeat the same advice. Its exclusion of child contacts from school and its counsel that 'children should not closely associate with any person who, within three weeks, was living in a community in which the disease was present until the person gave a negative naso-pharyngeal swab' had probably no real effect on the progress of the epidemic.

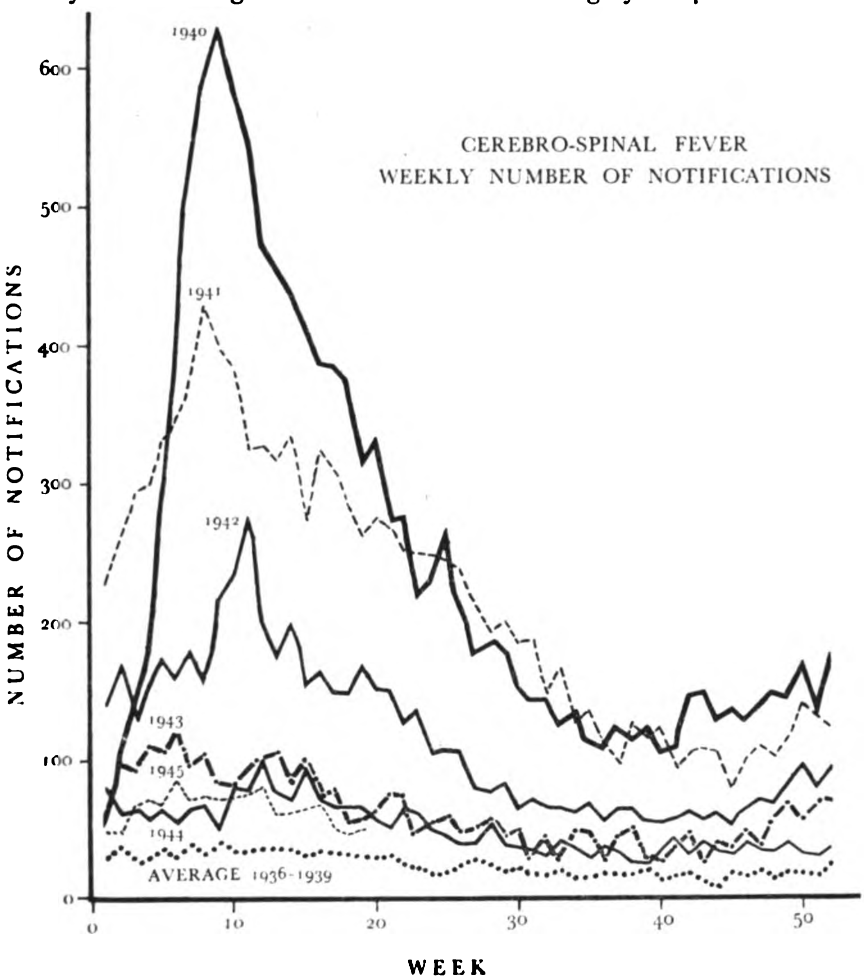
From the point of view of the Forces, an Army Medical Service Officer writes of this period as follows:—[18]

> 'It was indeed fortunate that the initial force of the wave of cerebro-spinal meningitis and meningococcal infections arrived during the early stages of the war, occurring as it did during that heaven-sent period of inactivity which characterised the period from September 1939 to May 1940. This period of inactivity proved valuable in several ways:—first it enabled the hospital beds at home and with the B.E.F. France to be prepared without the simultaneous influx of wounded; secondly it gave time to adjust our ideas as to the best use of sulphonamides, particularly as to dosage and as to the particular preparation to use. This period also saw the introduction of the soluble preparations to be given intravenously and intramuscularly, thus saving the lives of many patients suffering from the acute fulminating forms. So it was that, when the maximum incidence was being reached in France, we were no longer dependent upon the hospital accommodation of

our Allies, but could receive all that were sent for admission to our own medical units. Further, owing to lack of wounded and maimed, there was, at no time, pressure on our hospital beds at home, and as far as the hospital accommodation in France was concerned, any undue pressure that may have occurred was relieved by unhampered evacuation to bases, or if necessary to England without embarrassment from the air or sea.'

COURSE OF THE EPIDEMIC

(*a*) *Incidence in England and Wales.*—The prevalence of cerebro-spinal fever during the war years can perhaps best be appreciated by comparing the notifications of that period with those of immediately preceding pre-war years. (See Graph.) In 1936–9, during the first half of each year there was a seasonal rise without a definite maximum, and the number of cases was approximately twice that in the second half year. The range of the notifications was roughly 20–40 and 10–20



respectively in the two half-years. Following the outbreak of war, as noted above, there was a steep rise in notifications to 190 in the last week of January, a figure almost equal to the peak of the 1915 epidemic. But thereafter the rise was steeper still, to the peak figure of the epidemic —623 notified cases for the week ended March 2, 1940. An interrupted and more gradual fall then took place until the lowest figure for the second half of the year (107) was reached in the first week of September. This was five or six times the pre-war incidence of early autumn. Thereafter came a somewhat unusual autumnal increase coinciding with the increase of 'shelter population' during the bombing of London and other centres. From the end of 1940, the curve rose steeply to the maximum figure for 1941 (434 cases) in the week ended February 22. In 1941, the trend of the disease with its well-marked peak resembled that of 1940 but at a somewhat lower level. The same type of curve was found in 1942, but again at a lower level, the peak reaching 281 cases and the lowest figure being 50 cases per week. After three years of the peaked or epidemic type of curve, the trend changed back to that of peace-time but at a much higher level. The first half-year's curve in 1943 showed a maximum of 124 cases for the week ended February 13, but the upper part of the curve was flattened out over several months. The decline in incidence was continued in 1944 and 1945, the curves in these years again resembling the average of 1936–9, but at above twice the level. The graph includes notifications both of civilians and non-civilians.

The figures for notifications, deaths, and mortality per cent. of notifications for civilians and non-civilians in England and Wales are shown in Table III for the years 1939 to 1944.

(*b*) *Incidence in the British Army.*—On this question Major General R. C. Priest wrote:[18] 'Under the existing system of documentation it is impossible in any Home Command to obtain information regarding the incidence of cases of any particular disease. Patients are admitted to the military, E.M.S. and civilian isolation hospitals, and such admissions are not notified to the D.D.M.S. of a Command. Therefore no computation of incidence and mortality can be made until the Army record cards and the clinical records made by E.M.S. and isolation hospitals have been collected and analysed. In some areas oversea figures of incidence would be easily obtained because all patients would pass through our own Army medical units. In other areas, the incidence would be vitiated because some of our patients would have been admitted to medical units of our Allies. The figures in Table I must therefore be regarded as entirely provisional and incomplete.

'The incidence among troops in the B.E.F., France, was compiled from figures obtained direct from the Medical Directorate at Army H.Q. The chart shows the curve of weekly incidence of the disease in ratios per 1,000 from October 13, 1939, to April 26, 1940, among the troops in

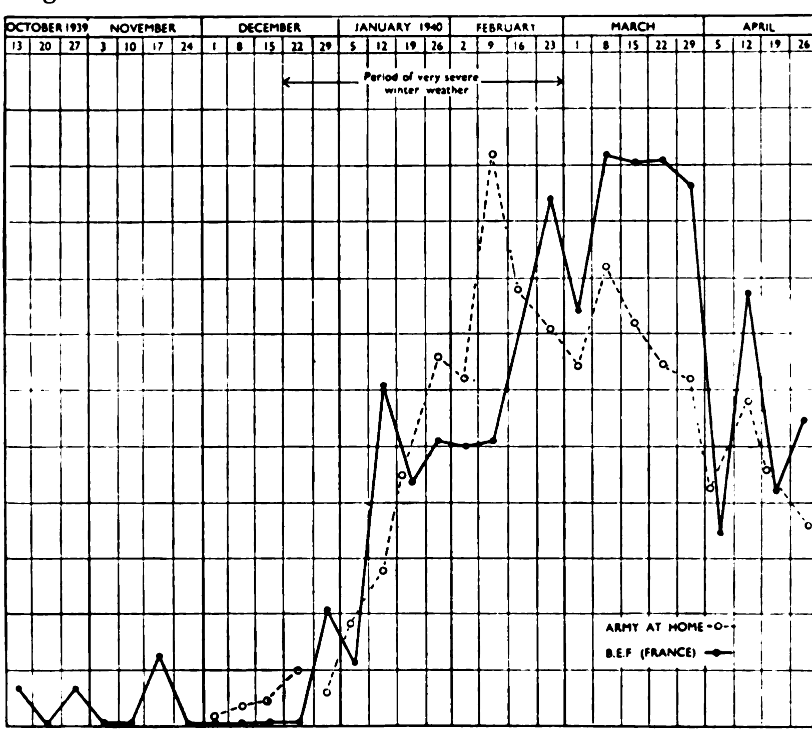
TABLE I

Cerebro-Spinal Fever in British Military Personnel
(*Provisional Figures*)

Year	U.K.		M.E.		C.M.F.		B.A.O.R.	
	Cases reported	E.A.R. per 1,000	Cases reported	E.A.R. per 1,000	Cases reported	E.A.R. per 1,000	Cases reported	E.A.R. per 1,000
1939 (Sept.–Dec.)	54	0·23						
1940	1516	1·46						
1941	938	0·49						
1942	460	0·23	50	0·15				
1943	238	0·16	49	0·13	40	0·10		
1944	183	0·11	25	0·12	19	0·04		
1945	237 (to Nov.)	0·23			22	0·06	40 (Feb. to	0·17 Oct.)

(E.A.R. = Estimated annual rate.)

France compared with the Army at home. For security reasons the actual numbers had to be omitted. As expected the curve is similar to and almost parallel with that for the general population in the United Kingdom.'



The Chart shows the curve of the weekly incidence of cerebro-spinal fever in ratios per 1,000, from October 13, 1939, to April 26, 1940, in the Army at Home and in the Army in France.

(*c*) *Incidence in the Royal Air Force.*—

TABLE II

*Cerebro-Spinal Fever in the Royal Air Force**
Total Force at Home and Abroad

Year	Number of cases	Incidence per 1,000	Deaths		Invalided		Average days in hospital
			Number	Per cent.	Number	Per cent.	
1940	367	1·1	18	4·9	6	1·6	39
1941	465	0·7	27	5·8	13	2·8	34
1942	280	0·3	17	6·1	7	2·5	37
1943	154	0·2	8	5·2	4	2·6	34
1944	114	0·10					
1945	117	0·12					

* Figures supplied by Air Vice Marshal Sir Alan Rook.

(*d*) *Comparison with the War* 1914–18.—The incidence of cerebro-spinal fever among civilians in England and Wales was about five times that of the war of 1914–18, and the mortality per cent. about one-third. The number of notified cases among non-civilians was approximately the same as that of the First World War and the mortality per cent. less than one-fifth.

TABLE III

Cerebro-Spinal Fever: Notifications and Deaths in England and Wales

Year	No. of notifications		No. of deaths		Deaths per 100 notifications	
	Civilians	Non-civilians	Civilians	Non-civilians	Civilians	Non-civilians
1939	1,414	86	503	14	35·6	16·3
1940	11,185	1,586	2,459	125	22·0	7·9
1941	9,893	1,184	2,005	98	20·9	8·3
1942	5,286	743	1,143	63	21·6	8·5
1943	2,976	327	746	34	25·1	10·4
1944	2,686*	296*	570	22	21·2	7·4

* Original notifications (uncorrected figures).

TABLE IV

Cerebro-Spinal Fever in the First World War: Notifications and Deaths in the United Kingdom

Population	Cases	Deaths	Mortality per cent.
Military .	4,238	1,928	45·5
Civilian .	6,021	3,955	65·6

TABLE V

Cerebro-Spinal Fever in the First World War: Incidence and Deaths in the B.E.F. France

Year	Cases	Incidence per 1,000	Deaths	Mortality per cent.
1915	313	0·55	—	—
1916	393	0·33	138	35·1
1917	701	0·43	198	28·2
1918	176	0·11	69	39·2

In all the above tables the much lower mortality among troops than among civilians is striking. This is, of course, chiefly due to the high proportion of troops who are in the most favourable age-group for this disease, 15–25 years, with most of the remainder in the slightly less favourable age-group, 25–35 years. Civilians, on the other hand, include a considerable proportion of infants and older people among whom the mortality, even with chemotherapy, is high. There are, however, other important reasons for the lower mortality in the Services. Major General R. C. Priest[18] has written:—

'As a result of sulphonamide therapy the reduction in mortality is best seen in the Services because they report sick early and soon find themselves admitted to medical units whose medical officers, by consultants' visits and by official instructions and memoranda, have been kept "aware" of the likelihood that an infection may be meningococcal. In consequence the disease with few exceptions is recognised early and treatment with sulphonamides in adequate dosage commenced immediately. This was exemplified during the outbreak in the B.E.F. France in 1939–40. During the early period when our units were not ready, cerebro-spinal fever patients were admitted to Allied hospitals in most of which they were treated by repeated lumbar punctures and specific serum and *not by chemotherapy*. As soon as our own medical units were ready to receive them, immediate treatment with sulphapyridine was given with a consequent remarkable fall in the mortality rate, thus:—

Death rate for the first 98 cases 16·3 per cent.
" " " " next 92 " 3·3 " "
" " " " " 31 " 3·2 " "

In the civil hospitals at home the older treatment with serum combined often with inadequate chemotherapy was carried on much longer than in the Service hospitals. Its relative inefficiency may perhaps be judged from Table VI.

TABLE VI

*Cerebro-Spinal Fever in the Royal Air Force—Home Force only**

Hospitals	Year	Number of cases	Deaths	Case fatality rate per cent.
R.A.F. . .	1940	124	3	2·4
Civil . .	1940	168	11	6·5
R.A.F. . .	1941	157	9	5·7
Civil . .	1941	215	12	5·6

* Figures supplied by Air Vice Marshal Sir Alan Rook.

SEVERITY OF THE OUTBREAK

The tables and graphs record by far the greatest outbreak of cerebro-spinal fever in the annals of Britain. The force of the epidemic was greatest in the period February to April, 1940, and it was then that a high proportion of very severe cases occurred including fulminating and acute cases of the encephalitic and adrenal syndromes.[20] In succeeding years the force of the epidemic was gradually spent presumably through a gradually rising immunity of the population. The war ended, however, with an endemic prevalence more than double that of peace-time, due partly, at least, to the continued abnormal shifting of population groups and to the abnormally overcrowded housing conditions of this period.

ORIGIN AND DISTRIBUTION OF THE OUTBREAK

At the beginning of 1940 a large army of home and colonial troops was scattered throughout the country in process of mobilisation and training. Owing to the explosive character of the outbreak in its early beginnings, no exact data are available as to whether it originated in the military or in the civil population. There are some indications that the outbreak was primarily military but that it spread rapidly to civilians. In the first few weeks, for example, cases were not infrequently encountered in soldiers' families when the soldier was home on leave, or a few days thereafter. Again, it was shown that in the first quarter of 1940, the regional distribution showed a strong preference for 'reception areas' where troops and 'evacuees' were thickly distributed. London and the great towns of the outer ring, which were 'evacuation areas' had considerably less than their arithmetical share of cases. In the second quarter of 1940, however, the notification rate fell from 68 to 43 per 100,000 in reception areas, but rose slightly from 47 to 52 in evacuation areas outside London.[21] This would suggest a particular association of the early part of the outbreak with troops and evacuated children, and that after the first three months this association was not so strong, the distribution then being more general.

After the earliest phase the disease 'prevailed impartially throughout the country; no county in England and Wales escaped, and there were no dramatic local outbursts'. London was somewhat exceptional owing to its massive evacuation of children and other population groups. 'Whereas in 1915 London was heavily attacked, in 1940 it returned only 880 notifications out of the total of 12,771.'[22]

An interesting sidelight on this distribution is provided from Australia where there was also a rise in prevalence of cerebro-spinal fever corresponding with the period of mobilisation there. According to Holmes,[23] both in 1915 and in 1940, the civilian population was affected more than the military camps in the early stages of the outbreak. In 1940, control measures in the camps appear to have had some success. Owing to the relatively small scale of the operations, it was found possible *to stop or minimise the early entry of recruits into the affected military camps* and also to keep recruits apart from seasoned occupants—a policy which was not tried or was not practicable in Britain. .

DEVELOPMENT OF CHEMOTHERAPY IN RELATION TO SERUM TREATMENT

In the early period of prevalence of cerebro-spinal fever in the B.E.F. France, no standard of treatment had been laid down and medical officers were giving sulphapyridine in varying doses according to the individual case. Some medical officers were following the dosage recommended by Banks (1939).[14] or [16] On January 31, 1940, a War Office memorandum made the following significant statement—'The combined use of anti-serum and chemotherapeutic agents does not appear to influence the course of the disease. If serum is used it should be given intravenously and intramuscularly and not into the theca.' Since the storage and use of serum presented considerable difficulties under Service conditions the medical officers in the Forces gladly adopted the implied recommendation to use chemotherapy alone for this disease. The first intimation of success on a grand scale was contained in a letter to the *British Medical Journal* from Major General Perry in May, 1940. Here the momentous news was given that 'in 900 Army cases treated by chemotherapy alone, the fatality rate was between 6 and 7 per cent.'. Later, many smaller series of Service cases were to be published from individual authors in both British and U.S. Forces, in which the case-fatality rates under treatment with sulphonamides alone, in these favourable age groups, were as low as 1 to 3 per cent.[24] [25] [26] [27] [28] [29]

While chemotherapy without serum was thus widely practised in the Services from the end of January, 1940, it was not so in the civil hospitals, where there was no official guidance, until the Ministry of Health issued its memorandum of March, 1940. Even then the change over to chemotherapy alone was by no means so rapid as it was in the Services.[30] In May, 1940, however, at a meeting of the Royal Society of Medicine in London, Banks produced further evidence in favour of sulphonamides alone without serum or routine spinal drainage. Among 120 consecutive cases of all ages from infancy to 74 years, treated during the worst period of the epidemic (January to April, 1940), there were 12 deaths of which 6 were in infants under 1 year of age. The gross fatality rate for all cases including fulminating and moribund was thus only 10 per cent.[20] Such evidence did not go unchallenged, especially by laboratory workers investigating experimental infections. Branham and Rosenthal[31] and Brown[32] had reported in 1937 that, in the treatment of established meningococcal infection in mice, combined sulphanilamide and anti-meningococcal serum gave better results than either drug or serum alone. Now, in June, 1940, Amies[33] confirmed this experimental laboratory-finding. He showed that the combination of drug and serum gave better protection in mouse infections than that obtained with the drug alone, and that it also gave a lower mortality in the infected mice so treated. He pleaded for further clinical trials of the combined serum and drug treatment. Accordingly the use of serum as an adjuvant to chemotherapy in severe cases was continued for a year or two in many civil hospitals,[30] but by the year 1942 it was virtually abandoned. In 1943, strong statistical evidence against routine combined treatment appeared in a review of 3,575 case reports to the Ministry of Health. Here, quite a clear-cut answer to the question was obtained:—'In nearly every age-group the results of combined serum and drug were less satisfactory than those of the drug alone'. In 1944, a review of 2,223 cases treated in Scotland suggested also that combined serum and drug treatment was in fact less effective than chemotherapy alone.[34]

COMPARISON WITH THE OUTBREAK IN U.S.A.

An outbreak in the United States, corresponding on all essential particulars with that in Britain, began in the winter and spring of 1943, that is, in the first meningococcal season which followed large-scale mobilisation. There was a similar steep rise in incidence with a relatively high proportion of fulminating and severe cases in the first quarter of 1943. In the Fourth Service Command among 1,518 cases reviewed by Thomas[24] it was noted that the curve of incidence of the common upper respiratory infections closely corresponded with that of meningococcal disease but preceded it by about two months. So overwhelming was the infection in many cases at this time that meningococci could frequently be demonstrated in films of the peripheral blood. More than two-thirds of the fatal military cases occurred in new recruits with less than three months' service. Improvements in organisation, diagnosis and technique of treatment followed a somewhat similar course to that noted by Priest for the B.E.F., France. The case-fatality rate became progressively reduced from 20 per cent. of 80 cases at the beginning of January, 1943, to as little as 2·1 per cent. of 761 cases in February and March. This notable improvement occurred in spite of continued or increasing severity of the disease. It was ascribed almost entirely to improvements in diagnosis and to organisation of early and efficient treatment with sulphadiazine, including an initial intravenous dose of 4 g. or even more. In 1943, results so good as to be evidently astonishing to those reporting them were obtained in one U.S. military or naval series after another.(25) (26) (27) (28) (29) But these results were not essentially different from those obtained in Service patients in Britain and France three years earlier. Most of the forms of meningococcal infection described in the British epidemic were also noted in the United States, e.g. mild meningococcaemia subsiding without treatment,(25) subacute and chronic meningococcaemia, with characteristic skin eruptions but without meningitis,(25) and fulminating cases with gross adrenal haemorrhage.(24) In one series 3 patients, believed from the symptoms to have had adrenal haemorrhage, recovered. The Americans were greatly puzzled, as we were at times, over necropsy findings. Out of 46 cases coming to necropsy in Thomas's series,(24) 18 had gross adrenal haemorrhage. In most of the others, however, the cause of death was not clear. The meningitis was cured or subsiding and death could only be ascribed to toxic action or increased intracranial pressure. A careful histological examination in some of these latter cases might possibly have revealed the capillary thrombosis and perivascular infiltration and haemorrhage described by Banks and McCartney(35) in encephalitic cases. Nevertheless it must be acknowledged that the exact cause of death in some cases with subsiding meningitis is one of the remaining unsolved mysteries of this disease. In Canada, Klein (1942)(36) treated a series of 41 cases with sulphapyridine alone and obtained excellent results. He concluded that low dosage is dangerous, as it throws too great a burden on the patient's resources, and that serum is apparently not essential as an adjuvant to chemotherapy in this infection.

The epidemiology of the U.S. Army outbreak was described by Sartwell and Smith (1944).(5) The incidence was somewhat lower than in 1918 but otherwise comparable with that in the First World War. The incidence in the civilian population increased in the same proportion as in the Army. It reached a figure of 23·3 per 100,000 per annum for the month of April, 1943. *The majority of all Army cases occurred in recruits of less than three months' standing*, the highest incidence being in the second month of service. The principal factor influencing the incidence in military units appeared to be the presence of a *high proportion of unseasoned troops, especially when there was a rapid turnover of such troops.*

The important carrier studies and experiments in mass prophylaxis carried out in the great U.S. military training centres yielded information of great value in the prophylaxis of the disease.(37) (38) (39) This may prove to have been the U.S.A.'s greatest contribution to the problem of meningococcal disease during the war.

INFLUENCE OF THE WAR UPON KNOWLEDGE OF THE DISEASE

This extensive war-time experience of meningococcal infections in many countries could not fail to influence our ideas and practice in many aspects of the disease. A summary of the more important of such influences is now attempted under the headings of epidemiology, prophylaxis, pathogenesis, treatment and sequelae.

EPIDEMIOLOGY

(1) *Spread of Infection.*—Confirmation was obtained of the main epidemiological principles of spread of infection which had been established before the war. These have been enumerated (pp. 170–1). The factor of bed spacing in the sleeping quarters of recruiting depots appeared to play little part in the spread of infection in this war. Glover had shown that when bed spacing was reduced to one foot or less there was a notable increase of carriers and clinical cases. The Army regulations on this point, repeated in the memorandum of January, 1940, which were based on Glover's findings, appear to have attained their object. In the B.E.F. France, for example, only one instance of infection arising in a sleeping room occurred among a collected series of 204 cases.

Overcrowding in public halls, canteens, dance rooms and at massed meetings of mixed units, where there was active movement, talking, coughing, sneezing and laughing, probably played a considerable part in the spread of infection and in the sporadic occurrence of clinical cases, scattered throughout many units, which is typical of this disease.

Overexertion and fatigue, especially in recruits, was stressed by Fairbrother[40] as a more potent factor than overcrowding in the spread of the disease. As in the War of 1914–18,[41] however, no conclusive evidence on this point was obtained.

The susceptibility of new recruits was again demonstrated in every Army, Navy and Air Force. The clearest figures available on this point are those of Sartwell and Smith[5] for the U.S. Army. They showed that out of a representative 1,337 cases, occurring early in the epidemic in all parts of the country, no less than 57 per cent. occurred in recruits with less than three months' service. Only rarely did men who had been in the Army for more than a year develop meningitis.

The occurrence of cases in new recruits appeared to be maximal when there was rapid turnover in the recruiting depots. One solution to this problem would appear to lie along the lines adopted in Australia namely, to minimize the entry of recruits into the affected military camps, thereby keeping the affected population of these camps relatively stable until the epidemic burns itself out.

(2) *Carrier Problem.*—Additional light was thrown upon the carrier problem by extensive studies in U.S. military camps. These were

stimulated by the need to investigate the situation arising out of the use of sulphonamides for mass prophylaxis in these camps. Among other things it was discovered anew that 'the experience of the worker counts for much in determining the carrier rate. One can easily double the percentage of his positive findings as a result of practice'.[37] The painstaking technique of Phair and his co-workers[39] in taking cultures from groups of persons at frequent intervals for periods as long as 10 weeks, and also in examining multiple colonies from each individual culture showed clearly the complex carrier pattern of the groups studied. Valuable confirmation was thus obtained of a conception which had been foreshadowed by the more limited work of the past. In one group of 100 soldiers from whom repeated cultures were taken during a period of 10 weeks, no less than 91 per cent. were found by Phair's method to harbour meningococci of specific type at one time or another during the period. Moreover, more than 50 per cent. of them harboured, at some time or other, two or more specific strains. Thus it became clear that the true carrier-rate of a group cannot be determined from single cultures. Indeed any static concept of a number of fixed carriers within a group could not be substantiated. A group presents a complex dynamic equilibrium of infection with an ever-changing carrier pattern. It is therefore absurd to attempt to control the disease through segregation of carriers. The group must be treated as a unit. Fortunately a new and practicable method of treating such a group had begun to emerge—simultaneous mass treatment of every member of the group with sulphonamide.

MASS PROPHYLAXIS BY SULPHONAMIDES

It was shown in Britain in 1940[40] that carriers of meningococci could be freed, at least temporarily, from these organisms by a short course of sulphapyridine, e.g. 3 g. daily for three days. In the same year this method was applied with success on a small scale in a residential nursery in Australia.[42] From 1943 onwards, several large-scale controlled experiments in semi-isolated U.S. military camps were strikingly successful in stopping the occurrence of clinical cases and temporarily reducing the carrier-rate to such low figures as nil to 5 per cent. for three to eight weeks. These experiments were carried out in training centres for some 10,000 men in rural districts, that is, in large semi-closed populations. At first, only the proved carriers were treated. Thus Cheever *et al.*[38] gave 8 g. of sulphadiazine in divided doses over three days to 161 carriers in a camp where many clinical cases of Group I meningitis and septicaemia were occurring. For one week thereafter all 161 carriers gave negative swabs except in one case where a change occurred from Group I to Group IIA meningococcus. The control group showed an actual increase during this period. By the thirty-seventh day after the treatment, the carrier-rate of the treated group had increased to 20 per cent., and of the control group to 81 per cent. The obvious conclusion from this experiment was that chemoprophylaxis must be simultaneous throughout the entire camp, since a fair proportion of those cleared tended to become positive during ensuing weeks if continually exposed to re-infection. Kuhns *et al.*(37) then applied mass prophylaxis simultaneously to an affected community of 8,000 men, using another similarly affected community of 9,300 men as controls. They gave 9 g. of sulphadiazine over three days to every member of the treated group. In the ensuing eight weeks no cases of meningitis occurred and the carrier rate fell to between 2 and 7 per cent. In the control group, however, 23 cases of meningitis occurred while the carrier-rates varied between 30 and 57 per cent. Toxic effects from the drug were negligible. In a second experiment on 7,000 men the dose of the drug was reduced to 2 g. daily for two successive days. The results were as good as in the first experiment. Other investigators progressively reduced the amount of drugs in such experiments. Thus Painton(43) gave 5 g. of sulphadiazine over twenty-four hours simultaneously to 18,000 men, and a follow-up for eight weeks thereafter showed that no recognisable clinical case had occurred. Finally, the apparent minimum effective dose was determined by Phair *et al.*(39) in a very thorough study of groups of 100 men. They found that in a non-segregated group receiving as little as 2 g. sulphadiazine in a single dose, the carrier-rate fell immediately from 25 per cent. to nil and very low carrier-rates were maintained in this group for the three weeks during which they were followed, that is, far beyond the period required for complete drug excretion. Low carrier-rates were also achieved immediately but not maintained in the group receiving 1 g. sulphadiazine. The significance of such sudden reduction of carrier-rates in relation to the stoppage of occurrence of clinical cases has been demonstrated in these experiments. The evidence therefore suggests that mass prophylaxis with a single dose of 2 g. sulphadiazine (or its equivalent) applied simultaneously to every member of a community may be successful in stopping an outbreak. It is considered, however, that before this measure is applied on a large scale studies of samples of the population should be undertaken to ascertain that the three main factors governing meningococcal epidemicity are actually present, namely (1) high carrier-rates, (2) predominance of Group I strains, and (3) high proportion of recruits or other non-immunes.(37)

War-time experience has thus provided the setting for the elaboration of a new and valuable technique in community prophylaxis which will probably replace entirely the laborious and relatively inefficient method of mass inoculation with vaccine. The new method is, of course applicable at present only to semi-closed communities whose members are under ready control, such as residential institutions and military and other encampments. Already, however, since the war, it is reported to have been applied with apparent success to the whole population of a city of 100,000 inhabitants.[44]

PATHOGENESIS

Although many doctors still think of meningitis as the sole clinical manifestation of meningococcal infection, the septicaemic stage of the disease has attracted attention for many years, and particularly during the War of 1914–18. It may indeed be claimed that the usual sequence of events was then established as (1) nasopharyngeal infection, followed by (2) bacteriaemia or septicaemia and by (3) meningitis.

The ordinary form of the disease, in which meningitis sets in after a few minutes, hours or days of bacteriaemia needs no description here. Certain points, however, are worthy of comment. The primary naso-pharyngeal infection may be sub-clinical or there may be an overt naso-pharyngitis. Is the latter due to meningococci or to other organisms? Swabs are rarely taken systematically at the onset of clinical signs of naso-pharyngitis, and so no categorical answer to this question can yet be given. Sporadic swab-taking, however, revealed at least two groups of cases during the war in which practically pure growths of meningococci were obtained from the tonsils in men complaining of sore throat, at a time when meningococcal disease was prevalent. Thus Van Rooyen and Morris[15] noted 4 cases of tonsillitis in which throat swabs yielded almost pure growths of meningococci, and 2 in which scanty growths of meningococci were obtained during the epidemic period of 1940. A group of cases of meningococcal tonsillitis was also discovered among soldiers reporting at an out-patient clinic in Wales early in 1940. Clinical naso-pharyngitis of pure meningococcal aetiology is thus possible but may be a phenomenon mainly associated with epidemic prevalence of the disease and therefore with highly virulent strains. We have not yet determined to what extent the meningococcus is responsible for the catarrhal naso-pharyngitis which precedes the onset of meningitis in a high proportion of cases. But we know that it plays at least a symbiotic part in this process, for meningococci of the same serological type as that isolated from blood and spinal fluid are constantly present in the naso-pharynx at the onset of typical symptoms of the disease. (Fildes, 1918.)[45]

Does true herpes zoster occur in this disease? Rolleston[46] described herpes of zoster type involving eyelids, ear, neck, face and hands. Priest states that herpes zoster appears about the fifth day, is remarkable for its frequency, its extensive distribution, atypical localisation and long duration. Mitchell-Heggs also refers to herpes zoster and states that areas of the skin supplied by the cervical plexus and the fifth cranial nerve are frequently involved. An illustration of extensive herpes in his article, however, shows a distribution which is irregular and does not involve exclusively the whole area of the skin supplied by one or more particular nerves, a feature which is usual in herpes zoster. Many extensive cases of herpes were seen but they could all be described as herpes febrilis, and none exhibited strictly this characteristic of herpes zoster. It would be surprising if the virus of herpes zoster, which is usually the virus of chicken-pox, happened to be present so frequently in cases of meningococcal infection. But combination of herpes febrilis with bacterial infections is quite common. It cannot therefore yet be said that herpes zoster and its virus are proved accompaniments of meningococcal meningitis.

Mild abortive cases have frequently been mentioned in the literature of this war. Symptoms of general febrile illness succeeded headache and slight signs of meningeal irritation. These passed off in a few days either spontaneously or, as a result of sulphonamide treatment. In many such cases the diagnosis could only be presumed in view of the prevalence of the infection at the time, but in some cases the meningococcus was isolated from the blood, and a slight pleocytosis found in the spinal fluid.

Chronic Meningococcal Septicaemia. Although this form of meningococcal infection was first described in 1902,[47] it received little attention in the literature of the First World War. From 1937 to 1939 there were a few references, but the syndrome was little known to British physicians at the outbreak of the war. In 1940, the syndrome was observed among British troops in France,[48] and also among civilians and soldiers in Britain. In 1942, its relative frequency was stressed as well as the rheumatic-like accompaniments, joint and muscle pains and sometimes serous arthritis. Other writers stressed the resemblance of the pyrexia to malaria. The characteristic clinical picture usually makes a clinical diagnosis possible. It consists of bouts of pyrexia usually every two or three days, with or without rigor and sweating; recurrent crops of papules on trunk and limbs (some with petechial centres) and larger circular raised areas of erythema resembling erythema nodosum; these erythematous areas may become purpuric and some of the latter may then form vesicles and ulcers, with meningococci in the exudate. There may be pains in joints, muscles, tendons and bones accompanying the rash or sometimes even occurring as presenting signs. In 3 cases described by Priest, there was no rash; one of these had 4½ months' pyrexia before the diagnosis was verified by a positive blood culture. Blood culture is positive in a majority of cases, but may be negative even after repeated attempts. In pre-sulphonamide days, the condition might endure for months or even years, finally burning itself out spontaneously or ending in meningitis. Moderate doses of any sulphonamide terminate the condition at once.

Fulminating meningococcal septicaemia. This highly and rapidly fatal condition presents a bewildering variety of symptoms. The course from onset to death may be as short as four hours. The onset is usually sudden, the patient sometimes awaking in the middle of the night, with restlessness, pyrexia, malaise and vomiting. Within a few hours a petechial rash appears and spreads to become a massive purpura. Consciousness may be lost early or the mind may be clear almost to the end. The blood-pressure is usually low when the rash is massively purpuric. In a minority of cases (usually infants) there is no rash and no hypotension but early and deep coma with commencing meningitis. It was recognised in the First World War that there were broadly two types of fulminating meningococcal septicaemia; one in which the brunt of the onslaught was on the cerebro-spinal system, and one in which it was on the peripheral circulation, the meningitis being slight or absent.(49) But no clear relationship was worked out between symptoms and pathological processes. This relationship was made clearer in the 1939–45 War by Banks and McCartney,(35) (50) in two papers describing meningococcal encephalitis and meningococcal adrenal syndromes. They showed that parenchymatous changes in the central nervous system, in addition to meningeal infection, were commoner, in epidemic times at least, than was generally realised. These changes may occur both in fulminating and acute cases. They consist of congestion and oedema with capillary thrombosis, followed later by inflammatory polymorph cuffing around the vessels of various parts of the central nervous axis; the condition may be generalised or focal. Clinically the symptoms of acute meningitis in such cases are complicated by those of encephalitis, especially continued deep coma, cyanosis and stertorous or irregular breathing. Such cases usually end fatally without recovery of consciousness notwithstanding the use of chemotherapy, although recovery was noted in one case which exhibited temporary parkinsonism while emerging from the acute stage. Some of the cases described in this paper as *meningococcal encephalitis* were found to have, in addition, haemorrhage or thrombosis in the adrenal glands. This led to a study of those fulminating septicaemic cases which showed massive purpura and bilateral adrenal haemorrhage—the syndrome which had become popularly known as the Waterhouse-Friderichsen syndrome. Banks and McCartney pointed out that there is no valid reason for the retention of this eponym. From the pathological standpoint the adrenal lesions are varied in character, and consist of pure haemorrhage, thrombotic necrosis with peripheral haemorrhage, gross oedema without haemorrhage but with areas of polymorph infiltration, and combinations of these lesions. From the 11 cases described(50) two distinct clinico-pathological syndromes were differentiated—the pure adrenal syndrome and the mixed or encephalitic-adrenal syndrome. The two have in common the sudden onset with fulminating septicaemia and purpura, very low blood-pressure, imperceptible pulse and collapse, and usually cyanosis; but, in the pure adrenal syndrome, the mental condition usually remains clear to the end, whereas in the mixed syndrome there is early coma which persists. In the former, respiration is either normal or there is dyspnoea of the air-hunger type, whereas in the latter there is rapid stertorous breathing, finally of the Cheyne-Stokes variety. Three cases, assumed from the symptomatology to be of the pure variety recovered under active therapy with sulphathiazole together with replacement therapy of adrenal cortical extract.

From pathological evidence on 3 cases, Morrison[51] stressed another factor in the causation of death in fulminating septicaemia. He found evidence of widespread oedema of tissues of the kind associated with general toxic capillary permeability, a mechanism which gives rise to the symptom of shock. He suggested that the toxic effect on the peripheral vessels seemed to be the primary cause of the symptoms, with the adrenal changes merely contributory.

The outcome of these war-time investigations may be briefly summarised as follows:—

(1) It is confirmed that meningococcal disease is basically a bacteriaemia and that meningitis, though the most commonly recognised form, is only one manifestation of the infection.
(2) Many abortive forms with mild symptoms can be recognised in epidemic times.
(3) Metastatic infection of many organs and tissues—e.g. joints, internal ear, eye, brain, heart valves, pericardium, pleura, testicle, purpuric lesions on the skin, etc.—may be associated with the 'ordinary form' (meningitis) or with any of the septicaemic forms.
(4) The clinical syndrome of chronic meningococcal septicaemia is firmly established and more widely recognised.

New clinico-pathological syndromes have been demarcated out of a confused medley of fulminating and acute cases. The key to these syndromes is to determine by the appropriate symptoms and signs whether the brunt of the infection is mainly (*a*) on the brain (encephalitic syndrome), or (*b*) on the adrenal glands and peripheral circulation (pure adrenal syndrome), or (*c*) on both (mixed or encephalitic-adrenal syndrome).

TREATMENT

The effect of war-time experience in stabilising the technique of sulphonamide treatment of cerebro-spinal fever was rapid and profound. Significant confirmatory evidence of the value of sulphonamides alone without serum was rapidly forthcoming in the first winter of the war. The scale of dosage worked out by Banks[14] for meningococcal disease was investigated statistically in two important reviews of large numbers of cases.[34] [52] On purely statistical grounds, no definite conclusion could be reached, as to whether this or lower dosage gave the better results. In the age-group under two years, however, it was found that there was a decline in fatality as the dosage increased.[52] A similar suggestion for the younger ages was also made in the other review. Treatment with sulphathiazole rather than with sulphapyridine was advocated in Britain early in 1941 by Banks[53] who reported a consecutive series of 96 cases so treated with only two deaths. The concentration of sulphathiazole in the cerebro-spinal fluid was found to be only 15 to 40 per cent. of that in the blood, averaging only about 1·3 mgs. per 100 c.cm. at the peak period of the dosage, and yet the drug was rapidly effective. In the U.S.A. the low penetration of sulphathiazole into the spinal fluid was held to render its use in meningitis undesirable on theoretical grounds, but the complete effectiveness of this drug in practice was convincingly demonstrated in Britain during the subsequent war years. Sulphadiazine practically replaced sulphapyridine in the U.S.A. in 1941. Both sulphathiazole and sulphadiazine proved to be as effective as sulphapyridine, if not more so, and by reducing the toxic effects of vomiting and mental depression, they rendered the patient much more comfortable and the nursing more pleasant. Treatment by penicillin was beginning to be tried towards the end of the war, and in Service cases yielded as good results as sulphonamides.[54] The dangers of intrathecal injections and the pain and disturbance of intra-muscular ones, however, appeared to contra-indicate penicillin treatment for the ordinary form of cerebro-spinal fever, since superlatively good results could be obtained with simpler sulphonamide treatment. It could be said at the end of the war that no case for routine penicillin treatment of meningococcal disease had been established, but that penicillin might with advantage be combined with sulphonamides in fulminating and certain other difficult cases.

COMPLICATIONS AND SEQUELAE

In the Official History of the War of 1914–18 the following statement appears regarding incapacitating sequelae:—'In estimating the disabling effects of the disease, certain organic lesions occur in a small proportion of cases, and a large proportion present functional nervous troubles which, under appropriate conditions, *avoidance of hospitalisation being the most essential*, entirely recover. Ultimate efficiency, except in a few organic sequelae, is in no wise lowered by an attack of the disease'. Experience in the Second World War confirmed this statement with few exceptions, but amplified it in respect of the functional or psychiatric sequelae. The latter were studied in greater detail and with more expert knowledge than was available in the First World War. In the Army special efforts were made to prevent any fixation of psychiatric symptoms and sequelae by suggestion. Such patients were not allowed to go on sick leave to their homes, where ignorant or misplaced sympathy might not only have retarded recovery but added something to their abnormal psychological state. Nor were they kept for long periods in hospitals. They were transferred to suitable convalescent homes (British Red Cross and St. John's

Ambulance Association) where they were supervised by Army medical officers who were instructed to reassure and encourage them in the idea that the new drug treatment abolished sequelae and led to complete recovery. Thereafter they were transferred to military convalescent depots where the same process of reassurance and encouragement went on. In the case of complications—such as facial and other palsies, arthritis or even persistent headache—reassurance was still the policy for it was known that these were of a transient nature. In the Royal Air Force, out of a total number of 1,266 cases only 30 were invalided. The causes of invaliding in 28 cases were as follows:—persistent headaches, usually associated with dizziness 6; anxiety state 5; depressive state 3; hysteria 3; progressive dementia 2; bilateral nerve deafness 6; sciatic neuritis 1; flaccid paralysis of lower limbs 1; general muscular weakness (diagnosis possibly poliomyelitis) 1. In these 28 cases the attack was recorded as severe in 6, moderately severe in 11, mild in 10, history lacking in 1 case. Of the 6 cases with bilateral nerve deafness, 3 had severe attacks.[56] It would appear that the correlation between severity of attack and invaliding is not high.

Complications and sequelae of organic origin are mainly due to:—

(I) Slow organisation of meningeal exudate and formation of adhesions—e.g. hydrocephalus, ocular, facial and limb palsies, and recrudescence or relapse.

(II) Inflammatory extensions of the meningitis, as in labyrinthitis with deafness.

(III) Metastatic inflammations, as in choroiditis or panophthalmitis, arthritis, brain abscesses.

(IV) Technical errors in treatment—e.g. abscesses from intramuscular injections, and sciatic palsy from intra-thecal injection.

(V) Toxic or embolic effects—e.g. myocarditis, peripheral circulatory failure, adrenal haemorrhage and oedema, cerebral and subdural haemorrhage, blindness of central origin, aphasia and hemiplegia.

(VI) Possibly some general damage to the central nervous axis, resulting in symptoms similar to those of the post-concussional state —e.g. the minor residual sequelae first noted by Rosanoff:[55] persistent headache, dizziness, mental depression, insomnia and failure of concentration and memory.

In the Second World War cases in Group I were immensely reduced as compared with those in the First World War, owing to the rapid cure and resolution of the exudate effected by sulphonamide treatment. Hydrocephalus was very rare and was seen only in patients, mainly infants, who came under treatment too late for chemotherapy to be effective. This was generally the result of an error in diagnosis of the early symptoms, or of early symptoms mild enough to be missed. Among 500 cases of all ages treated in Cardiff, Harries[30] had 5 cases of hydrocephalus, but in Edinburgh, out of a similar number, Joe[57] had only 1 case. Peripheral neuritis or radiculitis with flaccid palsies of external ocular muscles, face and limbs were much more transient than in the pre-sulphonamide days for the same reason. Again, relapses and recrudescences which were formerly frequent in this disease were found to be very uncommon in efficiently treated cases. Harries had 3 relapses and Joe had 2 in their series of 500 cases.

In cases in Group II, the damage seems to be done early and in a proportion of cases is irreversible when the patient comes under the influence of the drug. Labyrinthitis is the most serious complication of this group, for a considerable proportion so affected are left with permanent deafness. In Harries's series,[30] partial and temporary deafness was reported in 11 cases and permanent deafness in 7 cases. Joe[57] had 10 cases of deafness of which 5 recovered and 5 were permanent; 5 were bilateral and 5 unilateral. In 216 consecutive cases Banks had 9 cases of deafness of which 6 were permanent. In a follow-up of 1,075 cases in the London region, permanent, partial or total deafness was reported in 3·4 per cent.,[58] and in a similar follow-up of 986 cases in the South Wales region, some degree of permanent deafness was reported in 5·5 per cent.[59] Deafness is the one sequela which does not appear to have been much reduced by chemotherapy. Rolleston[46] found 10 cases of deafness among 502 naval cases in the First World War, an incidence of 2 per cent. The incidence, however, is usually under-estimated at the time of discharge from hospital, since unilateral cases and cases in infants may not be recognised for some months after discharge. From the above data, especially those of the follow-up series, it may be assumed that the incidence of permanent deafness is not usually less than 3 per cent.

In Group III, chemotherapy, if applied early, is often effective. Two cases of choroiditis with opacity of the vitreous cleared up completely a few days after drug treatment was begun, but a third case in an elderly person progressed to panophthalmitis and loss of the eye. In Joe's series,[57] there was one case of irido-choroiditis which cleared up. Rolleston[46] had 7 cases of panophthalmitis among 502 cases in the First World War, an incidence of 1·4 per cent. It is practically certain that the incidence of blindness from panophthalmitis and other effects of meningococcal infection was greatly reduced by chemotherapy. The same applies to the incidence of arthritis. The prognosis of arthritis was always good but was made better by chemotherapy.

Cases in Group IV mainly occurred in the early days of chemotherapy as a result of injection of sodium sulphapyridine. The irritant and highly alkaline nature of this preparation was not always realised. When the injection was unwittingly made subcutaneously, it produced abscess and sloughs; occasionally it was injected intra-thecally, generally with disastrous results, including permanent sciatic palsy.

In Group V, the complications occur only in the most acute or fulminating cases. Myocarditis is transient. Haemorrhage and oedema in adrenals, brain and the tissues generally have been described already in this chapter.

In Group VI the sequelae mainly consist of subjective symptoms. They were investigated by psychiatric methods by Pai[60] [61] and by Ballard and Miller.[62] The former examined 32 recent sufferers from cerebro-spinal fever presenting neurotic or psychotic symptoms. He considered that 4 of them had developed an organic syndrome, 8 a neurotic syndrome, and that in 12 other cases there was a predisposition to neurotic or psychotic illness. In his later paper he dealt with personality changes after cerebro-spinal fever in 51 cases. Among 24 who had had a severe illness with delirium, 16 showed a definite syndrome which was suggestive of an organic process, with perhaps slight functional overlay in a few instances. He considered that severity of the primary illness was a factor in the production of these sequelae and that persons with no hereditary or personal tendencies to neurotic breakdown may, after an attack of cerebro-spinal fever, acquire a neurosis. On the other hand Ballard and Miller, who examined 60 Royal Air Force cases referred to a Neuro-psychiatric Centre, were inclined to attribute more importance to a previous history of emotional instability than to severity of attack. The symptoms complained of were in the following order of frequency: headache, failure of concentration, backache, insomnia, depression, postural dizziness, functional ocular symptoms, muscular limb pains, effort symptoms, poor memory, dreams, dyspepsia, and vertigo. Many of these symptoms were frankly hysterical in nature. Of the 60 cases, 53 showed symptoms resembling the post-concussional state. The severity and persistence of these symptoms were found to be only partially correlated with the severity of the acute illness, but were strikingly correlated with the degree of psycho-neurotic predisposition, as determined by personality study. The authors considered that the symptom complex was a psycho-somatic reaction, initially organic in origin but perpetuated by emotional causes; and that *suggestion whether by doctors or others, plays a significant part in the production and perpetuation of symptoms.* The treatment of 49 cases by superficial psychotherapy and graduated exercises resulted in 45 being returned to duty and 4 invalided. Prognosis was found to be more closely related to the patient's previous personality pattern than to the initial severity of the symptoms.

Although these systematic investigations were not published until near the end of the war, action on the lines suggested by Ballard and Miller was taken in the Services much earlier, with satisfactory results in preventing permanent invaliding from suggestion. In the civil population the same problem was met with but to a much lesser extent than in the Services. The follow-up surveys reported by Maddock[58] and by Degen and others[59] showed that there was an appreciable incidence of such sequelae as persistent headache, loss of power of concentration, emotional instability and personality changes, but Banks's later follow-up study reported in Maddock's paper suggested that the final 'hard core' of psycho-somatic disability after two years or so was very small. Reference to the opening quotation in this section shows that the problem is an old one and is probably related particularly to the stress and strain of war. Progress was made, however, during the Second World War in the elucidation of the syndrome. Its relation not only to the preceding disease but to the patient's previous personality pattern was made much clearer, and the harmful influence of suggestion in prognosis and treatment was not only confirmed but in most cases successfully avoided.

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CHAPTER VII

ADVANCES IN TROPICAL MEDICINE

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CAMPAIGNS ranging from the Mediterranean littoral through the Continents of Africa and Asia to the islands of the South-West Pacific brought the armies of the British Commonwealth into regions where sub-tropical and tropical diseases are endemic and set many problems, some old and some new, to the medical services. From the intensive research stimulated by this challenge there have emerged many important findings which have a wide and general application.

MALARIA

Malaria, which experience has shown to be the greatest source of man-power wastage in regions where it is endemic, was a constant menace in Middle East Force, North Africa, Sicily, Italy and in East and West Africa, while in Burma and the South-West Pacific it appeared in its most serious form and for a time reached epidemic level. Differing conditions in these theatres called for varying methods of control and, in consequence, research projects covered the entire range of anti-malarial measures.

Mosquito ecology

Mosquito control played an important part in base areas and on lines of communication where conditions were relatively static. In such places much work has been done on the identification of carrier species, and many detailed and accurate surveys have been made which will be of permanent value. On the basis of these observations precise methods of species control have been devised which have proved to be both effective and economical in application. One or two instances out of many may be quoted.

In Northern Borneo[1] it was long believed that the principal vector was *Anopheles maculatus*, which is common in that area and is a proven carrier elsewhere, but when this assumption was carefully investigated it could not be confirmed. After a prolonged search it was found that the responsible vector was *A. leucosphyrus*, a species which is apt to escape notice because of its habit of entering huts to feed after midnight, and leaving again before dawn. This mosquito lays its eggs only in clear spring water in shady hill-side seepages. By locating danger-spots of this kind, and by clearing and burning the jungle for a short distance around, breeding was controlled with a minimum expenditure of labour.

A second example is to be found in the important observations made in West Africa regarding the two carrier species, *A. melas* and *A. gambiae*.[2] [3] [4] [8] These mosquitoes, although very closely related to each other, differ in their breeding habits. *A. melas* lays its eggs in the brackish water of coastal swamps found either in groves of the mangrove, *Avicennia nitida*, which occur as 'islands' in the more common *Rhizophora racemosa* with which these swamps are densely covered, or in patches of *Paspalum* grass in their vicinity. In Lagos, where there is only a small tidal fluctuation, it has been possible to reclaim large areas of swamp and at the same time to eliminate *A. melas* breeding by building bunds to keep out the sea water and by digging low-level drains fitted with one-way sluice gates to dry out the marshes. The eggs of *A. gambiae*, on the other hand, are deposited in small sunlit puddles or pools of fresh water but in a peculiarly erratic and unpredictable fashion. For the control of this mosquito large drainage schemes are rarely indicated and the best results are got by carefully locating and periodically treating its chosen breeding places.

These and other similar studies of the ecology of carrier species of mosquito have played an important part in the reduction of the vectors in many localities hitherto notorious for malaria.

Larvicides

A search for new larvicidal preparations produced nothing of note until the advent of dichlor-diphenyl-trichlorethane (D.D.T.) which proved to be much more effective for this purpose than anything hitherto known. For treating larva-infected water, D.D.T. is generally used as a 5 per cent. solution in oil of good spreading quality (as a dust it has proved less satisfactory). Quantities of less than a gallon per acre (1 or 2 quarts may be sufficient) are required for most types of water[5], whereas for the same area 10 to 20 gallons of anti-malarial oil are usually necessary. The economy affected in material, transport and distribution is obvious. The solution can be spread by means of simple sprays, either hand- or mechanically-operated. For inaccessible situations, or where it is necessary to treat a large area rapidly, it can be sprayed from aircraft when it may act not only as a larvicide but also as an insecticide by contaminating surfaces and hence poisoning adult mosquitoes. When applied to water, pools, etc. as a surface film, D.D.T. solution kills off all the larvae which may be present and maintains full control for some days, and limited control for a considerable time thereafter. D.D.T. as a larvicide has proved to be a very important addition to the armamentarium of the malariologist and has enabled mosquito eradication to be carried out on a scale never previously attempted.

Destruction of Adult Mosquitoes

The destruction of the adult mosquito is, in certain circumstances, an important anti-malarial measure. In India, during the war, large-scale controlled trials were carried out to assess the value of periodic spraying of dwelling houses with a 'knock-down' pyrethrum insecticide and it was found that this caused a well-marked reduction in malaria incidence.[6] When the properties of D.D.T. were discovered it was hoped it might be possible to use this substance in dwelling places as a long-acting insecticide by spraying the walls and other surfaces with a solution designed to dry and deposit a 'residual' coating of crystals which would persist for some months. When this method was put to practical test a number of interesting points were discovered. It was found that certain species of mosquitoes (e.g. *A. funestus*), when they enter a hut in search of a blood meal, usually settle on the wall or some similar surface for a time before they feed.[7] D.D.T. residual spray proved successful in killing off mosquitoes with this habit, as they became contaminated and ultimately died. Other species, of which *A. gambiae* is an example, enter the hut or room and feed without previously alighting, and thereafter fly to an outside resting place.[8] Should they attempt to settle they appear to be either repelled by the oil or irritated by the D.D.T. and take wing before a lethal quantity of the latter is absorbed. Much work remains to be done before a final conclusion can be reached as to the value and limitations of D.D.T. residual spray in mosquito control.

Repellents

Two new repellents, dimethyl-phthalate and dibutyl-phthalate, were discovered during the war. Both proved more effective than any previously known and, of the two, dimethyl-phthalate was more active against mosquitoes. Like other volatile substances its effect when it is applied direct to the skin lasts at most a few hours and, for this reason, it is of limited value as a protection for sleeping men. In impregnated fabrics its action is more prolonged, and a net of ⅜-in. mesh treated in this way was found to retain repellent properties for 72 hours.[9] Head-nets made of this material proved effective and relatively comfortable.

Chemotherapeutic control

For troops engaged in mobile warfare none of the methods which have been described, with the possible exception of repellents, is of practical value. The soldier must, of necessity, live in regions where he is exposed to the bite of infected mosquitoes. In such circumstances his only protection lies in the use of drugs capable of either destroying the parasites before they can produce an infection (causal prophylactics) or, alternatively, of preventing the appearance of overt symptoms of malaria (suppressants). It was known from the Macedonian campaign of the 1914–18 War that in a hyperendemic area quinine is ineffective as a causal prophylactic and has only a limited suppressive action. In any case, as the entry of Japan into the war and the loss of Java early in 1942 cut off the main supply of quinine, it became impossible to prescribe this drug on a large scale. Attention was accordingly directed to the synthetic anti-malarial preparations. Atebrin, manufactured by the Allies under the name of mepacrine, gave promising results as a suppressant in Malaya, Middle East, North Africa, Sicily and Italy, but, in the absence of controlled experiments, there was uncertainty regarding the optimum dosage and also regarding the degree of protection afforded by this drug. The appearance of malaria in epidemic form in the Australian Forces in North Guinea made it imperative to obtain accurate information on these points and, with this as its objective, Land Headquarters Medical Research Unit (A.I.F.) at Cairns, Queensland, was formed in 1943 under the direction of N. Hamilton Fairley.[10] [11]* This unit was staffed by physicians, parasitologists, entomologists and biochemists. Its *modus operandi* was to infect volunteers (of whom some 850 in all were engaged) using parasites and mosquitoes obtained in the first instance from the theatre of operations, and to test the action of the various drugs on these men under controlled conditions. A special feature of the investigations was the use of sub-inoculations of 200 c.cm. of blood from suspected infections into 'fresh' volunteers to determine the presence of a parasitaemia too slight to be recognised microscopically. The findings of this unit need only be briefly summarised here.

Quinine:

P. falciparum infections (malignant tertian malaria). Volunteers taking 10 gr. of quinine daily invariably developed malignant tertian malaria within the usual incubation period when exposed to heavy infection.

P. vivax infections (benign tertian malaria). 5 gr. a day were inadequate to suppress overt symptoms of malaria; 10 gr. daily gave suppression in two-thirds of the volunteers. All developed attacks some time after drug administration ceased.

Sulphadiazine, sulphamerazine, sulphamezathine:

P. falciparum infections. Volunteers taking 0·5 to 1 g. daily were fully protected against heavy infections, suppression being satisfactory and radical cure attained, provided the daily dosage was continued for 3 weeks after the last exposure.

P. vivax infections. 1·0 g. daily failed to suppress heavy infections.

Mepacrine:

(Because of the slow 'build-up' mepacrine was given in all cases for 4 weeks before the patients were exposed to infection. It was also continued for 23 days after the last exposure.)

P. falciparum infections. Volunteers receiving 0·1 g. daily failed to develop overt malaria at any time, although slight rises in temperature and generalised aches and pains were sometimes experienced. Sub-inoculation of 200 c.cm. of blood was positive from the seventh to the ninth day after infection, but never in the later stages after mepacrine administration had ceased. Mepacrine was, therefore, shown to act, not by preventing infection, but by killing young asexual parasites soon after they had gained access to the circulation about the seventh day after infection.

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* A full account of the work of this unit will be found in Volume I, Chapter 7, of the Australian Medical History.

P. vivax infections. 0·1 g. given daily produced suppression as in *falciparum infection*. Sub-inoculations were positive on the ninth day. Overt malaria developed from two to seven weeks after the administration of the drug was stopped.

Mixed infections. 0·1 g. daily gave suppression while the drug was being taken, even when the volunteers were exposed to various severe stresses and strains. After withdrawal of the drug, benign tertian malaria invariably developed, malignant tertian never.

By these experiments incontrovertible proof was obtained that 0·1 g. of mepacrine daily will suppress and cure *P. falciparum infection* (when taken before, during and after exposure to infection as noted) and will suppress *P. vivax infection* until some weeks after the drug is stopped.

Plasmoquine (pamaquin):

This drug was found to have prophylactic properties, but in a dosage too toxic for routine use.

Santochin and resochin (chloroquin: aralen):

These 4-amino-quinoles were synthesised by German chemists before the war and later resynthesised in America. Tested at Cairns, they were found to be schizonticidal in action, did not discolour the skin, and yielded results comparable to atebrin.

Paludrine:

The researches which led to the discovery of this biguanide were carried out during the war and it became available for trial in 1945.

P. falciparum infections. In doses of 100 mg. daily paludrine acted as a causal prophylactic, and sub-inoculation was invariably negative. Later experiments showed that a single dose of 50 to 100 mg. given between the 48th and 120th hour after infection had a similar causal prophylactic action, but given immediately before, or 144 hours after infection, failed to prevent overt malaria. This suggested that two doses of 100 mg. weekly, at intervals of 3 and 4 days, should give adequate cover and act as a causal prophylactic. Extensive field trials are necessary before a decision on this point can be reached.

P. vivax infections. In doses of 100 mg. daily paludrine was reported as giving complete suppression. Sub-inoculation on the 9th day was negative but some time after withdrawal of the drug all cases relapsed.

Paludrine was found to be of very low toxicity and continuous administration, as far as observations went, gave no significant side-effects and no staining of the skin.

Based on the results obtained in these experiments, mepacrine, in doses of 100 mg. daily, was adopted as the standard regimen for malaria suppression where local circumstances rendered such a course necessary. Where discipline was good, results were uniformly satisfactory. In the Australian Force malaria incidence fell to negligible proportions, and hyper-endemic regions were occupied with impunity. Comparable results were obtained in Burma[12] and Italy,[13] the degree of success being parallel to the thoroughness with which administration was supervised. These findings apply to non-immune subjects. Field trials have shown that the premunised natives of endemic areas, such as coolies in tea-gardens and rubber plantations, can be protected by a single weekly dose of the active suppressants, for example 300 mg. of mepacrine.

Some anxiety was naturally felt regarding the side-effects of prolonged mepacrine administration. Yellow staining of the skin was universal but of cosmetic significance only. More serious was the eczematous and pigmentary lichenoid dermatitis which developed in a limited number of cases, particularly in areas of high humidity where there was considerable sweating.(14) In some such cases the use of mepacrine had to be abandoned. Psychotic disturbances, which had been reported as a complication from time to time before the war, proved uncommon and gave no cause for anxiety.

Treatment

In the treatment of malaria no important new principles were discovered, but it is worthy of note that pamaquin, in combination with quinine or atebrin,(15) (16) justified claims which had been made on its behalf as early as 1928 when it was pointed out that this drug (then known as plasmoquine) had a powerful action in reducing the relapse rate in *vivax infection*. Pamaquin is an 8-amino-oxyquinoline and attempts were made in the United States to produce other and better analogues. Two such preparations, pentoquine(17) and isopentoquine, gave results comparable to those given by pamaquin. In terms of activity and toxicity they offered no outstanding advances. Fairley has pointed out since the war, in his Croonian Lectures, that variations in the sensitivity of different strains of the same species of parasite to a given anti-malarial drug illustrate the inadvisability of assuming that because a drug in a certain dosage is effective in one geographical area it will necessarily be equally so in another.

Life Cycle of the Malaria Parasite

Details of the exo-erythrocytic life cycle of *P. praecox* in canaries(18) and *P. gallinaceum* in the chick(19) were fully elucidated during the war years and focused attention on the possibility of a similar phase occurring in the life cycle of the human malarial parasite. Much suggestive circumstantial evidence emerged from the researches at Cairns, and most workers regarded the presence of such a form as being certain. It was not, however, demonstrated at this time.

Laboratory Diagnosis

The staining method devised by Field,(20) (21) and now known by his name, achieved a merited popularity. Thick smears, previously regarded with suspicion by the average technician, were used as a routine with a marked improvement in the ease and speed of laboratory diagnosis.

BLACKWATER FEVER

Cases of blackwater fever were of infrequent occurrence. The low incidence is attributed to the use of mepacrine rather than quinine, especially as a suppressant. In the Australian Forces in the South-Western Pacific, after the introduction of mepacrine suppression, cases of blackwater fever were non-existent despite the fact that the troops fought in highly malarious regions where, under other circumstances, a high incidence might have been anticipated.

Despite much research, the causation of the intense haemolysis which characterises this disease is still controversial.[22] Various theories on the production of auto-haemolysins have been propounded, but none have been substantiated. The mechanism of renal failure has also received attention. It is generally agreed that the primary cause is not, as was once supposed, blockage of the renal tubules: it is suggested that the fundamental cause is renal ischaemia and anoxia.

VISCERAL LEISHMANIASIS (KALA-AZAR)

Transmission

In the inter-war years extensive investigations on the transmission of visceral leishmaniasis were carried out by the Kala-Azar Commission in India. All the evidence pointed to the sandfly as the vector but numerous attempts to obtain final proof by infecting experimental animals (mice and hamsters) or man by the bite of sandflies were consistently unsuccessful, and investigations terminated in 1931. During the war a further series of experiments was carried out,[23] [24] [25] and it was found that if sandflies were given an initial blood feed on an infected subject and thereafter fed, not on blood but on fruit juice (raisins), they became capable after nine days of transmitting the disease to hamsters and mice. Using the same feeding technique, an attempt was made to infect five human volunteers. This was astonishingly successful, all five developing kala-azar. It would appear that this slight modification in the feeding of the sandfly was responsible for rendering its bite infective but no satisfactory explanation is forthcoming why this should be so. In any event, the case against the sandfly seems to have been definitely proved. Investigations into the species of sandflies capable of transmitting kala-azar in the different endemic areas have been pursued and reasonably complete information on this point is now available.

Prevention

Sandflies breed in cracks and crevices in the soil, or in brickwork or other similar places. Attempts to eradicate these breeding places have, in general, been unsuccessful, and attention has been directed to the destruction of the adult insect. D.D.T. in the form of residual spray in huts and dwelling places has been effective in preliminary trials. Its use on a large scale may prove to be an efficient method of dealing with this problem.

Treatment

Some interesting advances have been made in the treatment of kala-azar. It has long been known that the variety which occurs in the Sudan is more severe and more intractable than that found in India or in the Mediterranean areas. The latter two types as a rule yield readily to injections of pentavalent antimonial preparations, such as urea stibamine which is extensively used in India. Sudanese cases treated with antimonial preparations which were available at the beginning of the war either failed to respond or showed a high relapse rate. A new preparation (4-4′-diamidino stilbene or stilbamidine) gave promising results in these resistant cases but unfortunately proved to have unpleasant side-effects.[26] [27] [28] [29] [30] [31] The more serious reactions, some of them fatal, were found to arise from the use of old solutions which had decomposed under the action of light. But even when freshly prepared solutions were used, the majority of cases treated with stilbamidine developed lesions of the fifth cranial nerve, evidenced by patches of anaesthesia and disturbed sensation. These symptoms persisted over long periods of time. Because of these side-effects stilbamidine has, in general, fallen into disfavour. Two other related aromatic amidines, propamidine[32] and pentamidine, have been tried but the results have not been sufficiently good to encourage their use on a large scale. On the other hand, good reports have been made concerning a relatively new pentavalent antimonial compound, sodium stibogluconate, which was first synthesised in Germany.[33] [34] Originally this was prepared as a solution containing 20 mgs. of antimony per c.cm. Later it was found possible to increase the antimony to 100 mgs. per c.cm., in which form it is now generally used. Despite its high metallic content, sodium stibogluconate is relatively non-toxic and, moreover, causes so little local irritation that if necessary it can be given intramuscularly. Good results, both as regards immediate cure and lower relapse rate, have been obtained in Sudanese cases by a course of treatment consisting of 6 daily injections of 6 c.cm. of this preparation given intravenously.[35]

Diagnosis

Smears of bone marrow obtained by sternal puncture have proved useful for the demonstration of the parasite, being safer though probably less often positive than smears from splenic puncture. Diagnosis of Sudanese cases is notoriously difficult and the best results have been obtained by gland puncture.[36] A complement-fixation test first used in South America has been tried in India and has given remarkable results.[37] The antigen employed in the test has no obvious connexion with kala-azar. It was originally prepared from a human tubercle bacillus for the diagnosis of tuberculosis (the so-called Witebsky-Klingenstein-Kuhn antigen). Later, for convenience of preparation, an antigen made in the same way from Kedrowsky's bacillus was used with equal success. Positive results were given in over 90 per cent. of proven cases of kala-azar within four weeks of the onset of symptoms, while only 1 per cent. of false positives occurred in controls. If these findings are fully confirmed, this test should prove of value in the diagnosis of early cases.

CUTANEOUS LEISHMANIASIS

There have been no important advances in the treatment of cutaneous leishmaniasis, but it is worthy of note that Russian workers claim to have found a reservoir of infection in gerbils and certain other small mammals.[38] This is of interest in connexion with the epidemiology of visceral leishmaniasis in Southern Anglo-Egyptian Sudan where certain localities, although practically uninhabited, are reputed to be endemic foci of kala-azar, and were proved to be so when visited by patrols of the Sudanese Defence Force, several of whom became infected. It seems possible that rodents may be the source of infection in these places.

WEST AFRICAN TRYPANOSOMIASIS

At no time during the war did trypanosomiasis constitute a serious menace to the health of the Fighting Forces, but its widespread incidence among native populations, from whom recruits for the Services were drawn, made its control a matter of no small importance. Active measures to achieve this object have been pursued with considerable success.

Mass Treatment

Mass treatment of the infected population maintained its place as one of the best methods of reducing the incidence of sleeping sickness caused by *Trypanosoma gambiense*.[39] [40] [41] [43] In Nigeria a combined course of antrypol (Bayer 205) and tryparsamide, given in sequence or together, was the favoured treatment. More recently, trials have been made of the aromatic amidines as substitutes for antrypol. Of these, pentamidine has been more generally used. It is found to be less toxic than antrypol. No satisfactory substitute for the arsenicals in the treatment of infections involving the central nervous system has been discovered, and tryparsamide, despite its shortcomings, is still widely used.

Drug Prophylaxis

Both antrypol and pentamidine have been used prophylactically. Of the two, the latter appears the better: a single dose is claimed to afford protection for six months.[42] Large numbers of African natives have now been protected in this way with apparent success, and there seems good reason to believe that an efficient and practical method of controlling sleeping sickness has been discovered.

Tsetse-fly Eradication

Permanent control of sleeping sickness can only be achieved by the eradication of the vectors, *Glossina palpalis* and *G. tachinoides*. In the hot season these flies live in shady retreats on or near the banks of streams and, unless the 'micro-climate' provided by shelters of this kind is available, they cannot survive. In large tracts of country the fly population in contact with human beings has been notably reduced by the judicious use of protective or 'rod' clearings at fords and water-points. These clearings must extend 300 to 400 yards on either side, and all trees must be ruthlessly destroyed, although grass need not be cut.(41) (43)

Anchau Corridor Scheme

Mention must be made of the Anchau Corridor Scheme which links two railway lines in Nigeria.(41) (43) Initiated in 1937, this approached completion during the war years. An area approximately 65 miles in length and 600 square miles in extent has been rendered free of tsetse-fly by protective and barrier clearings. Entire villages from highly endemic localities, where anti-fly measures were impracticable, have been transplanted and re-settled in model compounds in this corridor. Adequate standards of sanitation have been enforced and the water supply, methods of agriculture, etc. have received expert attention. As a consequence, sleeping sickness except for cases contracted outside the corridor has disappeared and many other infectious diseases have been markedly reduced, with much improvement in the health and well-being of the villagers.

Selective Clearing of Trees

In the Northern territories of the Gold Coast a novel method of fly eradication has been attempted.(44) It has been found that only certain species of trees and bushes can provide the necessary shade for the flies, and these species have been identified and listed. By starting at the top of a series of tributaries and working down an entire river system, cutting down these particular trees and destroying the stumps by digging them out or burning them, it has been possible with a minimum of expense and deforestation to clear the country permanently of tsetse. In a period of four years the incidence of sleeping sickness in a district of approximately 10,000 square miles was reduced to 2 per cent. of its previous level by this method.

EAST AFRICAN TRYPANOSOMIASIS

East African sleeping sickness caused by *Trypanosoma rhodesiense* and transmitted by *Glossina morsitans*, presents an entirely different problem in which mass treatment and drug prophylaxis play no immediate part. It is closely linked with animal trypanosomiasis, and extensive schemes for its control, which however involve no new principles, are in progress.

In general, the incidence of the *rhodesiense* type of sleeping sickness has not been high.

AMOEBIASIS

In contrast to other tropical diseases there is little progress to report in relation to amoebiasis. In most theatres the intestinal form of this disease occurred in the expected numbers, i.e. somewhere between 5 and 15 per cent. of all cases showing dysenteric symptoms. In such circumstances treatment along the accepted lines gave results comparable to those achieved under peace conditions. On the Burma front a very different state of affairs obtained. Shortly after this theatre was opened cases increased rapidly in number and severity, and a high level was maintained throughout the campaign. In the first quarter of 1945 as much as 36·5 per cent. of all diarrhoeas in one area was caused by amoebic infection.[45] Relapses were of common occurrence, and in fact large numbers of patients relapsed repeatedly in spite of all treatment, and had to be invalided.

Treatment

The unwonted severity of the symptoms was at first attributed to inadequate treatment, as of the essential drugs only emetine hydrochloride was available in unlimited quantities. In time this shortage was remedied and stocks of emetine bismuth iodide, oxyquinolines and arsenical preparations (carbarsone or stovarsol) became available. Various 'blunderbuss' courses of treatment embodying all these drugs were employed and, though results were thereby improved, the situation was far from satisfactory. Intractable cases, invalided from India, remained obstinately resistant to standard treatment even under home conditions. It was observed that the amoebic ulcers were complicated by an advanced degree of secondary bacterial infection. This yielded in a satisfactory way to the administration of penicillin and succinylsulphathiazole and subsequent amoebicidal treatment was successful.[46] Although this line of attack has not proved universally satisfactory, it has opened up a new approach to the problem as a whole by emphasising the fact that the lesions in amoebic dysentery are referable only in part to the entamoeba, and that other concomitant factors, possibly related to the bacterial flora in the intestine, are also concerned in maintaining infection. Despite much research no new amoebicides of importance have been discovered. Emetine remains the only known drug which exercises a potent action on the trophozoites, especially in metastatic lesions in the liver and elsewhere.

BACILLARY DYSENTERY

Bacillary dysentery, like malaria, has in the past been one of the chief causes of wastage in armies living under active service conditions. Thanks to the discovery made during the war that certain of the sulphonamide drugs exercise a specific action on dysentery bacilli it has been possible to avert major outbreaks of this disease and to bring about rapid cure in all cases, however severe, which came under early treatment.

Sulphaguanidine Treatment

During the second half of 1940 troops in Egypt and Palestine increased rapidly in numbers and, as an almost inevitable consequence, conditions favourable for the spread of bacillary dysentery developed (though fortunately the season of maximum incidence was past for the year). A steady stream of cases occurred, the majority of which were mild and self-resolving. There was, however, a far from negligible minority, mainly infections with Shiga's bacillus, which ran a very different course, becoming progressively more severe and, in some cases, going on to a fatal termination. On such cases the standard treatment with salines, together with massive doses of potent antitoxin, had little, if any effect. The general trend of events gave every reason to anticipate the occurrence of outbreaks of severe dysentery of the type only too familiar in the War of 1914–18. Early in 1941 a small supply of sulphaguanidine was received in Cairo and was used for the treatment of certain severe cases of long standing. The results were immediate and dramatic.[47] Within twenty-four hours from the start of treatment a feeling of relief and well-being was experienced, the temperature fell, the abdominal discomfort disappeared, and the stools decreased in number and within a few days became solid and free from blood and mucus; appetite returned and soon the patients began to recover weight. Periodic examinations with the sigmoidoscope revealed a rapid healing of the bowel lesions in keeping with the general improvement in the patients' condition. Further trials showed that with sulphaguanidine treatment results of this kind could be confidently expected in the vast majority of uncomplicated cases,[48] [49] and that cure was correspondingly more rapid when patients were treated at an early stage in the disease. It was some time before supplies of sulphaguanidine sufficient to treat all cases of bacillary dysentery became available. At first its use was restricted to the more severe type of case, but in due course it was administered as a routine in all case of clinical bacillary dysentery and, at a still later date, was given freely even to patients with 'simple' diarrhoea. In the Middle East Force this policy led to the virtual elimination of severe cases of bacillary dysentery. Milder cases continued to occur, particularly in unsalted troops arriving in the Tropics for the first time, but the majority of these infections cleared up in a few days. Elsewhere these findings were confirmed. In the fighting over the Owen Stanley ranges on the Kokoda trail in 1942 a severe dysentery epidemic broke out and gravely jeopardised the operations.[50] All available supplies of sulphaguanidine were rushed forward and administered to all men showing suspicious symptoms. Within ten days the epidemic was controlled and many consider that 'sulphaguanidine saved Moresby'. On the Burma front the incidence of bacillary dysentery in certain units during the Imphal battle, where sulphaguanidine was not available in bulk, was described as 'devastating'.[45] In September, 1944, adequate supplies were received and were freely used. A prompt drop in dysentery cases occurred and during the season of maximum incidence in 1945 the numbers were only one-fifth of those in the corresponding period in 1944.

Sulphaguanidine was chosen for the treatment of bacillary dysentery because when given by mouth it is imperfectly absorbed from the bowel and is found in high concentration in the contents of the large intestine. It was thought that because of this property it might exercise a direct local action on the dysentery bacilli in the bowel wall. Subsequent trials showed that certain of the more readily absorbed sulphonamides were almost equally efficacious in relieving symptoms and in fact sulphadiazine has been adopted by the U.S. Medical Corps as the standard treatment for bacillary dysentery. In the British Army, however, sulphaguanidine remained the drug of choice because of its low toxicity and because of the negligible danger of renal blockage, which is particularly apt to complicate sulphonamide treatment in hot countries where dehydration is common and fluid excretion limited.

Antitoxin Treatment of Shiga Infections

In the period before sulphaguanidine was introduced an opportunity arose to test the value of a highly potent Shiga antitoxin.[47] It was found that when this was given in massive doses a noticeable reduction in toxaemia resulted, which lasted about twenty-four hours. In early cases of a severe type it appeared that this sometimes tipped the balance in favour of the patient and enabled his natural defence mechanism to overcome the infection. In advanced cases no such permanent result ensued. As the effect of the antitoxin weakened, symptoms returned to their previous severity and the disease pursued its inexorable course. In combination with sulphaguanidine treatment, antitoxin was of value in the acute case coming under treatment at a late stage. Alone, it was of disappointingly limited value.

Laboratory Diagnosis

The introduction of desoxycholate medium for the isolation of the dysentery bacillus added appreciably to the number of positive results. This medium proved of much value in isolating the organism in the later stages of the disease and, particularly, in convalescence. As a consequence, the detection of carriers has been greatly facilitated.

Bacteriology

Throughout all the theatres of war the dysentery bacilli which were isolated and identified belonged, with few exceptions, to one or other of the recognised types.[51] A few new types of minor importance were however found, of which the only one of numerical significance was the mannitol-fermenting strain which was named *Shigella etousa*.

PLAGUE

Apart from a few trivial outbreaks, cases of plague did not occur in significant numbers in the Allied Armies. The disease was, however, endemic in India and this afforded an opportunity to evaluate sulphonamide therapy. It was found that the mortality rate was appreciably lowered by treatment with sulphathiazole, sulphadiazine and sulphamerazine,[52] [53] and this effect was increased when these drugs were given in combination with antiserum. At a more recent date streptomycin has proved even more successful in lowering the death rate. Unfortunately, both antiserum and streptomycin are at present too costly for mass treatment.

Evidence has accumulated which suggests that a vaccine of living non-virulent organisms gives better protection than a killed vaccine.[54] This has the further advantage of exerting its full effect in one dose. Unfortunately, the keeping properties of a living vaccine are limited and for this reason it is not well suited to the needs of active service.

In the prevention of plague the value of D.D.T. in killing the flea-vector has been explored with results that are distinctly encouraging.

CHOLERA

Cholera did not appear in epidemic form in the fighting forces during the war. Outbreaks were, however, reported in prisoner-of-war camps in Thailand;[55] and in India the incidence among the civil population reached epidemic level from time to time.

A number of relatively small-scale experiments were made with sulphonamide therapy (mainly sulphaguanidine) and the results were consistently favourable, there being a significant reduction in case mortality.[56] [57] [58] No large-scale field trials were made and the value of this method of treatment cannot be finally assessed until the information which such trials would afford is forthcoming.

RELAPSING FEVER

Several severe outbreaks of louse-borne relapsing fever occurred in native communities in Africa,[59] but the armies were never seriously affected. On the other hand, scattered cases of the tick-borne variety appeared from time to time among troops stationed in the endemic areas, particularly throughout Middle East Force from Syria to Tripolitania.[60]

In Tobruk[61] and Cyprus[62] infection was traced in a number of cases to bites received while sleeping in a cave, and elsewhere the sporadic nature of the disease suggested that infection of man was accidental and that the reservoir of infection was probably in some small mammal. Attempts to locate the reservoir host were however unsuccessful.

Both vectors—the louse and the tick—are killed by D.D.T., and outbreaks of louse-borne relapsing fever have been rapidly controlled by dusting the populace at risk with 5 per cent. D.D.T.[59] It has been shown that D.D.T. spray kills ticks,[63] but under 'jungle' conditions its use for the prevention of relapsing fever is impracticable.

Louse-borne relapsing fever yields to treatment with organic arsenicals. No remedy was discovered for the more intractable and sinister tick-borne disease, although attempts were made to find one. It has been claimed that in experimental animal infection large doses of penicillin in the early stages prevent involvement of the central nervous system and thus the development of nerve lesions, but others consider there is no evidence of such curative action.[64] [65] [66]

The problem of preventing and curing tick-borne relapsing fever is still largely unsolved.

SCRUB TYPHUS

Scrub typhus, an acute fever caused by infection with *Rickettsia tsutsugamushi*, is conveyed by the bite of larval mites which feed predominantly on wild rodents, particularly rats. Under peace conditions the disease is uncommon, as human beings rarely intrude into the mite-rat domain. In jungle warfare the case is very different and men are freely exposed to the infected mites. This occurred both on the Burma front, where in the June–December period of 1944 there were in the 14th Army some 4,000 cases of scrub typhus with a 10 per cent. mortality,[69] and in the South-West Pacific where until suitable preventive measures were adopted there was a steady increase in incidence reaching its peak in the last quarter of 1943, when 859 cases were admitted to hospital.[68]

Scheme of Investigation

These heavy casualties drew attention to the importance of scrub typhus, and investigations designed to find methods of prevention and treatment were undertaken by the G.H.Q. (India) Field Typhus Research Team and the Medical Research Council Typhus Team in the British sector of the Burma theatre, while a team of fourteen workers from the U.S.A. Typhus Commission worked with the American Army on their portion of this front; in New Guinea the problem was investigated by the A.A.M.C. The problems to be studied were the exact identity of the disease (for this was at first uncertain) and its distribution, the bionomics of the vector or vectors responsible for its spread, and the importance of rats and other small mammals as reservoirs of infection. As a result of the work of the teams the identity of the disease was firmly established as scrub typhus, and strains of *R. tsutsugamushi* were recovered from a number of areas. The reasons for the patchy distribution of foci of infection were elucidated and the information thus gained was used in making surveys and in giving advice about potentially dangerous spots. The vector was found to be *Trombicula deliensis*, and the bionomics of this mite, with special reference to the infection of man, were worked out in detail. It was concluded that scrub typhus may be broadly regarded as a 'man-made' disease arising from the intrusion of man into the jungle and from primitive cultivation which upsets the normal balance of Nature. A system of surveys comparable to that used in malaria prevention was evolved, and various methods of prevention were studied. Strains of *Rickettsia* were isolated from several species of small mammals, chiefly from species of rats, but also from the bandicoot, the tree-shrew, and the field mouse.

Methods of Prevention of Scrub Typhus

(1) *Destruction of rats and other small mammals.* This method was found to be quite impracticable under jungle conditions.

(2) *Avoidance of mites.* Three types of terrain were shown to be particularly favoured by mites. These are abandoned clearings or domestic waste-land, water-meadows and the grassy banks of rivers and streams and the verge of forests or coppices where trees end and scrub begins. By avoiding such places the risk of being bitten by mites can be reduced. Much can also be done by clearing and drying out the sites of camps, by constructing paths, and by sleeping in hammocks instead of on the ground.

(3) *Use of repellents.* The use of repellents was explored principally by the Australian workers, and provided a practical solution to the problem.[68] [69] Dibutyl phthalate proved highly efficient and was applied to clothing by rubbing in with the hand (a simple method which experiments had shown to be preferable to spraying or steeping and which was carried out by the soldier himself). Clothing treated in this way repelled mites even after it had been washed six or seven times—in practice the clothing was re-impregnated once a fortnight—and men clad in it escaped being bitten. By this method alone the incidence in the Australian Force in New Guinea was reduced from 859 in the quarter ending December 31, 1943, to 13 in the three months ending December 1, 1944, an achievement of great interest and importance.

(4) *Vaccine.* The promising results claimed from the use of a rickettsial vaccine in epidemic typhus encouraged efforts to make a similar vaccine for scrub typhus. It was found impossible to culture *R. tsutsugamushi* in the developing egg, but ultimately it was found that a rich concentration of rickettsia was present in the lung tissue of infected cotton rats, and that this could be used for vaccine production. Preliminary tests in mice showed that this vaccine possessed protective properties and a large-scale project (known as Special Operational

Store-Tyburn) was quickly organised in the early months of 1945 to produce bulk quantities of the vaccine.[70] [71] In all, 300 litres had been prepared when production was stopped on October 31, 1945, by which time, as the Japanese war had come to an end, the need for vaccine no longer existed. From the scientific point of view, it is a misfortune that vaccine did not become freely available until the cessation of hostilities. In the absence of the conditions associated with jungle fighting, both the incidence and mortality of scrub typhus fell to such an extent that it was impossible to stage a properly controlled experiment to determine the value of the vaccine. Selected formations were however inoculated,[72] [73] and an analysis of figures, admittedly open to criticism, showed an incidence of 1·8 per 1,000 per annum among 15,000 fully protected troops, while the incidence in unprotected troops over the same period was 3·1, a difference which is statistically not significant. Only 9 cases were reported in fully protected men, and 24 in partially protected men. The available evidence suggests that the vaccine has no marked effect on the clinical course of the disease but it is impossible to draw definite conclusions. It will always be a matter for regret that this boldly conceived experiment yielded no decisive results, either positive or negative.

DENGUE AND SANDFLY FEVER

Research on dengue and sandfly fever by a team of American workers led to the isolation of only dengue viruses in the South-West Pacific area and only sandfly viruses in the Mediterrenean area. There were at least three distinct but related immunological types of dengue virus and two of sandfly fever.[74]

Dengue

Cases of dengue occurred in considerable numbers among Australian troops in New Guinea living in jungle or cocoanut groves far removed from native villages. The recognised vectors, *Aedes aegypti* and *A. albopictus* were not to be found in these regions, and careful search showed that *A. scutellaris* was responsible.[75] By studying the habits of this mosquito and attacking its breeding places and at the same time taking steps to protect troops, and particularly those suffering from dengue, from its bite by repellents and nets, the incidence of the disease was kept under control.[76] Although the virus of dengue can be cultured on the chorio-allantoic membrane of the developing chick, this is generally found unsatisfactory ; nevertheless it is worthy of note that the Japanese claim to have produced a vaccine in this way which conferred a considerable degree of protection. It was, however, found possible to propagate the virus in mouse brain, and after a number of passages the virus lost its capacity to produce any significant symptoms other than the rash in man, and could be used to prepare a satisfactory vaccine.[74] These researches were initiated but not completed during the war.

Sandfly Fever

Sandfly fever was of relatively common occurrence among troops in the Mediterranean area. Observations made on the duration of natural immunity after an attack showed that this may last only a few months and that the same person may suffer from two or even three attacks in the same season, though in contrast to this it was noted that the residents of an endemic area may enjoy a high degree of immunity.[77] [78] No successful vaccine has been developed. It has already been noted that it is not practicable to eliminate sandfly breeding places. In Malta a 'residual' spray of D.D.T. has been used with success for the destruction of the adult fly, and dimethyl phthalate has given good results as a repellant.[80] By these means better control of infection has been achieved.

YELLOW FEVER

The yellow fever belt in Africa spans the continent from west to east and extends a varying distance north and south of the Equator.[81] Cases are relatively common in West Coast colonies but are much rarer and more sporadic elsewhere in the belt. Large-scale outbreaks are exceptional but in 1940 an epidemic, in which there were some 15,000 cases with 1,600 deaths, occurred in the Nuba mountains in Anglo-Egyptian Sudan.[82] The possibility of further explosive outbreaks elsewhere was a matter of considerable anxiety during the war years. Two problems claimed considerable attention: the prevention of the spread of the disease beyond the boundaries of the existing endemic area, and the epidemiology of sporadic cases occurring without any obvious connexion with a known source of infection.

Prevention of Spread

As the vector of urban yellow fever (*Aedes aegypti*) is a common domestic mosquito throughout most tropical and sub-tropical countries, there is grave danger of an outbreak of this disease if either infected mosquitoes or infected human beings are brought into a 'clean' locality. This risk has of recent years been greatly intensified by the expansion of air traffic, which not only affords rapid transport for infected mosquitoes but also makes it possible for an unsuspected human case to travel far from the endemic area while in the incubation stage of the disease. That no such spread has taken place is a tribute to the efficiency of the methods used to prevent it. These comprised anti-mosquito measures in airfields and aeroplanes, and the inoculation with yellow fever vaccine of intending passengers from or through the endemic zone, carried out sufficiently in advance of the journey to avoid all chance of the subsequent development of the disease. For those not so protected, rigorous quarantine measures were enforced. The success of inoculation against yellow fever was attributable largely to the special properties of the pantropic attenuated virus 17D, developed shortly before the war, which was universally adopted for vaccine production.[83] This virus is non-virulent, circulates in the blood to such a limited extent that it is non-infective to mosquitoes (an important matter when inoculations are being carried out in places where *Aedes aegypti* occur), yet stimulates antibody production. Experience during the war has shown that immunity resulting from inoculation lasts at least 4 years.[81] The virus grows well in the developing chick embryo, and mass production of vaccine was successfully undertaken. Human serum was used in the manufacture of earlier batches of vaccine but was later omitted when it was shown to be responsible for outbreaks of haematogenous jaundice which occurred in both British[84] and U.S.A.[85] Forces. The vaccine was used not only for the protection of travellers but also for immunisation of the population of endemic areas and of troops stationed there, with results which were highly satisfactory.

Epidemiology

The discovery of antibodies to yellow fever virus (detected by the mouse-protection test) in the serum of a not inconsiderable percentage of the inhabitants of certain regions in Africa where clinical yellow fever, if not actually unknown, is extremely rare, suggested the existence of a jungle type of yellow fever corresponding to that found in South America.[86] [87] [88] Further investigation in Uganda showed that these positive results occurred chiefly in tribes living on the verge of the Bwamba forest, and that similar evidence of previous infection was present in various species of monkeys which inhabited the forest, including an arboreal species which never left the tree-tops. An arboreal mosquito, *Aedes africanus*, was shown to be a potential vector and is believed to carry the infection from monkey to monkey; *Aedes simpsoni*, a domestic species found in the villages, was also proved to be a carrier of the virus. It therefore seems probable that monkeys constitute the reservoir of infection and that the virus is passed on to man by one or other of these mosquitoes. These human infections, which are shown by the age distribution of positive immunity tests to occur chiefly in younger people, may be predominantly mild, but too little is known of the events in native villages to assert this with certainty. Investigations designed to substantiate these ideas are still in progress. The conception that African yellow fever is primarily a disease of monkeys and that sporadic cases and outbreaks in human beings are fortuitous infections from this reservoir is in conformity with the known facts of the epidemiology of the disease, and is of great interest and importance. It indicates, but does not solve, the problems which are involved in the prevention of yellow fever in man.

SCHISTOSOMIASIS

While there are no advances of importance to record either in the prevention or cure of schistosomiasis it is worthy of note that, by the application of simple precautionary measures based on knowledge gained during the War of 1914–18, there was no repetition of the outbreak which then occurred in Egypt, although large numbers of troops were stationed in this hyperendemic area.

In treatment, trivalent antimonials, despite the unpleasant side-effects which they evoke, remained the treatment of choice. An intensive course of sodium antimonyl tartrate lasting over two days, first used in Rhodesia,[89] has given good results there, but elsewhere has been criticised because of its toxicity.

In the Eastern theatre, Australian troops operated in areas where infection with *Schistosoma japonica* was endemic, and a number of cases, some of considerable severity, occurred. Difficulty was experienced in establishing the diagnosis by finding the eggs in the stools, especially in the acute phase of the disease. Sedimentation methods proved useful but the best results were obtained from the examination of scrapings taken through the proctoscope from small yellow nodules which occur in the mucosa.[90] Complement-fixation tests, using as antigen an alcoholic extract of the livers of *Planorbis* snails infected with *S. spindole*, proved very useful in the detection of persistent infections.[91]

FILARIASIS

Filariasis (caused by infection with *Wuchereria bancrofti*) became an important problem to United States troops stationed in the Pacific Islands, but caused little concern to British and Commonwealth troops who were outside the endemic area. American workers[92] have shown that certain antimonial drugs, particularly neostibosan, have a lethal action on the adult worm. The microfilariae circulating in the bloodstream are not affected by the drug, and slowly die off during the nine months following treatment. This observation has, however, been overshadowed by the post-war discovery of a piperazine product, known as 'Hetrazan', which appears to be highly specific for these worms, and also for *Onchocerca volvulus*.

SPRUE

Sprue was of common occurrence in the Burma campaign from 1943 to 1945 when over 3,000 cases occurred.[93] Many of these were relatively mild and at first there was some doubt as to whether or not they should be classified as sprue. Cases of this type in Indian troops were designated para-sprue.[94] As experience increased it was found that these milder cases were fundamentally similar to the more typical severe cases and could not be differentiated from them. The fact that over 1,000 men were invalided on account of sprue by the Standing Medical Board in Poona indicates that the more severe cases were by no means uncommon.[95]

Long residence in unfavourable surroundings was not an essential part of the aetiology, as some cases developed in troops recently arrived in India and occurred in men eating full rations and living in a relatively innocuous climate.[96] Sprue was found to have a well-marked seasonal incidence, the peak occurring in June, i.e. at or about the break of the monsoon.[97] This precedes the peak of the dysentery curve by about two months and suggests that sprue is not directly related to a previous attack of dysentery. In individual cases however an attack of dysentery occasionally unmasked pre-existing sprue. A number of cases having other characteristic symptoms did not show typical sprue stools. In general, however, an excessive fat content in the stool, together with a high ratio of split to unsplit fats, was a constant feature.

Biochemical examination of the blood of sprue patients after a standard meal revealed a flat curve of fats and sugar, indicating slow absorption.[98] [99] [100] Both glucose and fatty acids are believed to undergo phosphorylation prior to absorption, and evidence has been adduced to show that the slow absorption is due to defective phosphorylation. This suggestion was supported by the observation that the blood-glucose curve could be restored to normal by the administration of phosphate.[101] Unsplit fats and fructose are absorbed without phosphorylation and it was found that in sprue cases the chylomicron count (which reveals particles of unsplit fat) gave irregular results while the fructose curve was normal. It was also shown that in some cases there was a defective absorption of salt,[102] resulting in a low serum-sodium and serum-chloride level, and a subnormal absorption of vitamins.[103] The macrocytic anaemia which was common in late cases had already been shown to arise from a lack of the haemopoietic factor, and low absorption of calcium was also a well-recognised feature of the disease.

These observations led to the formulation of the theory that sprue was caused by a breakdown of the enzymic systems concerned in phosphorylation and that this breakdown was attributable to lack of co-enzymes which embodies some member or members (identified or unidentified) of the vitamin-B_2 complex.[104] It was further suggested that the vitamin shortage was not necessarily caused by low intake, but arose from defective biosynthesis attributable to change in the intestinal flora. This hypothesis has not yet been confirmed by experimental methods.

In treatment, a carefully regulated diet played an important part. One rich in protein and relatively poor in carbohydrates and fat proved most satisfactory. Treatment with pure vitamins such as nicotinic acid and riboflavin was disappointing and it was found that crude liver extract was more effective.[105] [106] When given parenterally this produced improvement of the blood symptoms and cleared up the lesions in the mouth and tongue. The intestinal symptoms (diarrhoea and absorption of fat, etc.) were however more slowly influenced but, with suitable diet and nursing, gradual improvement occurred. Yeast extract in large doses is claimed to exercise a favourable effect on fat absorption. Folic acid, which was not available until after the war, acted in much the same way as liver extract but was slower in influencing the bowel symptoms and, in general, was less effective in chronic cases.[107] It had no action in arresting nervous symptoms when these had developed.

TROPICAL MACROCYTIC ANAEMIA

Among Indian troops many cases occurred which had symptoms resembling the nutritional macrocytic anaemia of pregnancy seen in under-nourished Indian women. This condition was much more common in troops with vegetarian habits who, under active service conditions, were unable to get the milk and other protective foods they normally consumed in their own homes.[108] The clinical features of these cases had much in common with the so-called 'para-sprue' syndrome, and, in general, yielded to the same form of treatment. The aetiology of these forms of anaemia remains obscure. A relationship to chronic malarial infection and a deficient food intake has been observed.[109]

DEFICIENCY DISEASES

Although deficiency diseases were relatively uncommon they assumed importance among troops on the Burma front where from time to time difficulty was experienced in supplying the authorised rations. They also occurred among prisoners-of-war, particularly those captured by the Japanese. In some cases the deficiency arose from the prejudices—religious or other—of native troops who refused to eat certain items included in the ration scale, and so upset the balance of their diet.

Scurvy was practically unknown and, when circumstances required it, ascorbic acid tablets were used to supplement diets poor in vitamin-C. Vitamin-A deficiencies were also rare. It was found that red palm oil was a useful source of fat-soluble vitamins and on occasion this was given with satisfactory results.[110]

The majority of deficiency diseases were the outcome of a low intake of the various components of the vitamin-B series. Advances in modern knowledge of these vitamins gave rise to the hope that it might be possible to label accurately each type of vitamin-B deficiency and to cure it by administering the appropriate vitamin. Such hopes were soon dispelled, partly because it became obvious that in most cases multiple deficiencies occurred simultaneously, partly because certain symptoms yielded to none of the purified vitamins, thus suggesting the existence of further hitherto unrecognised components of the complex, and partly because it was found that cure could rarely be achieved unless the quality of the diet (mainly in terms of protein) was raised to satisfactory standards. In other words, the best treatment was to provide an adequate ration of fresh 'protective foods' with a generous proportion of first-class protein. As a supplementary measure the administration of yeast or yeast extract (Marmite), containing all the known and also presumably the unknown factors, proved in most cases (but not all) better than the administration of selected pure vitamins. In cases where nervous changes were present it was found important to start treatment as soon as possible, for the more advanced lesions often proved to be irreversible.

Despite this generalisation, many interesting observations relating to individual components of the complex were made.

In East Africa cases of classical beriberi occurred from time to time among native troops. Although these cases improved when treated with vitamin-B_1 (thiamin), cure was more rapid when both thiamin and yeast were given together, thus suggesting a deficiency of some other factor additional to vitamin B_1.[111] An unusual condition, cerebral beriberi or Wernicke's encephalopathy, was observed in prisoners-of-war in Singapore.[112] Symptoms were characteristic, leading up to amnesia, disorientation, and semi-coma. Response to injections of thiamin was rapid and seemed, with other more circumstantial evidence, to link this condition to vitamin-B_1 deficiency. It seemed possible that the condition was produced by a severe acute deficiency, while the usual symptoms of beriberi were related to a more gradual vitamin starvation.

In contrast to cerebral beriberi, 'spastic syndrome' occurred in prisoners-of-war in the Far East, associated with vitamin-B_2 deficiency.[113] The spastic changes chiefly affected the lower limbs and in some cases resulted in a paralysis so severe as to render the patients permanently bedridden. Mental changes were present, characterised by dullness and loss of emotional control, going on in some cases to coma. Muco-cutaneous lesions suggestive of hypo-riboflavinosis were present in about one-third of the cases and another one-third had the 'burning feet' syndrome, to be mentioned later. The course of the illness was not influenced by thiamin or nicotinamide. It has been pointed out that the syndrome bears a close resemblance to lathyrism. In this connexion it is of interest to note that the controversy regarding the aetiology of pellagra is not yet finally settled.[114] It is maintained that the symptoms which develop in maize-eating communities differ from those found in other circumstances, and certain observers consider that maize contains a toxic 'pellagragenic' substance.

The 'burning feet' syndrome was common and distressing.[115] [116] [117] Characteristic features were 'pins and needles' sensations and a dull ache or, on occasion, an excruciating burning pain starting commonly in the ball of the great toe and spreading over the sole of the foot. The pain was worse at night and caused loss of sleep. In most patients signs of riboflavin deficiency were present but, while treatment with riboflavin cleared up these signs, it made no improvement in the 'burning feet'. Thiamin and nicotinic acid were equally ineffective but it was claimed that rapid improvement and cure followed the intramuscular injection of calcium pantothenate.

Nutritional Oedema

This condition, which was common in undernourished prisoners-of-war, was caused by a low concentration of serum proteins, directly attributable to starvation. Typical cases were quite distinct from 'wet' beriberi, but in many intermediate cases both starvation and vitamin deficiency existed side by side, so that an overlap of symptoms occurred.

SICKLE-CELL ANAEMIA

The sickle-cell trait is found in Negroes or their descendants, and occurred among African troops. The condition is inherited as a Mendelian dominant[(118)] and can be recognised by making a sealed preparation of citrated blood and examining after twenty-four to forty-eight hours, when many of the red cells will be found to have lost their round shape and their elasticity, and to have become irregular—often sickle-shaped—and rigid. The sickling is brought on by anoxia, and can be reversed by oxygenation of the blood. Those having this trait are subject to haemolytic crises, which may develop either (apparently) spontaneously, or as the result of some unusual stress such as an acute infection.

Research in West Africa was concerned mainly with the causation of the phenomenon and the methods of demonstrating its presence, but did nothing towards its cure, although the importance of diagnosis and the avoidance of crises was stressed. Its relative frequency may be gauged from one investigation in which the trait was found in 12·4 per cent. of African soldiers, and crises occurred in about 0·6 per cent. of those affected.[(119)]

CONCLUSION

This review is not claimed to be complete. It has been confined to those aspects of tropical medicine deemed to be most important, and a number of subjects which would have been included in a more lengthy paper have been omitted, some because of their relative insignificance, others because our knowledge concerning them has made no appreciable advance. Further and fuller details concerning many matters briefly touched on here will be found in the Australian and Indian medical war histories and in that of the U.S.A.

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CHAPTER VIII

THE TYPHUS FEVERS

By C. H. ANDREWES
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LOUSE-BORNE typhus, which might well have proved one of the most killing diseases in the War of 1939–45, provided in fact one of the greatest recent triumphs of preventive medicine. Work in the years preceding the war (Barykine, 1938; Cox, 1938) led to the development of a valuable immunising agent against the disease. Even more important were discoveries of the insecticidal powers of D.D.T. and other substances, proper application of which could keep lice under control. On the other hand, mite-borne scrub typhus or tsutsugamushi disease proved an unexpected menace in jungle fighting in New Guinea, Burma and elsewhere and was not readily kept at bay.

At first, work on typhus was carried out independently in several laboratories. In November, 1943, at the request of the War Office, the Medical Research Council appointed a Typhus Research Committee, of which Major-General L. T. Poole, then Director of Pathology, Army Medical Services, was chairman. One of this committee's chief duties was to co-ordinate the research already in progress at the National Institute for Medical Research with that sponsored by the Army, and to secure close liaison with workers in the United States and the Dominions; at the time of its appointment, research on typhus was hampered by the conditions of secrecy imposed on such work. The committee attempted, therefore, both by personal contact and by the circulation of memoranda, to ensure that cognate unpublished material reached the interested investigators among the Allied nations as quickly as possible. At first the committee was wholly concerned with louse-borne typhus. Work on vaccines for this disease, and on the new delousing powders, was in an advanced stage of development, and the Typhus Research Team was already established in North Africa. In December, 1943, the work of the committee was greatly extended, following an urgent request from South-East Asia Command for help in combating serious outbreaks of scrub typhus that had appeared among the Allied troops in Burma.

Work in Britain, as in other countries, led to the occurrence of laboratory infections with flea-borne (Van den Ende *et al.*, 1943) and with mite-borne (Van den Ende *et al.*, 1946) typhus, chiefly through inhalation of infected particles when rodents were being inoculated intranasally. A specially designed inoculation box (Van den Ende, 1943) was effective in preventing laboratory infections by the aerial route and a modification of it was of great value in subsequent large-scale manufacture of scrub typhus vaccine (Buckland *et al.*, 1945).

INFECTION WITH RICKETTSIA PROWAZEKI (LOUSE-BORNE OR EPIDEMIC TYPHUS)

Attention will be devoted here mainly to four aspects of typhus:—vaccine production and testing, serology and antigenic structure of rickettsiae, chemotherapy, and insecticides; these were subjects more particularly studied in Great Britain.

(*i*) *Typhus Vaccines*

Cox (1938) was able to cultivate rickettsiae in the yolk-sac of developing eggs in large numbers; these (Cox and Bell, 1940) could be killed with formaldehyde and proved an excellent material for making a vaccine. The Cox vaccine was further improved by Craigie in Toronto, who treated impure suspensions of rickettsiae by shaking with ethyl ether and recovering the organisms from the aqueous fraction (Craigie, 1945). Development and large-scale manufacture of these vaccines was carried on in the United States and in the Dominions, especially Canada; shortage of eggs in Britain was a compelling reason for not making the vaccines over here.

In 1939 Castaneda, and in 1940 Durand and Sparrow, showed that murine typhus would multiply enormously in the lungs of mice; later, *R. prowazeki* was grown in the same way. Giroud and Panthier (1942) were able to cultivate rickettsiae similarly in the lungs of rabbits whose resistance was lowered by chilling. In France and elsewhere on the Continent, rickettsiae thus obtained, rather than those cultivated in egg-yolks, were used in making vaccines. Several vaccines (Blanc, 1939–40; Laigret, and Durand, 1939) made from living attenuated murine strains were used in North Africa but were not generally deemed satisfactory.

In Britain, laboratory studies in relation to vaccination were carried out at the National Institute for Medical Research, Hampstead, and at the R.A.M.C. emergency vaccine laboratory at Tidworth and later at Everleigh, Wilts. Immunological tests—agglutination, complement-fixation and neutralisation—indicated that strains of epidemic typhus were antigenically indistinguishable, whether coming from Poland, Russia, Iran, Irak, Egypt, North Africa, Italy, Syria or Palestine. This fact indicated that one type of vaccine should protect against the disease anywhere in the world (Stuart-Harris *et al.*, 1946).

Many methods had been used for comparing and evaluating typhus vaccines. Studies in Germany (Gildemeister and Haagen, 1940; Otto and Bickhardt, 1941) showed that living rickettsiae injected intraperitoneally into mice had an acute lethal effect, simulating the effect of a toxin. Bengtson, Topping and Henderson (1945) found intravenous injection to work even better. An 'antitoxic' property in sera of immunised mice could thus be assessed; so could their active immunity against intravenous inoculation of living rickettsiae. Another method of study was based on the finding that mice inoculated intranasally with dilute rickettsial suspensions would develop in their lungs discrete grey spots whose numbers were sufficiently reproducible for accurate quantitative work (spot-count technique). Immune sera reduced the numbers of these spots, and a neutralisation test was thus available (Van den Ende and Mills, 1946); the results it gave were not always identical with those obtained by agglutination. Fulton *et al.* (1946), used these recently devised tests side by side with the older ones of active immunisation of guinea-pigs, rickettsial agglutination, complement fixation and agglutination of Proteus OX 19 in an endeavour to compare different vaccines. Fulton and Begg (1946) had described a method of purifying by the aid of kieselguhr rickettsiae contained in mouse-lung suspensions. The potency of vaccines made by this and other methods was found to depend wholly on their rickettsial content and not on any 'soluble antigen'.

(*ii*) *Studies of Antigenic Structure*

Earlier work had shown that the agents of louse-borne typhus (*R. prowazeki*) and of flea-borne or murine typhus *R. typhi* (= *mooseri*) were antigenically related but not identical. Suspensions from infected rodent lungs had previously been used for agglutination tests (Castaneda, 1939; Hudson, 1940). Fulton and Begg's (1946) purified suspensions of rickettsiae were used for antigenic comparison of epidemic and murine strains. They showed that the surface antigen of either organism gave rise to a heterogeneous group of antibodies, some of which reacted with the heterologous strain. Boiled suspensions acquired a new serological specificity, which was the same for the two strains. The OX 19 antibody was found to be distinct from those reacting with the undegraded surface antigens, but to correspond to a fraction of the antibody reacting with boiled rickettsiae. The soluble antigen separated from rickettsiae by ether extraction behaved like a partly degraded constituent of surface antigen. The results were similar to those described by Craigie *et al.* (1946) and Shepard (1945).

Such serological studies had an important practical application in epidemiology. It became possible, by *in vitro* laboratory tests, to decide with some confidence, even in vaccinated people, whether an infection was due to the louse-borne or flea-borne rickettsiae (Stuart-Harris *et al.*, 1943; van Rooyen, and Bearcroft, 1943). Similar results were reported from the United States of America (Plotz, 1943).

(*iii*) *Chemotherapy*

Prior to the war, no drug with specific activity against rickettsiae was known. At the National Institute for Medical Research such a compound was intensively sought. The spot-count method was used as the basis;

mice were infected intranasally with typhus, and injected with test drugs over a period of several days; reduction seen in the spot-count when they were killed a week later was used as an index of the efficacy of the compound. Seventy compounds of various types, from commercial and other sources, were tested without the detection of any activity. Then, in November, 1942, two compounds—*p*-sulphonamido-benzamidine (V 147) and the corresponding amidoxime (V 186)—were found to have very considerable potency against the rickettsial infection in mice (Andrewes *et al.*, 1944). The toxicity of the active drugs for animals and man was examined, and it was felt that the results were sufficiently encouraging to call for a field trial in human cases of typhus fever. A joint team, under the auspices of the Army and the Medical Research Council went to Algiers for this purpose; their activities were transferred to Naples when typhus broke out there in December, 1943. The drugs, particularly V 186, were given to civilian cases in hospital; of alternate patients admitted with typhus, one received the drug, the next being given orthodox supporting treatment only. Unfortunately, no benefit from the drug treatment was noted, one adverse factor being the difficulty in obtaining cases for treatment within the first few days of the onset of the disease. The detailed clinical, haematological and biochemical studies of typhus made during these trials form a valuable record and were published together with data on serological and histological material subsequently examined (Van den Ende *et al.*, 1946). An attempt was made to exploit by chemical studies the observation of the anti-rickettsial activity of V 147 and V 186 (Andrewes, King, and Walker, 1946); in the course of a long programme of synthetic work it was found that, unlike the antibacterial activity of the familiar sulphonamides, the anti-rickettsial activity in this series was highly specific, being completely abolished, for instance, by substitution of the hydrogen atoms of the sulphonamide group to form analogues of sulphapyridine and sulphathiazole. Activity was also largely or completely destroyed by interposition of a methylene group between the benzene ring and the sulphonamide or amidine groups. The only compound found to have activity equal to that of the original sulphonamidobenzamidine was the corresponding amidoxime.

(*iv*) *Insecticides*

Rickettsia prowazeki cannot cause trouble, if lice are controlled. The relative rarity of trouble from typhus fever can be ascribed to progress in the field of insecticides (Buxton, 1946). Early work in Britain dealt largely with 'lethane' (preparations of thiocyanates). A lethane body-belt proved effective in keeping its wearers free from lice and was extensively tried on native labour in the Eastern Mediterranean as well as in the Army. A powder insecticide, A.L.63, containing derris and naphthalene, was evolved in 1940 and was effective until superseded by D.D.T.

The United States Army used an insecticidal powder, MYL, which contained pyrethrum.

In December, 1942, the Swiss firm Geigy, A. G. brought the possibilities of D.D.T. (dichlor-diphenyl-trichlorethane) to the notice of entomologists in Britain and America. D.D.T. had been first synthesised by Zeidler in 1874, but not until 1940 had its insecticidal properties been appreciated; since then it had been used in Switzerland on a limited scale against agricultural insect pests, house flies, etc. In Britain, the claims made for D.D.T. for use against lice were examined and it was found to be clearly superior to any other known insecticide in this respect; its chemical stability and very low volatility, together with its relative safety to man, were a unique combination of desirable qualities. American workers independently reached the same conclusions with regard to D.D.T., and its large-scale production was agreed upon. One important advantage of D.D.T. over 'lethane' was that it is not readily washed out of impregnated garments. The part subsequently played by D.D.T. in checking the Naples typhus epidemic is now well known (Wheeler, 1946). It was used as a 10 per cent. dust and this could be blown up the arms, down the neck and up the trousers or skirt without undressing the infested person. The American typhus commission thus treated up to 70,000 people in a day. The usefulness of the A.L.63 and MYL powders before D.D.T. was generally available in Naples must not be overlooked (Crauford-Benson, 1946). By the aid of garments impregnated with D.D.T. the troops engaged in the fighting on the Continent after D-day were kept virtually free of lice.

INFECTION WITH RICKETTSIA TSUTSUGAMUSHI (MITE-BORNE OR SCRUB TYPHUS)

(i) *Vaccines*

This disease caused unexpected and very serious trouble especially in New Guinea and Burma and even in areas such as Ceylon and the Maldive Islands where its existence was previously unsuspected. When the imminence of war with Japan necessitated the despatch of British forces to Malaya and Burma, the menace of this disease was realised. In December, 1941, at a conference held in London, decisions were taken which resulted in Dr. R. Lewthwaite being flown from Singapore to Melbourne, to work on the preparation of a vaccine from fertile eggs—along the lines which had proved successful in louse-borne typhus. No success was, however, achieved in this endeavour, and meanwhile scrub typhus became a serious hazard in jungle warfare. The Typhus Research Committee recommended that fresh work should be initiated at the National Institute for Medical Research by methods involving growth of rickettsiae in rodent lungs. Success was ultimately achieved in making a vaccine of high rickettsial content from the lungs of cotton-rats, and this was effective in protecting mice against scrub typhus in the laboratory (Fulton and Joyner, 1945). A limited field trial of the vaccine was begun in the autumn of 1944, small amounts being despatched to Lewthwaite for the inoculation of selected Army units. Before any answer as to the efficiency of the vaccine in man had been obtained, an urgent request was received from South-East Asia Command in November, 1944, for one and a half million doses of the vaccine, the dead-line date for the first 100,000 doses being fixed for August, 1945. In spite of the lack of positive scientific evidence of protection in man, the Army authorities decided that, in view of the very large numbers of troops involved and the possibility that the vaccine might save lives, its mass production should be undertaken. Large quantities of the vaccine were prepared by the Wellcome Foundation for the Ministry of Supply, and as the material became available it was sent to Headquarters, Allied Land Forces, South-East Asia Command (Buckland *et al.*, 1945). The sudden end of the war against Japan prevented the assessment by the Army of the efficiency of the vaccine. Subsequent work suggests that the existence of antigenic differences among scrub typhus strains would have made the evaluation of the vaccine more difficult.

(*ii*) *Ecology*

Work on scrub typhus generally was carried out under South-East Asia Command by the Medical Research Council's Scrub Typhus Commission under Dr. Lewthwaite; this began its operations in July, 1944. Doubt as to the exact identity of the disease affecting the Allied troops had already been dispelled by the isolation of the causal organism, *Rickettsia tsutsugamushi*, from human cases; and field work by members of the Commission in infected areas as widely separated as Imphal in Assam and Addu Atoll in the Indian Ocean repeatedly confirmed the presence on jungle rodents of the known Malayan vector mite, *Trombicula deliensis*; some of these mites yielded strains of *R. tsutsugamushi*.

With a view to extending knowledge of the epidemiology of the disease, a field laboratory was established at Imphal. Here detailed studies of the mites, their mammalian hosts, the botanical associations in infected areas, and other factors of importance in scrub typhus were carried out.

Meanwhile the Commission began an active campaign to reduce the incidence of the disease, which had reached alarming proportions. In the period July–October, 1944, 3,000 cases occurred in Fourteenth Army alone, with a mortality of 5 to 20 per cent., and there was the prospect that much larger forces would soon be deployed in infected areas. Furthermore, ignorance of the rôle of the mite had lent an air of mystery to the outbreaks, so that the troops at risk were unduly alarmed. An immediate requirement was to dispel their exaggerated fears by instruction as to both the true cause of the disease and the means of prevention. With these objects in view, a film was made showing the

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life-history of the mite, its habitat, the technique of certain counter-measures, and other relevant features; the anti-malarial organisations were utilised to disseminate information about preventive measures; and frequent interviews and lectures were given with the same purpose. Measures against rats, the common animal reservoir of the disease and host of the mite, were unlikely to prove effective under active service conditions, so special attention was directed towards anti-mite precautions. These involved principally the improvement of camp sites so as to make them unfavourable to mites and by the use of acaricides, the so-called 'repellents'.

(*iii*) *Acaricides*

The most practical measure in the control of mite-borne typhus proved to be the use of substances for killing the trombiculae (acaricides). Studies, largely by Australian workers (McCulloch, 1946), showed that dimethyl phthalate and dibutyl phthalate could be used to impregnate clothes and that these acquired the property of quickly killing mites coming into contact with them. The effect persisted after several launderings of the garments, especially in the case of dibutyl phthalate. Later, benzyl benzoate was used and proved as effective as the phthalates. Their success against mites depended largely on the thoroughness with which troops could be made to treat their clothes—particularly socks and lower parts of trousers.

INFECTION WITH RICKETTSIA BURNETI (Q. FEVER)

Q. fever was described in Queensland in 1937; the natural infection there apparently occurs in bandicoots and the vector is a tick (*Haemaphysalis humerosa*). It is also known in North America and Panama. Some surprise was induced when the infection turned up as a cause of so-called 'atypical pneumonia' in 1944–5 in Italy, among British, New Zealand and American troops. 'Balkan grippe' in Greece seems to have been the same infection. Diagnosis was established by American workers by isolation of the causative agent in guinea-pigs and from the results of complement-fixation tests against antigens made from *Rickettsia burneti*. The mode of infection in the Mediterranean area remains unknown. Possibly the infection is by inhalation of dust containing droppings from an arthropod vector (Robbins and Ragan, 1946; Caughey and Dudgeon, 1947). The agent has proved a very fertile source of accidental laboratory infections.

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CHAPTER IX

(i)

Infective Hepatitis

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ONCE again, during the War of 1939–45, infective hepatitis crept among the armies of the world and, as in the War of 1914–18, made its greatest ravages on the armies massing round the Mediterranean shores. Tens of thousands of men were affected. The wastage of man-power was vast. Intense interest was aroused. The control of the disease was of great strategic importance, and the solution of its essential problems was a challenge avidly accepted by a multitude of keen investigators in all theatres of war. Researches were made by workers in the field, in the hospitals and in the laboratories, and much that is new has been learnt. It is possible only to give a brief survey culled from the findings of many of these workers and from personal observations. Remarks in this chapter are confined to infective hepatitis itself. Homologous serum jaundice, post-arsphenamine jaundice and the possible rôle of syringes in transmission are discussed in the succeeding section.

INVESTIGATIONS

Dible *et al.* (1943) confirmed the morbid pathology. Important aetiological discoveries were made by Cameron *et al.* (1943), Findlay and Willcox (1945), Havens, Paul, Van Rooyen *et al.* (1945), and MacCallum and Bradley (1944). The clinical picture attracted many observers. The epidemiology was studied first by Cameron *et al.* (1942) in Palestine. Later, in the Middle East, the massive outbreak during the winter of 1942 was surveyed by Spooner (1943) in the Eighth Army, and by Cullinan (1943) in the Ninth Army. The epidemiological trail was followed in Italy by Truelove and Trotter (1944) and McKinley and Truelove (1945), and in the United Kingdom by McFarlan (1945).

The startling experience of the grave outbreak among the forces in Egypt and Syria during the late months of 1942 led to renewed effort. A committee on jaundice was formed by Brigadier Bedford (1943) in the Middle East. At home, in response to a request by Lieut.-General Hood, Sir Wilson Jameson invited the Medical Research Council to establish a team of workers in the United Kingdom under the chairmanship of Professor Witts (1943) to investigate the disease and correlate the work of various investigators who were studying the problem.

This short list does not include the host of other workers, too numerous to name, who studied the disease, and it should be recorded here that great contributions came from the medical officers in the field. Nor, in general, is mention made of the important contributions which came from the medical services of the Dominions, the United States of America and our other Allies. As a result of these investigations the morbid pathology has been confirmed. It is now certain that the syndrome of infective hepatitis is a single entity. The cause of the disease is almost certainly a virus, of which there may be different strains. The clinical picture has been clearly defined. Fresh and striking epidemiological facts have emerged. Yet, in spite of this accumulated knowledge, the method of infection is still uncertain, treatment remains empiric, and attempts to control the spread of the disease have failed.

PATHOLOGY

Dible, McMichael and Sherlock (1943), by means of aspiration biopsies, confirmed the findings of Roholm and Iversen (1939) that the essential histological picture of infective hepatitis is one of hepatic cell necrosis and autolysis, associated with leucocytic and histiocytic reaction and infiltration. The centres of the lobules show the first of these changes most markedly, and the portal tracts the greatest cellular infiltration. The changes in the liver are related to the severity and the duration of the disease. They found no evidence that there is a form of jaundice resulting from duodenal catarrh and obstruction of the common bile duct by mucus. Nor is there any other evidence that such a condition exists. Necropsies from undoubted uncomplicated cases of infective hepatitis, such as those described by Gaskell (1933), Barber and Osborn (1939), and observers during the War of 1939–45 (Magnus, 1942), all show essentially the same parenchymal lesion with no inflammation of the bile canals or ducts. Recovery is the almost invariable rule in infective hepatitis. When death does occur, the post-mortem picture is that of acute or subacute necrosis of the liver.

NOMENCLATURE

In the light of the morbid pathological findings and of certain clinical observations such as the unity of the clinical picture, the lack of gall-bladder enlargement, the early return of bile in the faeces, and the normality of bile obtained by intubation (Van Rooyen and Gordon, 1942), the phrase 'catarrhal jaundice', after its long life, was given a decent burial. The phrase 'infective hepatitis' replaced it.

AETIOLOGY AND TRANSMISSION EXPERIMENTS

It has long been thought that infective hepatitis results from an infection; and, further, that the infective agent is a virus. Unfortunately, it has not yet been possible to transmit the disease by any route to any laboratory animal. Experiments have therefore been made on human volunteers. In spite of the difficulties attached to the use of such material, particularly to eliminate chances of accidental infection, most important results have been obtained.

Early in the war Cameron (1943) had injected into 7 volunteers serum and whole blood obtained from patients with infective hepatitis in the pyrexial phase. Six of these were followed up and all developed jaundice within six months; and 1 after thirty days (Cameron *et al.*, 1943). Voegt (1942) also claimed to have infected 1 out of 4 volunteers by feeding them with duodenal fluid obtained from 2 patients suffering from infective hepatitis, and to have transmitted the disease by inoculation of human serum. MacCallum and Bradley (1944) collected material from several individuals in the pre-icteric stage of infective hepatitis. They produced jaundice in 3 out of 4 volunteers, sixty-four, seventy-five and ninety-two days after subcutaneous injection of serum; and in 2 out of 14 volunteers twenty-seven and thirty-one days after spraying faeces into their noses. Havens, Paul, Van Rooyen *et al.* (1944) fed 3 volunteers in the U.S.A. with capsules containing frozen faeces and extracts of urine and faeces dried and filtered by Van Rooyen in the Middle East, and produced jaundice in 2 of them twenty and twenty-two days later. Findlay and Willcox (1945) have now produced jaundice in man by feeding with unfiltered faeces, with Seitz-filtered faeces, and with urine obtained from patients suffering from infective hepatitis.

It seems right to conclude from these experiments that the causative agent is a virus which is excreted in the faeces and possibly the urine, and that the incubation period is longer when the agent is introduced parenterally than when given orally.

CLINICAL PICTURE

The symptoms, signs, and course of infective hepatitis are the same wherever the disease occurs. Wilson (1944) compared cases returning to England from the Middle East with cases arising spontaneously in home units and found no significant difference between them. Nor does the clinical picture differ materially from the description given of the disease in the Middle East during the War of 1914–18. (Official History of the War 1914–18, Medical Services. (1922).)

General description. The clinical picture is dramatic; its details are unlikely to be forgotten by past victims. The onset of jaundice is often preceded by an initial period of illness characterised by anorexia, malaise and sometimes fever, and enlargement of the liver. A few days later, the urine is seen to be dark or the patient jaundiced, or both. A few days later appetite returns, followed by a sense of reasonable well-being. Soon the urine becomes free from bile and the jaundice begins to clear. Seven weeks from the onset of symptoms, the majority of patients are free from jaundice and fit to return to duty. Relapses are few, complications (if hepatic necrosis is excluded) negligible or non-existent, sequelae infrequent, and mortality very low.

Duration and course. Table I shows the time of events in a sample of 78 cases of infective hepatitis before and after the appearance of dark urine or jaundice. None had relapsed from a previous attack and none

TABLE I

Showing the Days on which certain events occurred in 78 cases of Infective Hepatitis admitted to No. 3 General Hospital in the Lebanon at the end of 1942

(CULLINAN, 1943)

(Day of First Appearance of Dark Urine or of Jaundice = 0)

	Range total cases	(Days) 90 per cent. of cases	Median (day) total cases	Mode (day) total cases
Days of illness before dark urine or jaundice	(−) 15–0	(−) 6–0	(−) 3	(−) 3
Days after dark urine or jaundice:				
Admission to hospital	0–50	0–13	7	4
Return of appetite	0–55	0–20	9	5
Return of sense of well-being	1–56	1–19	10	9
Urine first free from bile	5–79	5–26	16	14
Got up from bed	7–73	7–29	19	17
Left hospital for convalescence	11–101	11–49	33	31

had been receiving anti-syphilitic treatment; otherwise, they were unselected. The disease lasts longer in young adults than it does in children. This is because of the difference in age. The older the patient, the longer the disease tends to last. In children it is usually brief; in old people it may last for months.

Until the method of spread is more clearly understood, early diagnosis and prompt removal of the patient from his fellows must be regarded as

TABLE II

Some Initial Symptoms complained of by 366 unselected Patients suffering from Infective Hepatitis, questioned shortly after the onset of the Disease

(CULLINAN, 1943)

	Number	Percentage
Anorexia or inability to eat	315	93·7
Vomiting during the first few days	95	28·3
Abdominal pain or discomfort	185	55·0
Fever or 'shivery'	201	59·8
Headache	93	27·7
Pain in the back	66	19·6

essential. Fortunately, especially during an epidemic, diagnosis can be made almost at the onset by an exact knowledge of the initial symptoms. (See Table II.)

PRE-ICTERIC PHASE

By far the most frequent and striking first or early symptom, is anorexia; either loss of appetite or inability to eat. In no other disease is this early anorexia more constant or more marked, and its diagnostic importance cannot be overstressed. Loss of appetite, though sometimes gradual, is frequently sudden and may be dated to a meal. Usually it is complete. The sight and even thought of food is revolting. Sometimes there is an aversion to certain foods only, particularly to greasy foods, fats, butter, eggs, chocolate, onions, and tea with milk. Other patients think they can eat but have to stop after the first few mouthfuls because they feel 'full up'. The anorexia is accompanied by loss of desire to smoke or to drink alcohol. Some officers thought they had a severe 'hang over' (Sayers, 1942). Appetite remains impaired until after jaundice has appeared, usually for about five more days. Then, gradually or suddenly, it returns and is often voracious and occasionally peculiar. (One patient had an intense desire to chew magnesium sulphate crystals and sour gooseberries.)

Other early abdominal symptoms are of less diagnostic importance. Sometimes there is nausea. Occasional vomiting, often large in amount suggesting delayed gastric emptying, is not uncommon during the first few days. There may be a feeling of abdominal distension or a dull ache or soreness, sometimes amounting to real pain, under the right rib margin, aggravated by lying on the right side or by movement.

Malaise is almost invariable and ranges from a feeling of mild listlessness, worse towards evening, to one of utter wretchedness. But even when this is most severe the patient does not look particularly ill. A feeling of relative well-being seldom returns until a day or so after the appetite has come back.

Fever is a common but inconstant and often misleading early symptom. It varies in type and in its time of onset. In most outbreaks it was present in about 60 per cent. of cases, but in some it appeared in nearly all (Cameron *et al.*, 1943). Typically, the patient feels hot and cold and shivery, and cannot get warm, and sweats in bed at night. The temperature is raised, but not above 103° F. Often the fever is atypical and closely resembles other acute conditions such as coryza, malaria, and particularly sandfly fever (Cameron *et al.*, 1943; Boyd, 1943). Sometimes the resemblance was so close that one wondered whether these atypical fevers were always an integral part of infective hepatitis or whether they represented another disease which acted as a precipitating factor. But this was never proved. Fever, when it does occur, usually lasts for two days and seldom longer than five. Most often it comes on early and lasts until the appearance of jaundice and then falls sharply. Less often there is a short febrile period followed by an afebrile interval of two or three days during which time the patient feels perfectly well before the onset of anorexia. Very rarely fever persists for a few days after the appearance of jaundice. If it lasts longer the diagnosis is almost certainly incorrect. In the Middle East several such patients were found to be suffering from fever due to *Paratyphosus C.*

Other symptoms such as headache and pain in the back and very occasionally urticaria have been observed during the pre-icteric phase, but are of minor diagnostic importance.

The tongue is usually clean. Labial herpes is not observed. The liver is enlarged in a high proportion of cases before the appearance of jaundice, and often tender.

The pre-icteric phase ends with the appearance of bile in the urine or frank jaundice. The urine is often dark one or two days before jaundice is detectable in the sclerotics. Fortunately for early diagnosis in the field, simple methods such as the 'shake' test will demonstrate the presence of biliuria. The 'histamine skin-test' will show up an occult bilirubinaemia (Klein, 1931; Brodribb and Cullinan, 1936), although the test is seldom positive much before bile can be detected in the urine (Gordon, 1943). Other pathological investigations are of little practical value for diagnosis in the pre-icteric phase. The blood may show a leucopenia affecting the neutrophile granular cells, but this is almost a normal finding in the East. There may be an absolute increase in the number of monocytes (Sayers, 1942; Jackson, 1945), but this is more marked soon after jaundice has developed when it may be as high as 20 per cent. of the total white cells (Jackson, 1945; Miles, 1944). The cephalin-cholesterol precipitation test (Hanger, 1939) was held in high esteem by our American colleagues, who also recorded a sharp increase in the serum-globulin fraction without reduction of the serum albumin (Barker, 1945).

POST-ICTERIC PHASE

The symptoms and signs of infective hepatitis when jaundice is once established are well known and merit only brief description. With the onset of jaundice the condition of the patient begins to improve. He is usually afebrile. The appetite returns after a few days, abdominal symptoms disappear, and there is a feeling of moderate well-being shortly after. The liver is enlarged, one to three fingers' breadths below the costal margin in the right mid-clavicular line, in about 70 per cent. of cases, and remains so for a variable period before or after the urine becomes free from bile. The spleen is palpable in only about 5 per cent. of cases although some observers put the figure much higher (Cameron *et al.*, 1943). The stools, pale for a few days, rapidly regain their colour. Bile disappears from the urine usually about fourteen days after its first appearance. By then jaundice is rapidly clearing but it may be another two or three weeks before the last trace has left the sclerotics.

The blood-sedimentation rate is raised at some stage of the disease in 50 per cent. of cases and is highest usually when the bilirubin has fallen nearly to normal (Miles, 1944) and may remain elevated for some time afterwards (Sayers, 1942; Evans, 1943). The Van den Bergh reaction is positive biphasic. There is early positive bromsulphthalein retention (Pollock, 1944). The hippuric acid test shows evidence of impaired liver function (Gordon, 1943), and, as judged by this, maximum liver damage occurs early in the disease (Pollock, 1944). The same remarks apply to the galactose-tolerance test which is impaired during the first two weeks (Dixon, 1944). Recovery, as judged by biochemical tests, is rapid in convalescence, with little evidence in most cases of persistent damage remaining longer than twelve weeks from the onset (Pollock, 1944). Probably, the most useful test for complete biochemical recovery will prove to be the thymol turbidity test (Maclagan, 1944).

Recrudescence. Sometimes, for no apparent reason, symptoms recrudesce while the patient is still in bed. One observer put the figure of recrudescence as high as 15 per cent. (Wilson, 1944.)

Convalescence. This is usually uninterrupted and patients are fit to return to duty about four to five weeks after the urine is free from bile. Even at the end of this time the icterus index, a simple and reliable test when carefully performed, is frequently raised above its normal figure 7 1 (Sayers, 1942; Cullinan, 1943), but this may only represent the continued gradual removal of small quantities of bilirubin from the bile-stained tissues. Nevertheless, many patients, after going back to duty, still feel below par and have symptoms of lassitude, undue fatigue, and dyspepsia, for several more weeks or months. Ultimately, these symptoms disappear and there is little evidence of what was once feared, that many patients would drift into a state of subacute or chronic hepatitis.

Complications. If subacute or acute necrosis of the liver is regarded as an extension of the disease, complications are very rare, if indeed they occur at all. Complications reported may well have been coincidental. Ascites has been found to accompany some cases of infective hepatitis, particularly in middle-aged women, but this was not remarked during the war years.

Relapse or re-infection. About 5 per cent. of patients have a second attack of infective hepatitis, often coming on about one month after the first attack. In the interval between the attacks the patient has apparently been quite well, and the second attack, though having all the characters of the first, bears no relation to it in duration or severity. Biochemically this second attack does not differ from the first one and recovery of liver function between the two appears to be fairly good (Pollock, 1944). It is impossible to say whether such second attacks—and sometimes there are more—are relapses or re-infections.

INFECTIVE HEPATITIS WITHOUT JAUNDICE

During epidemics, one expected to find a large number of cases with clinical or pathological evidence of infective hepatitis which were sufficiently mild not to develop obvious jaundice. In fact, the number found was remarkably small, even when the condition was carefully looked for. The average number recognised in just under two thousand cases of infective hepatitis in three different theatres of war was 3·6 per cent. (Hartfall, 1944; Cullinan, 1943; Hunt, 1944).

MORTALITY

The mortality, which appears to increase with age, is about 0·2 per cent. Fatal cases usually die of acute necrosis and cholaemia, often with an associated haemorrhagic state (Bedford, Q.3, 1943). The average day of death from the onset of symptoms is the nineteenth and the mode of onset of the disease does not differ from that of non-fatal cases (Smith, App. C.Q.1, 1944).

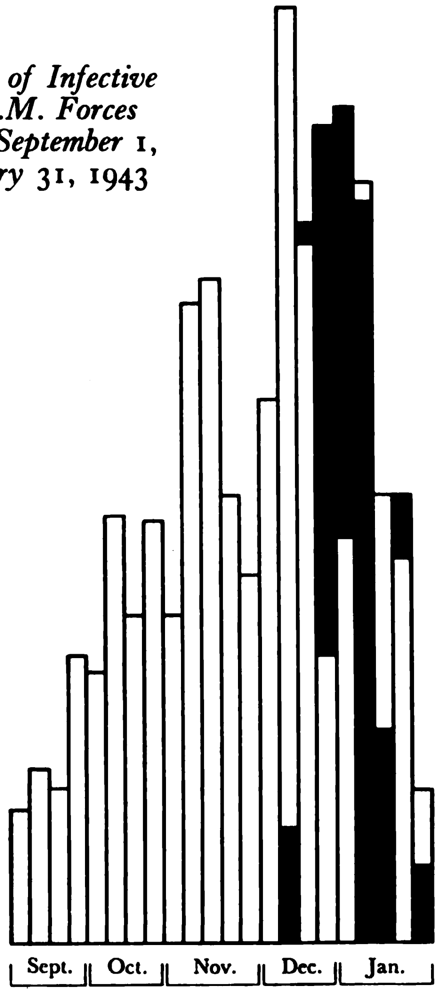
TREATMENT

Immediately infective hepatitis is diagnosed, the patient is put to bed and if possible, during an epidemic, nursed in a special ward. He is regarded as infectious until jaundice is well established. As soon as the acute phase is over bathroom privileges are allowed, but otherwise the patient is not allowed to get up until the urine has been free from bile for three days. He then potters about the ward, doing nothing strenuous, for one or two more weeks. Finally, he has two further weeks' convalescence before returning to full duty.

In the early acute phase the patient is naturally able to eat very little, but as soon as appetite returns a good generous mixed diet is given, containing liberal amounts of protein, including skim milk, sugar and fruit drinks, and devoid of cooked but not of uncooked fats. Vitamin supplements of the B complex are sometimes added. Indigestion is relieved by simple alkaline mixtures. As in so many other infections, liberal feeding speeds up convalescence. This is, however, empiric therapy. Although there is experimental evidence that protein supplement and thio-amino-acids protect the liver in animals which have been depleted of protein, there is none that they are of value in animals which have been receiving an abundance of protein (*B.M.J.*, 1945). There is a suggestion, however, that a high protein diet or methionine may prevent development of massive hepatic necrosis (Himsworth, 1945). In practice, it is difficult to assess the value of any special therapy in infective hepatitis because by the time patients are admitted to hospital the worst of their symptoms are nearly over. For example, 50 per cent. of the patients referred to in Table I had recovered their appetite and felt reasonably well three days after admission and 50 per cent. had no bile in their urine nine days after admission. More precise methods of assessment are required than evidence of clinical improvement alone. However, Wilson (1945) giving methionine in amounts equivalent to doubling the protein intake, was unable to detect any significant difference in treated and control groups in either clinical or biochemical criteria of severity. Similar findings have been recorded by others (Higgins *et al.*, 1945). It may be mentioned here that sulphonamides, which may be necessary for the treatment of incidental bacterial infections, appear to have no deleterious effect in patients suffering from hepatitis (Cullinan, 1943).

GRAPH 1

Weekly Trend of Infective Hepatitis in H.M. Forces in Syria from September 1, 1942 to January 31, 1943



KEY: OLD TROOPS ☐ NEW TROOPS ■

Alcoholics are no more likely to acquire infective hepatitis than teetotallers and when they do the disease does not run a more severe course. But during the disease and in convalescence alcohol is most injurious. Tolerance is less. Further, an injudicious drink may be followed next day by the appearance of bile in the urine. Some even think that alcohol plays a part in bringing about a second attack (Damodaran and Hartfall, 1944). It is wise to forbid patients to drink alcohol for at least six months after the illness.

EPIDEMIOLOGY

General. Infective hepatitis is widespread throughout the world. It tends always to be endemic and at times to become epidemic, frequently among troops in times of war. It is independent of climate but in the Northern hemisphere epidemics start in the late summer, reach their peak in mid-winter, and die down in the spring. This seasonal swing was well marked in the Mediterranean outbreaks described below (see Table III and Graphs 1, 2, 3 and 4) and was seen even in the absence

TABLE III

Incidence of Infective Hepatitis among British Army Troops

(D.D.M.(S.)R. 1945)

(Highest and lowest monthly rates per 1,000 strength)

	United Kingdom	Middle East Forces	Central Mediterranean Forces
1942			
Lowest	0·05 Jan.	0·2 Mar.	—
Highest	0·2 Nov.	8·2 Dec.	—
1943			
Lowest	0·1 Sept.	0·4 May	0·1 June
Highest	0·3 Apr.	5·1 Jan.	10·1 Nov.
1944			
Lowest	0·1 Aug.	0·6 May	0·8 June
Highest	0·3 Jan.	1·7 Dec.	3·8 Jan.

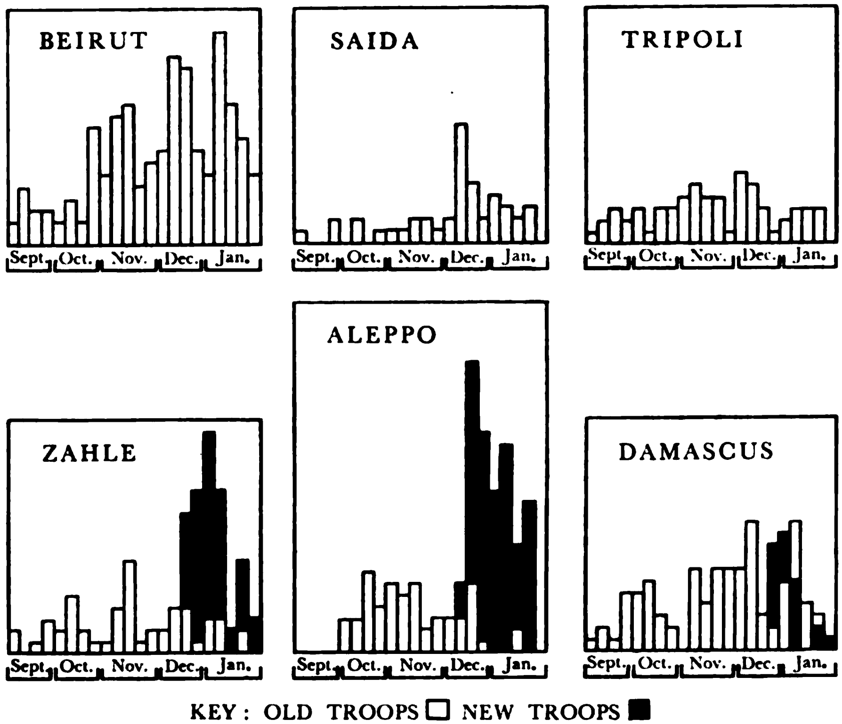
of major epidemics. In India the seasonal incidence appears to vary on the two sides of the country in keeping with the monsoons (Cameron, 1943). Large-scale epidemics really consist of a number of smaller epidemics occurring not only in separate districts but often in separate groups in the same district. The detailed trend and peak of these smaller epidemics may differ considerably from each other. (See Graphs 2 and 3.)

History. The first recorded outbreak of infective hepatitis in military history was in Minorca in 1745 (Truelove, 1945). Later epidemics have been described in the American Civil War of 1863–5 (Blumer, 1923), among German troops in the Franco-Prussian war of 1870 and in the South African War of 1899–1902. During the 1914–18 War there was a large epidemic in the Middle East which started in 1915 in certain camps in Alexandria and spread rapidly to Gallipoli, Mudros, Salonika and ultimately to Mesopotamia. At the same time there were small outbreaks in France and Flanders.

The War of 1939–45. In this war the story is similar. In most theatres the incidence of the disease increased, but among the armies round the Mediterranean there were massive epidemics. Infective hepatitis appeared in the British Expeditionary Force in 1939. It was remarked among German troops at the end of 1940 in Belgium and Northern France (Dietrich, 1942), in Norway, and in other occupied countries and on the various fronts (Gutzeit, 1942). Increased prevalence was reported in the United Kingdom, Northern Ireland, Iceland, West

GRAPH 2

Weekly Trend of Infective Hepatitis in H.M. Forces in Six Separate Districts of Syria from September 1, 1942, *to January* 31, 1943

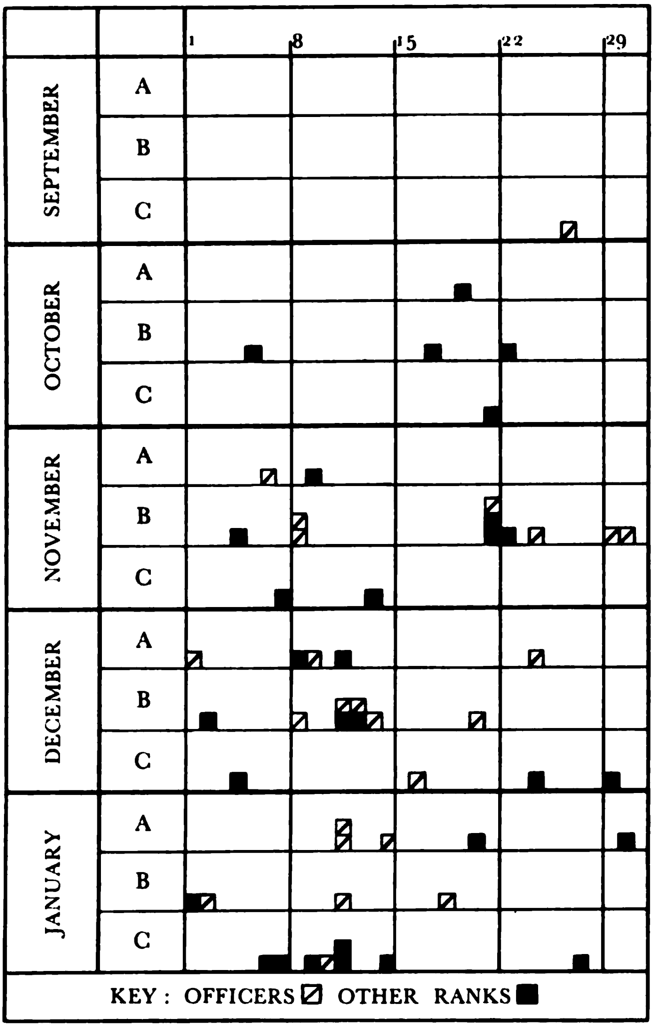


Africa, United States of America (A.M.D. Bull., 1942), prisoner-of-war camps in Germany and Italy, Switzerland, Chunking (M.R.C., J.C. 3, 1943), India, Australia (D.G.M.S., A.M.F., 1944), and in the forces in Persia and Iraq (Lipscomb, 1944). In the United Kingdom the prevalence steadily rose until 1943 and then steadily fell, but there was no real epidemic; the case incidence never exceeded 0·3 per 1,000 per month either of the total forces or of all the troops in 21 Army Group, of which the British formed the largest part (D.D.M.(S.)R., 1945). The story concerning troops round the Mediterranean was very different. Here, there were at least four large widespread epidemics; two in the Middle East Forces at the end of 1942 and 1943, and two in the Central Mediterranean Forces at the end of 1943 and 1944.

Infective hepatitis among British troops in the Mediterranean area. Cameron *et al.* (1943) described an outbreak of infective hepatitis among

GRAPH 3

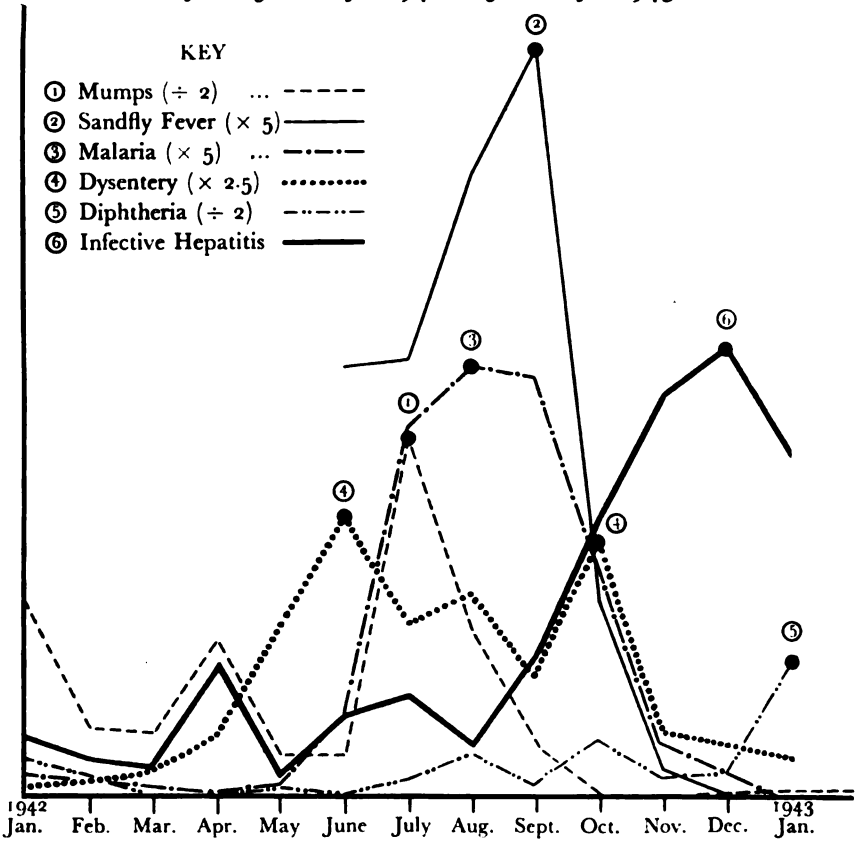
Case Incidence of Infective Hepatitis in Three Regiments, A, B, C, of an Infantry Brigade in the 9th Army, from September 1, 1942 *to January* 31, 1943



British troops in Palestine in the autumn and winter of 1940. In the autumn of 1941, when the British were back on the Egyptian frontier, Small (3Q, 1941) already referred to the disease as an important cause of casualties and noteworthy for its widespread distribution throughout the Middle East Command. The first grave epidemic appeared in the Middle East Forces at a critical time in the campaign shortly before the advance at El Alamein in the autumn of 1942 (Table IV). At this time the army in the Middle East numbered nearly a million men. The Eighth Army was in the Western Desert up to El Alamein. The Ninth

GRAPH 4

Incidence of Certain Infectious Diseases in 9th Army (Ex-Cyprus) from January, 1942 to January, 1943



Army was in the Lebanon and Syria. There were garrisons and Base installations in Cyprus, Malta, Palestine, Egypt, Aden, Sudan and Eritrea. The epidemic started in September, 1942, and ceased by March, 1943. It was widespread throughout the Command extending even to Malta (Hartfall, 1944) which was then under siege conditions. Incidence differed greatly in different groups (see Table IV) and also in sub-groups of these groups. It was here that the gravity of the situation appeared. The disease followed the forefront of battle. The brunt fell on the Eighth Army and heaviest of all on its front-line troops (Spooner, 1943).

In the Eighth Army the epidemic appeared in September in those front-line units of the New Zealand Division which were holding the Southern Sector of the El Alamein line. In this group, during the course of the outbreak which reached its peak in October, 14 per cent. of the men were affected (Kirk, 1945). In the same month the epidemic appeared in the Australian Division in the north. The peak of the outbreaks was passed by the end of October (Spooner, 1943). The New Zealanders and the Australians had no contact with each other and were separated by the British troops who were themselves at first unaffected. On the night of October 23, the barrage started; by November 3 the battle was won. The peak of the British epidemic came later in December. As Spooner (1943) said, 'It was well that it did, for the disease cost many of the regiments taking part in the battle 8 or 9 per cent. of their total strength and up to one-third of their officers'.

TABLE IV

Incidence, per 1,000 *strength, of Infective Hepatitis in British and Dominion Troops in M.E.F. during December* 1942

(SPOONER AND OTHERS, 1943)

Egypt plus Eighth Army .	9·83
Eighth Army alone . .	15·00
Ninth Army . . .	9·86

The next massive epidemic was in Italy in the autumn of 1943. It started in September and reached its peak in November. Following the invasion of Sicily, the Eighth and Fifth Armies had landed in Italy in September. Naples was taken on October 1. Further advance was checked by rain. This time prevalence was not greatest in front-line troops but was spread generally throughout the Central Mediterranean Forces. Concurrently, there was another large epidemic in the Middle East Forces, but this was of little military importance because that Command was now static. In the winter of 1944, after the liberation of Florence the disease once more flared up in Italy. The pattern of this epidemic reverted to that of 1942 in the Middle East Forces (Truelove, 1945). For example, in the New Zealand Division, which had an overall morbidity of 11 per cent., the heaviest incidence fell on its infantry (McKinley and Truelove, 1945).

Wastage. Table III shows the highest and lowest monthly rates per 1,000 strength of British Army troops (D.D.M.(S.)R., 1945). The gravity of the situation lay in the length of time spent in hospital, and in the predilection of the disease for front-line troops and particularly, as will be described later, for officers. In the six winter months of

1942–3 infective hepatitis cost the British troops in the Middle East over half-a-million man-days in hospital. McKinley and Truelove (1945) estimate that during epidemics the disease becomes at least equal to battle casualties in numerical importance and exceeds in importance any other individual cause of temporary loss of man-power.

SUSCEPTIBILITY

Age. The young are more susceptible than the old. Infective hepatitis was more common among troops in the 21–25 age-groups and less common in the age-groups over 30, compared with a control group of other diseases (Truelove and Trotter, 1944). Frequency of incidence falls off with advancing age, most steeply in the youngest age-groups of the Army population (D.D.M.(S.)R., 1945).

Race. Some races are less susceptible than others. The Indians are an example. The incidence among their troops was less than among the British, not only when they were at home, as shown in Table V, but when they were abroad. Towards the end of 1942 in Cyprus, which was at that time almost a closed community, the relative incidence among British, Indian and Cypriot troops was respectively 9·8 : 2·6 : 1 (Coghill, 1942; Bedford. Q. 1, 1943). In the Mediterranean, Canadian and New Zealand troops were highly susceptible, British troops moderately, and Indians and Maoris relatively immune (Truelove, 1945).

British Army Officers. One of the most curious facts about infective hepatitis is its predilection for British Army Officers. They are affected approximately four and a half times more often than British Other Ranks. During the 1942 epidemic in the Middle East the relative proportion of officers and other ranks who developed the disease in the Ninth Army was 4·6 : 1 (Cullinan, 1943) and in eleven regiments of the Eighth Army 4·7 : 1 (Spooner, 1943). It was the same in Italy. During the 1943 epidemic the relative proportions in 56 Division was 4·0 : 1 and in 22AA Brigade 4·7 : 1. In India, the ratio was approximately 2 : 1. (See Table IV.) This increased prevalence cannot be explained on the basis of age or length of overseas service (Truelove and Trotter, 1944). Indeed, it is very difficult to explain at all. Only a slight excess is found among New Zealand officers (McKinley and Truelove, 1945), and none at all in Australian officers (D.G.M.S.A.M.F., 1944).

Individual chances of infection. During epidemics infective hepatitis is spread over a very large number of units or groups which may be widely separated from each other. Yet, with a few notable exceptions, only a few cases occur in each particular group. This was clearly seen in the 1942 epidemic in the Middle East, both among the front-line groups of the Eighth Army and among the scattered units of the Ninth Army. For example, in Syria and Lebanon, over a period of five months, there were 478 cases from 206 units. The chances of any one person developing infective hepatitis during an epidemic are small. Sometimes this freedom

TABLE V

Incidence, per 1,000 Strength, of Non-Amoebic Hepatitis in India Command during 1944

(McDONALD, 1945)

Category	Hospital admissions
Officers, British (British Service) . .	54·99
British other ranks	28·47
Viceroy's commissioned officers and other ranks. (Indians)	5·54

is startling. Throughout the 1942 epidemic in Syria and the Lebanon only one nursing sister was affected. Among the staff of a hospital in Egypt, where 1,500 cases of infective hepatitis were treated within a short period of time, only one nursing sister and three orderlies, not employed in the 'jaundice' wards, developed the disease (Boyd, 1943).

Immunity and experience. Infective hepatitis may assume epidemic proportions in newcomers to a district where the disease is already endemic, without any increase among the old inhabitants. For instance, in the Mikveh Israel Agricultural School, Tel Aviv, fresh arrivals of emigrants sometimes developed the disease in epidemic proportions, as many as 30 per cent. being affected, with no increase in morbidity among the resident children. Similar findings are reported by Spooner (1943), from information concerning new and old inhabitants in a large prisoner-of-war camp in the Middle East. Epidemics of infective hepatitis in Allied troops were unaccompanied by a concomitant rise in civilian morbidity in the same areas either in Egypt (Van Rooyen and Kirk, 1946), Syria and the Lebanon (Cullinan, 1943), or Italy (McKinley and Truelove, 1945). In Australia there was a high incidence among newly arrived American troops from January 1942 onwards, but no accompanying increase of the disease among Australians (D.G.M.S., A.M.S., 1944). Findlay (1948) thinks it probable that there are different strains of infective hepatitis virus to which the adult inhabitants of a country have acquired some degree of immunity. Newcomers, on the other hand, have no such acquired immunity to new strains. Further observations about immunity are confusing. There is evidence that a group heavily infected in one season is likely to have a comparatively low incidence in the next year (McKinley and Truelove, 1945). But, whether liability to attack diminishes progressively with length of residence in a theatre of prevalence is extremely doubtful. Again, there is no evidence that troops arriving in the Middle East fresh from the United Kingdom are more susceptible than others who have been there for some time. Graph 3 illustrates the case incidence of infective hepatitis in three regiments of approximately equal size, forming an infantry brigade. Regiment B had been in the Middle East for some years, although some of the men were newcomers. Twenty-six men developed infective hepatitis, eighteen of whom had been in the Middle East for one year or more, and eight of them for five years. The whole of Regiment C, which was a unit of similar size, composition and circumstance, had just arrived from the United Kingdom. Only sixteen men were affected. Finally, there is no evidence that one attack of infective hepatitis confers permanent immunity. Men of the Ninth Army suffering from the disease in 1942 gave a past history of jaundice at least as often as did a sample of healthy troops.

Incubation period. Assuming for the moment that infective hepatitis is an infection which may be transmitted from case to case, what is the incubation period? Pickles (1930), from a study of small epidemics in little villages in England, puts it between three and five weeks, usually about one month. In the Middle East it was easy to find many examples of this such as the following.

> There was a hospital high in the hills of Cyprus which was isolated from other military units except for another hospital half-a-mile away and was far removed from any town. On December 8, 1942, one of the staff felt ill, was admitted to hospital on December 10 and became jaundiced on December 12. A Sister nursed this man on December 10 and 11. On January 8 (28 to 29 days later) she felt ill and was jaundiced a few days later.

To test the validity of the incubation period, 200 patients from small scattered units were closely questioned. Ninety-eight knew of contacts with other men who were in the pre-icteric phase of their disease. Forty-four knew of only one contact or at the most two. In these the time-interval between contact and the development of symptoms ranged from eleven days to two months, but the mode was four weeks (Cullinan, 1943).

Period of infectiousness. It has been the general experience of all observers that when the initial symptoms are over and jaundice is established, the disease is no longer infectious. On the other hand, there is considerable evidence that the disease is infectious in the pre-icteric phase. Assuming a case-to-case spread, the period of infectiousness must be short. Otherwise the remarkable periodicity of the disease at intervals of approximately one month in small villages at home cannot be explained (Pickles, 1939; Newman, 1942).

One other possibility must be borne in mind. The disease may be infectious before the appearance of any symptoms. If this were so it would explain much that is obscure. The following is an example of such a possibility:—

> Captain T. in daily contact with Lt. Colonel M. until the latter was admitted to hospital with infective hepatitis on January 5.
>
> February 2 Mrs. T. came from Egypt to stay with Captain T. in the Lebanon. February 9 Mrs. T. returned to Egypt. February 17 onset of

pre-icteric symptoms in Captain T. (jaundiced February 26). March 10 onset of pre-icteric symptoms in Mrs. T. (jaundiced March 14).

Captain T. knew of no contact other than Lt. Colonel M., Mrs. T. knew of no contact at all.

METHOD OF SPREAD

Large epidemics consist of a number of small epidemics spread over a wide area. Comparison of these small epidemics with each other often reveals that what appears to be an important epidemiological factor in one has no bearing in another. This is seen particularly when comparing outbreaks among the front-line troops of the Eighth Army residing in the desert and among the scattered units of the Ninth Army living under comfortable conditions in Syria and the Lebanon. With the discovery that the infective agent is present in the human faeces during the early days of the disease, it might be thought that the method of spread would be easy to follow. This is not so. Nor is it likely to be until much more is known about the spread of virus disease in general. The method of spread is not clear even in acute anterior poliomyelitis, the aetiology of which is much better understood than that of infective hepatitis. Incidentally, these two diseases, apart from the difference in their incubation periods, have many epidemiological features which are strikingly in common. Epidemiological observations have been many, and speculation rife, but no agreement has been reached. Here, only a few findings will be recorded.

Water, as the means of transmission, can be excluded. The epidemic in Syria in the winter of 1942 broke out at the same time in six different districts, widely separated from each other (see Graph 2), in a large number of units with separate water supplies. For similar reasons food, including tinned food, is an unlikely vehicle.

All animal and insect vectors can be dismissed with the possible exception of the fly. Flies are present in all countries where the disease is known. Kirk (1945) relates that at El Alamein the epidemic among New Zealand troops was localised to an area five miles square in the south of the line which was occupied by two brigades of front-line troops. This part of the line differed from others in that it was ground which had been fought over and recaptured from the Italians and Germans at the battle of Ruwyeisat Ridge before being occupied by the New Zealand troops. It contained enemy faeces and inadequately buried bodies. Flies were prevalent in incredible numbers. An epidemic of infective hepatitis had been going on for some time among the enemy troops. Kirk concludes that infection was conveyed by flies from bodies and faeces. The men were unable to protect their food, mess-tins, mouths, or hands from the hordes which swarmed over everything. Although supporting evidence for the theory of fly-borne infection came from many other sources, there are also serious objections to the theory. The 1942 epidemic in Syria reached its height when the fly population was at its lowest.

Personal contact seems to be the most constant common factor. It was stated earlier that out of 200 patients, 93 knew of previous personal contact with another man during the pre-icteric phase of his disease. This was in an area where many of the units had only a few cases in each of them. Contact need only be brief. In one brigade it was easy to trace contact among the officers and difficult among the men, which suggests that dormitory spread is unimportant. Speech spread is still possible in the messes—people talk less in bed.

The most interesting suggestion is that feeding utensils spread the disease. This would explain much that is obscure, such as the frequently observed fact that two men might develop the disease on the same day, without any knowledge of previous contact. Truelove and Trotter (1944) found a certain amount of evidence that there was a greater incidence of infective hepatitis when soapy water was used for washing up than when plain water was used. This hypothesis was never proved.

Epidemics of associated acute illness such as influenza, gastro-enteritis, sand-fly fever, and malaria were reported in some outbreaks of infective hepatitis, but in many there were none.

Conditioning factors such as climate, exposure and physical fatigue cannot be incriminated. Dietary deficiency can play no part: men in the Eighth Army at the time of El Alamein were superbly fit and nourished.

Why British Army Officers are more prone to the disease than other ranks remains obscure. Certainly, if feeding utensils are the vectors, the chances of infection are greater in officer's messes. Van Rooyen and Kirk (1946) consider that British officers form a social class less exposed to the virus and therefore more susceptible. But in the Royal Navy officers were not more affected than ratings (Truelove, 1945). Officers drink more alcohol than other ranks, but teetotal officers, or those who drink very little, appear equally susceptible. Conditioning factors such as fatigue do not account for the difference.

CONCLUSION

In spite of all our added knowledge the epidemiological puzzle remains unsolved. Many new and exciting pieces in the jigsaw have been fitted into place, but the key pieces are still missing. The final picture of the disease has not yet emerged.

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(ii)
Epidemiology of Infective Hepatitis in England, 1944-47

EPIDEMIOLOGICAL STUDIES FROM THE MEDICAL RESEARCH COUNCIL'S JAUNDICE LABORATORY IN THE DEPARTMENT OF PATHOLOGY IN THE UNIVERSITY OF CAMBRIDGE

By A. M. McFARLAN
M.B.

Reports of epidemics of infective hepatitis in several parts of England between 1938 and 1942 suggested that the disease was increasing in prevalence and that the winter of 1942–3 was the time of peak incidence. In nine counties of Eastern England between the Thames and the Wash with a population of about 2·6 millions, voluntary notification was introduced in May, 1943, and compulsory notification in November of the same year. The incidence of the disease showed an overall downward trend from 1943 to 1947, broken by a rise in the spring and summer of 1946 due to a recrudescence in some urban areas in the south of the region. The numbers of notifications in the four years from 1944 to 1947 were 3,563, 1,569, 1,976 and 1,034 and the attack rates per 1,000 were 1·3, 0·6, 0·7 and 0·4.

Seasonal variations in incidence were superimposed on the general downward trend. An autumnal rise was shown in all four years. In 1944, 1945 and 1947 the numbers of notifications fell from January to a minimum in August and rose in September and the following months. In 1946 there was a rise in March and again in April, a peak in May and then a fall to the end of the year, with a small rise in September. The rise in this year at an abnormal season was due mainly to the cases in the south of the region.

The sex incidence, estimated from the percentage of male and female cases, showed an excess of females in 1944 and 1945 (54·6 and 55·0 per cent.) but this excess was due to an excess of females in one age-group only (20–39 years) and was due to the small number of males at risk owing to the absence of many men in the Services. In 1946 and 1947 the percentage of females was 49·3 and 48·3.

The age incidence, estimated from the percentage of cases in age-groups, was highest in children of school age. The percentage of patients aged 5 to 14 years was 45·7, 42·4, 33·4 and 29·2 in the four years, considerably higher than expected in a group forming about 15 per cent. of the population. The fall in the percentage in this group was balanced by an increase in the percentage of males in the 20–39 age-group from 7·7 and 9·9 in 1944 and 1945 to 17·8 in 1946 and 22·1 in 1947. The real age incidence was therefore probably similar in the four years. Although in a few small epidemics the chief incidence was upon adults, in most epidemics, as in the notification figures, the highest incidence was upon children of school age.

Attack rates in urban districts were lower than those in rural districts in 1944 (1·2 vs. 1·7 per 1,000), equal to them in 1945 (0·6) and higher in 1946 (0·8 vs. 0·5) and 1947 (0·5 vs. 0·3). During epidemics attack rates in day schools in rural districts were frequently of the order of 30 per cent. whereas in schools in urban areas they were seldom over 10 per cent.

The geographical distribution of epidemics and of districts with a high prevalence in successive years suggested that from 1944 to 1947 there was a continuation of a previous centrifugal spread from London and the south-east to the periphery. Evidence was obtained in 1942–3 of centrifugal spread from a town to surrounding villages in three areas in the eastern part of the region.

Many sporadic cases occurred in villages in all four years: during 1944 cases were notified from 609 villages and 51·9 per cent. of them had only one case in the year; in the following years 59·0, 61·9 and 63·5 per cent. of villages reported single cases. In each year a number of large towns and urban districts showed a steady succession of apparently unconnected cases throughout the year. In some towns this endemic type of prevalence followed an epidemic, in others there appeared to have been no preceding epidemic. Only in three urban districts in the south of the region with an increased prevalence in the spring and summer of 1946 was there a rise from an endemic series of cases; elsewhere the prevalence remained stationary or declined.

Epidemics showed a slow evolution over five or six months. In large towns there was a slow rise and fall and frequently a subsequent endemic series. In smaller towns and villages the cases were spread over many months with occasional explosive outbursts and finally an absence of cases for months or years. In several day and residential nurseries for children under 5 years of age, cases occurred for months, most of them at monthly intervals in nurses aged about 18 and only a few in the children. In an institution for mental defectives an outbreak due to spread by contact had an explosive burst a month after an epidemic of upper respiratory infections.

The incubation period can be accepted as about 25 to 35 days, with 20 to 40 days as the usual interval between onset in cases where contact has occurred before and after onset in the infecting case.

Cases are as a rule infectious for a short period about the time of onset of symptoms but some observations suggest that there may be a period of infectivity early in the incubation period, about a month before the onset of symptoms.

Contact was the probable mode of spread in epidemics and carriers were probably involved. No evidence of water-borne or food-borne infection was obtained. On epidemiological grounds pharyngeal secretions are probably a source of infection in addition to faeces, in which the infective agent has been demonstrated. The main points in favour of this view are the seasonal incidence, the transmission of infection in some instances by casual contact and the geographical scatter of cases during an epidemic.

(iii)
Infective Hepatitis and Allied Conditions

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RESEARCHES IN AETIOLOGY

During the War of 1914–18, some 25 per cent. of certain units of British troops serving in Gallipoli and in Alexandria contracted infective hepatitis (Martin, 1917). Shortly after the arrival of United Kingdom troops in Palestine and Egypt in 1940 infective hepatitis again appeared. As previously, the cause of the disease was completely unknown, and the earliest investigations of Cameron (1943) showed that whereas it was common among troops entering the country, cases were apparently rare among the local adult population of Palestine. Intensive investigations by Cameron and others at the 23rd (Scottish) General Hospital at Sarafand failed to shed any light on the mode of transmission of infection, neither was it possible to isolate any cultivable bacterium with regularity from patients or from post-mortem material; animal inoculation tests also proved to be negative. Faced by such difficulties Cameron injected six human volunteers intravenously with infected blood, successfully reproducing the condition in these men, and thereby demonstrated the artificial communicability of the disease. Following the departure of Cameron to India Command, laboratory investigations were renewed in 1941 by van Rooyen and Gordon (1942) at the 15th (Scottish) General Hospital, Agouza, Cairo, with special reference to isolation of an infective agent of the virus type. A wide range of laboratory animals including monkeys, baboons, pigs, gerbilles, jerboas, and desert rodents indigenous to these parts of the world were inoculated by numerous different routes—with the co-operation of the late Dr. John Bland of the Giza Ophthalmic Research Laboratories—but without success. In view of the many thousands of cases which had occurred, and loss of man-power, in the text of an official report on the subject van Rooyen in 1942 proposed to the D.D.P., Colonel J. S. K. Boyd, that higher authority be sought for the performance of human inoculation tests at Abassia Military Detention Barracks. The proposal received the attention and support of Professor L. J. Witts, Chairman of the

Infective Hepatitis Committee of the Medical Research Council, who visited the site of the proposed experiment in 1944; but it was impossible to carry out human transmission in Egypt on Service patients. Simultaneously, the United States Army Commission on Respiratory Diseases were studying the occurrence of the disease in American forces in Egypt and Sicily and Italy. Special attention was paid to an agent of the virus group, having in mind the possibility of spread by intestinal content, occurring in fatal cases among British and American troops in Egypt (Paul, Havens, and van Rooyen, 1944). The need for human volunteers was immediately appreciated, stools were collected from American troops and arrangements made for collection of similar material from British soldiers. In Britain, MacCallum and Bradley (1944) performed similar experiments and successfully reproduced infective hepatitis, after an incubation period of twenty-seven to thirty-one days, in human cases of rheumatoid arthritis by feeding them with faecal material. The results of Havens *et al.* (1945) also showed that the infective agent was transmissible by faeces and the incubation period could be as short as twenty to twenty-two days. Independent confirmation of these results was provided by Findlay and Willcox (1945) in West Africa, who also demonstrated the infectivity of urine as well as filtered faecal material. In Italy an outbreak of infective hepatitis affecting the American 86th Mountain Infantry Regiment was traced by Gauld (1945) to drinking contaminated well water. In the ensuing years increasing evidence was provided from the U.S.A. workers as to the occurrence of the virus of infective hepatitis in human faeces. Other accounts also suggested that contaminated water and milk could transmit it.

At the time of writing this account, it is generally agreed that the virus is present in the blood, the faeces and possibly urine during the disease. It is true, however, to say that notwithstanding this fundamental information, the spread of the disease by this agency in the M.E.F. in the years 1940–4 was the subject of the most careful inquiries by numerous officers of the R.A.M.C., but then (and even now), there was still no obvious evidence to prove that the disease was spread by bad hygiene or poor sanitation.

EPIDEMIOLOGY AND SPREAD IN THE MIDDLE EAST

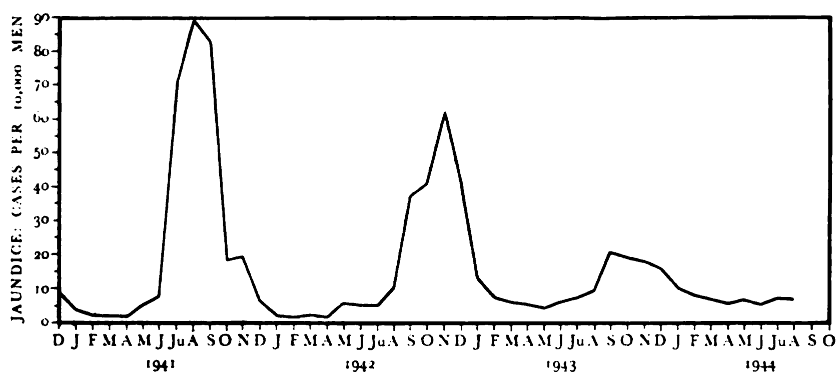
The mode of transmission of the disease has puzzled many workers. Spooner (1943) scrutinised the case histories, movements, and contacts of numerous patients in Egypt during 1942, with inconclusive results. Since the aetiological agent has been discovered in faeces, one is tempted to recapitulate the course of epidemiological events in retrospect.

Seasonal Incidence

Through the help of Col. N. Hamilton Fairley and Lieut. J. B. Fletcher, Officer Commanding Statistical Subsection Medical History and Information Section, it was possible to estimate the number of cases which occurred among the Australian forces who served in Egypt and Libya throughout the year 1941. During the period up to September, 1944, some 25,827 cases were notified in United Kingdom, Dominion and Colonial troops serving in Egypt, Cyrenaica, Tripolitania, Palestine, Syria, Cyprus, Sudan, Eritrea, Malta and Aden. When these two groups are considered together it emerges that the majority arose in Syria, Palestine and Egypt, and the greatest morbidity was recorded in December, 1942, in Egypt and the Eighth Army, where 7·82 per 1,000 contracted the disease. For the corresponding period the figures for Palestine and Syria were 4·50 and 2·46 per 1,000 men respectively. The latter was due to large movements of troops and their concentration in chosen sites rather than to any peculiarity on the part of the terrain itself.

GRAPH

Incidence of Infective Hepatitis in Middle East Force



The graph illustrates the epidemiological characteristics of the condition and is constructed from thousands of notifications embracing a large body of newcomers to the Middle East, over a space of three and three-quarter years, scattered throughout a stretch of territory extending from Eritrea to Tripolitania. The curve shows the tendency of infective hepatitis to recur annually in the later summer and autumn. Progressive decline in the magnitude of successive annual epidemics could be attributable to reduction in the scale of military establishments, lesser operational needs, corresponding improvement of sanitary arrangements and healthier living conditions. The gradual development of active immunity through prolonged residence within the endemic area might well have contributed too. The effect of seasoning among troops through exposure to clinical or sub-clinical infection in epidemic areas in Italy was studied among American troops by Gauld (1945).

The graph shows that the Middle East area was a permanent endemic centre of infection, and jaundice followed the dysentery season each summer, when the fly menace was at its worst and the maintenance of effective personal hygiene and sanitation was at its lowest ebb. It is, therefore, not impossible that if sanitary conditions were bad at any place and enough susceptibilities were present there, the disease could have appeared at any month of the year.

Immunity of Local Inhabitants

There is reason to believe that the adult native inhabitants of Palestine, Egypt, Malta, and the neighbouring territories are singularly resistant to attack. In Palestine, Cameron (1943) reported that infective hepatitis was an endemic disease of childhood among the local population, whereas British troops who entered the area were soon infected. The same was applicable to European Jewish emigrants to Palestine (Btesh, 1944). On the island of Malta, Dixon (1944) found that British troops were twelve times more vulnerable to attack than locally enlisted Maltese. (See also Hartfall, 1944.) In Egypt, during 1941–3, although many thousands of cases occurred among our soldiers, persistent inquiries from local doctors showed that Egyptian civilians were apparently unaffected. The entry of susceptible newcomers to an endemic area thus reveals the presence of latent infection such as occurred when British troops poured into Egypt during 1941 and 1942. This point was described by Spooner (1943), who referred to the histories of ten field regiments, R.A., in the M.E.F., in the following passages: 'Two of these regiments landed in the Middle East in September, or early October, after a jaundice-free voyage. They spent a short time (ten and thirty-seven days respectively) training and equipping themselves in the Canal and Nile Delta area, and then went into the Alamein line in mid-October, for battle, and fought until the end of the first week in November, when after a short rest in the desert, they returned to clean base camps in the Cairo area. Both of these regiments had their main epidemics after returning to the Delta, about a month after battle.'

Sub-clinical Attacks

Perhaps one of the most significant aspects of the epidemiology of infective hepatitis has been the existence of unrecognised cases in the field. During the North African campaign, Hunt (1944) mentioned that the disease at its onset was one of the important causes of pyrexia of unknown origin, and that many sufferers did not show jaundice. (See also Lisney, 1943; Cullinan, 1939; Cameron, 1943.) During the siege and aerial bombardment of Malta unique opportunities arose for the study of the malady among the isolated community of British, Indian, and Maltese troops, plus their civilian associates. Dixon (1944) emphasised that sub-clinical attacks were common and, for example, out of six men in a post one might report with jaundice, another with indefinite gastro-enteritis symptoms, and another with diarrhoea. Dixon also went so far as to assert that the prevalent variety of gastro-enteritis, popularly called 'Malta tummy', constituted a sub-clinical variety of the illness. Moreover, during the period of intestinal dysfunction, excessive indulgence in alcohol not infrequently precipitated an attack of jaundice. Hartfall and Damodaran (1944) have amplified the same theory.

Some Inferences

In the opinion of some observers the circumstances suggest that the virus is ubiquitously distributed throughout the Mediterranean countries; the local adult population of the latter is immune to attack; and such resistance is probably acquired during childhood by repeated consumption of food contaminated with virus. Thus van Rooyen and Kirk (1946) believed that when British troops occupied an infected locality the mechanism of their response to infection resembled that of the local children. Other ranks habitually patronised native cafés and eating-houses and within a short time every man ingested infective material. Some received large doses and developed the typical jaundice, others suffered from pyrexia of unknown origin; others experienced vague gastro-intestinal symptoms of disease popularly referred to as 'Malta tummy' or 'Gyppy tummy', without developing jaundice, but in all probability the bulk of the men swallowed subminimal infective doses of virus and so rapidly developed progressive tolerance to successive amounts of virus.

Susceptibility of Officers

Spooner (1943) drew attention to the liability of officers to contract jaundice, and he stated that 'in certain Eighth Army regiments 8 to 9 per cent. of the total strength of the unit were affected, which often included as much as a third of the officer personnel, who seemed to be 4·7 times as prone to infection as other ranks'. The same applied to the Italians. According to some, alcohol has been blamed, but like Spooner (1943) we are not satisfied it is the whole answer. Other factors worthy of greater consideration were that although the living conditions of officers in Egypt, during the Middle East campaign, were such as to shield them from mass infection from the external civilian population, their mode of life encouraged its dissemination among the officer class. Officers serving abroad live differently from other ranks. They tend to congregate as isolated communities, patronise the cleanest eating-houses, sleep in the best available quarters, and in general possess the necessary authority to demand the best ablution, sanitary and laundry facilities procurable. On the other hand, because of the isolation and relative segregation from the civilian population which officers pursue abroad, opportunities for the spread of infection from one to another at hotels, social clubs, and fresh-water swimming-pools are numerous, not to mention the use of improvised portable bathing facilities designed to conserve water in desert areas. The cumulative effect of such personal habits may be that for a long time after he has entered the country, the officer denies himself the opportunity for intake of subminimal infective doses of virus. The commissioned class thus constitute an unprotected herd, and as soon as a case develops in an officers' mess, infection rapidly spreads in the direction of intimate susceptible contacts.

Mixed Units, Air Crews, and Civilians in Britain

If the above explanation were right, in circumstances in which officers and men serve together, one would expect the incidence of the disease to be similar. This may be so with air crews (see Havens, 1944). Since infective hepatitis virus has been demonstrated in stools, it is obvious how men could become infected in flight, where ablution facilities are limited and water rationed, particularly in view of the recent claim by Findlay and Willcox (1945) to have demonstrated the virus in urine.

Again, if our line of reasoning were correct, in Great Britain where the standards of living and sanitary arrangements are of a relatively uniform type, class selection should be absent. Epidemics are commonest among school children and hospitals, but in general class distinction is lacking, the disease spreads by personal contact irrespective of age, sex or what section of the community the individual may belong to, civilian or military (see Ford, 1937; Cullinan, 1939; Newman, 1939; Lisney, 1943; Evans, 1942; Cookson, 1944).

For practical purposes the population in Britain can be regarded as susceptible, less a few adults who have derived immunity during childhood. Troops from the British Isles contracted jaundice more frequently than men from other parts of the Empire. The situation can be contrasted with the cosmopolitan Middle East, where the virus is ubiquitously distributed so that instances of case-to-case contact infection are difficult to trace, because the level of adult mass-immunity is high.

Prevention of Epidemic Infective Hepatitis

In theory, attention should be paid to every obvious source of potential infection, but in practice this is impossible to achieve. Prompt recognition and segregation of early cases masquerading as mild pyrexia of unknown origin, or gastro-intestinal disturbances of indefinite type, routine biochemical examination of blood and urine, and the employment of skin tests for detection of latent jaundice—all may assist (Cullinan, 1939, and Havens, 1944). The resistance of the virus of infective jaundice to physical and chemical agents coupled with its high degree of infectivity introduces a fresh crop of difficulties.

The hygiene of most units of the M.E.F. was excellent, judged according to the dysentery rate, but far more was demanded to deal with infective hepatitis, and it must be admitted that this throws some doubt on the hypothesis that epidemiologically hepatitis behaves like an infection contracted *ex alimentatione*. In the desert campaigns the Army Hygiene Services accomplished a magnificent task under trying conditions. The reader should not omit to study the classic description of the situation given by Richmond and Gear (1945) who reported that after the retreat from Gazala to Alamein the fly menace assumed the proportions of a plague. Perhaps in future something can be accomplished by unit propaganda and an appeal to all ranks to improve their personal hygiene, such as by the washing of hands after defaecation, urination, and before taking food. Notwithstanding such counsel many major vehicles of potential infection will continue to pass unchecked—namely, bed linen, clothes, towels and unprotected food and water—and men must live in close proximity. Under war conditions appropriate remedial measures are hard to effect. The highest incidence of hepatitis in the Eighth Army in the desert was approximately 8 per 1,000, and to combat this single item the requisite labour to disinfect the garments of so many men would have been disproportionate to the reward in prospect.

Infective Hepatitis in Other Areas

Although the Mediterranean constituted the principal area of endemicity and British interest, there was evidence to believe that the disease was pandemic in distribution. Cases occurred among troops in Italy (McFarlan, 1945), Ceylon (Jayawardene, 1945), the Mariana and Tinian Islands (Getty, 1946), and also in the homelands of Great Britain and the U.S.A., where sporadic outbreaks of infection occurred throughout the duration of the war.

CLINICAL PATHOLOGY

HAEMATOLOGY AND SEROLOGY

It has not yet been possible to devise any single laboratory test which is diagnostic for infective hepatitis, but a number of tests on the blood and urine may be of value when taken in conjunction with the clinical signs and symptoms. Certain liver-function and other tests may aid in determining the prognosis of an individual case.

It has been recognised for a number of years that there may be a typical blood picture in cases of infective hepatitis. This had been confirmed repeatedly during recent years by observers all over the world, who have found a leucopenia with an absolute neutropenia and an increase in the number of large mononuclears in varying percentages of individuals, chiefly in the pre-icteric stage. Miles had described the typical blood picture based on a detailed follow-up and analysis of the white blood-cell counts of eighty Service patients.

Pre-icteric Stage

There is a leucopenia with a relative increase in unsegmented neutrophils and an absolute neutropenia. The total number of lymphocytes is decreased, but there is an absolute, as well as relative, increase in the number of large lymphocytes, the mature, small lymphocytes being decreased. Abnormal cells are predominantly plasma and Turck cells and these are usually more than 2 per cent. of total white blood corpuscles. This picture is indistinguishable from rubella and from a few cases of malaria, but there is only rarely any difficulty in differentiating from infectious mononucleosis.

Icteric Stage

The total number of white blood-cells increases and there is a definite absolute monocytosis. All types of cell slowly return to normal. The normal properties of segmented and unsegmented neutrophils are recovered within a fortnight; abnormal cells disappear in about the same time and lymphocytes and monocytes return to normal in about six weeks. In ten cases the bone-marrow was normal except for an excess of typical plasma cells.

Miles (1946) carried out complement fixation with a large number of antigens from fatal cases of various kinds of hepatitis, and acute and convalescent sera from a similar variety of cases. The only positive results obtained were in tests using antigens made from livers of fatal cases of hepatitis in individuals who had been receiving arsenotherapy and the sera of individuals convalescent from the same condition. All other combinations of antigens and sera failed to fix complement. It was considered that this was probably due to a linkage between the arsenoxide and liver proteins. However, all attempts to confirm this theory by in vitro or animal experiments were a failure.

Findlay and Martin (1943) described a complement-fixation test, using as antigen the liver of a fatal case obtained within a few minutes of death. They obtained positive results with convalescent sera from cases of infective hepatitis and homologous serum hepatitis. All other workers have failed to confirm these results using similar tissues and methods. No truly specific diagnostic precipitation or agglutination test has been described.

Liver-Function Tests

Many attempts have been made to increase the sensitivity of known tests of hepatic dysfunction as an aid to early diagnosis, differential diagnosis and prognosis.

Pollock (1945) who was interested essentially in early diagnosis used a modification of the Malloy-Evelyn method of estimation of serum bilirubin, to show that there was an increase in the amount of direct bilirubin several days before there was an increase in the total serum bilirubin. Results of the use of the sensitive Hunter's test indicated that small amounts of bilirubin were present in the urine, as many as ten days before the appearance of jaundice. The use of this test in contacts in an epidemic in a nursery suggested the presence of a very small proportion of completely symptomless cases. When Pollock used a dose of 5 mg. of the dye per kilo. body-weight in the bromsulphthalein excretion test he found that demonstrable liver damage may be present at least eight days before the appearance of icterus. In one patient there was abnormal retention when first tested sixteen hours after the onset of symptoms. Abnormal results with this test were the earliest constant abnormality found. Pollock found that the hippuric acid synthesis was usually returning to normal by the time jaundice appeared and normal values were found in convalescent patients with persisting clinical symptoms and raised serum bilirubin. Rennie considered the hippuric acid synthesis a satisfactory test for liver function. One patient showed impairment of the function twenty months after dismissal from hospital though showing no clinical evidence of hepatic disease. Sherlock (1946), however, has found low results in various conditions in which liver damage could not be detected by biopsy technique or other function tests. The cephalin-cholesterol-flocculation test of Hanger, though widely used in U.S.A., has been little used in Great Britain. It is an empirical test of liver function, the basis of which is not yet completely understood. Dick found the test was positive early in the disease and the results ran parallel with clinical severity so that it was useful in prognosis. Negative results were obtained in cases of obstructive jaundice so that the test was thought to be of value in differential diagnosis. MacLagen developed the thymol-turbidity test which was thought to have probably the same basis as the cephalin-flocculation test. It does not test any known function of the liver. It is simple to perform and the ingredients are stable. It does not differentiate infective hepatitis from cirrhosis but it is selective for obstructive jaundice in which the test is usually negative or only weakly positive. The test was positive twice as often in infective hepatitis as in arsenotherapy hepatitis. Though it is questionable whether any single test is available which will differentiate between acute infective hepatitis, chronic hepatitis, cirrhosis or obstructive jaundice, or indicate the probable prognosis, Higgins and his colleagues (1944) found the results of a battery of tests to be of great value. They consider that estimation of the amount of bilirubin, phosphatase, albumin and globulin in the plasma from a single specimen, usually provides as much diagnostic and prognostic information as can be obtained from most elaborate tests of liver function. From the point of view of differential diagnosis of subacute hepatitis, a moderate rise in bilirubin and phosphatase is accompanied by striking changes in the plasma proteins and a gross reduction in laevulose tolerance. In carcinoma with extra-hepatic obstruction the jaundice is associated with a rise in phosphatase, there is usually no change in the plasma globulin, and the laevulose tolerance is not greatly impaired. The changes in carcinoma of the liver without extra-hepatic obstruction are the same except that jaundice is not intense; the phosphatase is still notably raised. The plasma bilirubin is probably a reliable guide to immediate prognosis in acute hepatitis but of little value in subacute or chronic forms.

THE PATHOLOGICAL PICTURE

Virchow's theory that infective hepatitis, or catarrhal jaundice as it was then known, was due to obstruction of the ampulla of Vater by a plug of mucus was gradually losing favour in the period 1922–39. The small number of cases that had come to necropsy in the early stages of the disease suggested that the lesion was in fact an inflammatory reaction in the liver itself involving the parenchymal cells. The results of aspiration biopsy studies of Roholm and Iversen in Denmark fully confirmed this view. In 1941–2 Dible, McMichael, and Sherlock (1943) applied the aspiration-biopsy technique to the study of the liver in patients with infective hepatitis, serum hepatitis, and arsenotherapy hepatitis in Great Britain. They found the pathological picture was essentially the same in all three types. It consists of hepatic cell necrosis and autolysis associated with a leucocytic and histiocytic reaction and infiltration. In more severe cases there is disorganisation of architecture of hepatic lobules. The reticular framework is comparatively well preserved. The glycogen content of surviving liver cells is also usually well preserved and there is little or no fatty change. The centres of the lobules show the cell necrosis and autolysis most markedly and the portal tracts the greatest cellular infiltration. In certain cases, which are either mild from the beginning or in which the lesion is retrogressing, the periportal cell accumulations predominate, in contradistinction to the more severe cases in which hepatic cell degeneration is more pronounced and the histiocytic and leucocytic infiltration is more widespread. The end-stage may be acute or subacute necrosis or cirrhosis. No inclusion bodies were seen. Lucke in U.S.A. has described similar changes in yellow fever vaccine (serum) hepatitis.

HOMOLOGOUS SERUM HEPATITIS

In January, 1943, medical officers of the Ministry of Health published a memorandum pointing out the obvious importance of transfusion jaundice. The failure to find a susceptible experimental animal, and the obvious importance of the problem of communicable jaundice, necessitated the use of human volunteers in experiments to determine the properties of the causative agent and possible means of control.

The delayed jaundice in individuals receiving certain batches of yellow fever vaccine containing human serum, first described by Findlay and MacCallum in 1937, was presumed to be caused by an icterogenic agent present in the serum used. From 1937 to 1942, the serum used in the vaccine had come from single donors all of whom were observed for a month after collection of the serum and before it was used. No cases of jaundice occurred as a result of injection of the vaccine during this period. In 1942, due to demand for greater quantities, it became necessary to use samples of supposedly normal human serum from blood-bank pools. A short while later, jaundice occurred in individuals who received vaccine containing such serum.

MacCallum and Bauer injected human volunteers with samples of the same batches of serum used for the vaccine and proved for the first time that the serum was responsible for the vaccine jaundice. The pool of serum readily produced jaundice when inoculated subcutaneously but not when inoculated intranasally in small groups of recipients. Multiplication of the agent in tissue cultures of minced chick embryo and serum tyrode could not be demonstrated.

Some of the cases of jaundice which occurred as a result of injection of the icterogenic vaccine were seen by Findlay and Martin in West Africa. They inoculated the nasopharyngeal washings from 4 of these patients into 4 volunteers. Three of the 4 recipients were considered to have developed mild jaundice after an interval of 28, 30 and 50 days respectively. MacCallum, Stewart and Bradley failed to produce any evidence of hepatitis in 20 individuals who received a 5·0 c.cm. dose of an icterogenic pool by either the nasal or oral routes. This same pool produced hepatitis in approximately 50 per cent. of individuals who received it by the intradermal, intravenous, or subcutaneous routes. The agent present in the icterogenic measles convalescent serum described by MacNalty in 1937, was resistant to phenol. The agent in the present icterogenic serum survived heating at 56° C. for one hour in a water-bath.

The agent in this batch of serum was not inactivated by triple ether extraction in the cold, and attempts to inactivate it by exposure to ultra-violet light were unsatisfactory. In one experiment, using a lamp which provided 80 per cent. of its energy at 2537°A. inactivation did not take place. In this experiment the layer of exposed serum was probably too deep for complete penetration of inactivating rays. In a second experiment, where the lamp used provided 95 per cent. at 2536°A. one of 10 recipients became jaundiced. Examination of the irradiated serum by Kerwick by electrophoresis revealed that gross changes had occurred in the proteins. A very small residue of probably unchanged gamma globulin was detectable. The exposure here was probably longer than necessary for inactivation as shown by American experiments. Recent experiments in U.S.A. indicate that an icterogenic agent in human serum was inactivated by ultra-violet light when the serum was flowing in a very thin layer.

Immunity

As a result of re-inoculation, accidental or experimental, with material from either infective hepatitis or homologous serum hepatitis or natural exposure to these diseases, a certain amount of knowledge has been gained concerning the homologous and heterologous immunity in these two diseases. MacCallum and Bauer (1944), using an icterogenic agent from a pool of sera, failed to infect 10 individuals convalescent from serum hepatitis but infected one of 2 men who had recovered six months previously from infective hepatitis and also the only normal control injected. MacCallum, Stewart and Bradley (1939) re-infected both the individuals who were six months convalescent from experimental serum hepatitis when they re-inoculated them subcutaneously with serum from a case of infective hepatitis. Neefe, Stokes and Gellis (1945) in the U.S.A. used two groups of 6 and 8 volunteers in two sets of conclusive experiments. They used strains of infective hepatitis and homologous serum hepatitis which had high attack rates. The members of each group receiving one of the two agents became infected; after six months' convalescence they were re-inoculated with the same agent; after a further six months' convalescence they were inoculated with the second agent. These groups showed complete immunity to re-inoculation with the homologous agent, but none to the heterologous.

Though some pools of serum may contain the virus of infective hepatitis it seems probable that the agent causing homologous serum hepatitis is usually not the same as that causing infective hepatitis. No method of detecting the presence of the agent in a pool of serum is known except inoculation into human volunteers.

Syringe-transmitted Hepatitis

It will be seen from the above that apparently normal individuals may harbour an icterogenic agent in their blood which can reproduce the disease in susceptibles when injected in very small amounts. Further application of this knowledge provided an explanation of the cause of certain outbreaks of jaundice in groups of people receiving injections or venepunctures in clinics for various reasons.

In the years 1939–45, hepatitis, a known hazard of arsenotherapy, became a much more serious problem in certain clinics when large numbers of patients were having venepuncture done and receiving subcutaneous, intramuscular or intravenous injections of therapeutic substances. This was the case in certain diabetes-clinics, sanatoria, and arthritis-clinics, but it was particularly true in the venereal disease treatment clinics for Service personnel. Here the hepatitis was confined to syphilitic patients who for some months had been receiving weekly intravenous injections of arsenical preparations. (Before the injection was made, a few drops of blood were aspirated into the syringe to ensure that the needle was in the vein.) In each of these venereal disease treatment centres, a practicable system had had to be improvised quickly to deal with a large stream of men attending for intravenous therapy. Apparatus was scarce and syringes were easily broken during boiling, so the sterilisation technique between patients was usually reduced to a thorough wash of the blood-contaminated syringe in running water. This was generally assumed to be adequate in the particularly difficult circumstances, as no septic complications were noted and the possibility of syringe transmission of diseases other than sepsis was scarcely considered. The incidence of hepatitis gradually rose to 30 per cent. of syphilitic patients and in certain centres was about twice this figure. From observations of the existing conditions, laboratory experiment, and theoretical considerations, it was suggested by Bigger and by MacCallum that this hepatitis was being transmitted in the course of venepuncture and intravenous injections. It soon became clear that this explanation was the correct one.

On investigation, it was found that the incidence of hepatitis tended to be very low in venereal disease clinics where the syringes were sterilised between patients, whereas it tended to be high in clinics where the syringes were merely washed. This evidence was unfortunately obscured and complicated by the frequent transfer of Service personnel from one clinic to another, so that patients who had already been infected in one clinic were liable to develop their jaundice after they had been under treatment for several weeks at the second clinic. An outbreak of hepatitis in a camp for syphilitic prisoners-of-war in 1943 gave clearer evidence on the matter :—

> The 34 prisoners formed a closed community and lived together under the same feeding and sleeping arrangements. For convenience they were however, divided into two equal and unvaried groups for intravenous therapy. The syringes and apparatus were thoroughly sterilised between the treatment of the two groups, but they were not sterilised between the injections of the individual patients in either group. It so happened that an already infected man was included in one of the groups. He developed jaundice a few weeks later but by this time the 16 other men in his group had received injections with syringes contaminated with his blood. After the usual incubation period, 8 of these 16 men developed hepatitis. There were no cases of hepatitis among the 17 men of the other group who had been protected by the sterilisation of the syringes between the treatment of the two groups (Sheehan, 1944).

In view of other evidence of a similar nature, two small clinical trials were made in which syphilitic patients were given all their intravenous therapy, from the very first injection, with carefully sterilised syringes and apparatus (Sheehan, 1944; Salaman *et al.*, 1944). These trials were small, because many of the original patients were posted elsewhere before they had been under observation long enough. However, the results in the remainder were so good that a large-scale trial was undertaken, with War Office co-operation, to avoid movement of the patients. In this very conclusive investigation (Laird, 1946) 167 patients were given all their intravenous therapy with careful sterile precautions. Only one doubtful case of jaundice developed in the group, though, in the same centre, hepatitis occurred in about one-third of the patients who came to the centre after having had non-sterile treatment in other clinics.

Syringe-transmitted hepatitis was noted to develop in about 70 to 120 days after the first potentially infected injection. From the study of the records of the dates and times of the intravenous injections of such patients, it was, in a number of special cases, possible to fix with a fair degree of certainty, the exact date of the infection, and to identify the other patient whose blood had transmitted the infection. The transmitting patient usually developed his jaundice about twenty to sixty days after he had transmitted the infection, so that his blood must have been highly infectious from very early in the incubation period (Sheehan, 1944).

This high infectivity of the blood throughout the long incubation period accounts adequately for the progressive increase of hepatitis in groups of men attending every week for intravenous injections in venereal disease treatment centres. In certain clinics the syringes must have been almost continuously contaminated and almost all the patients must have been exposed to infection. There is little evidence as to the infectivity of the blood of patients who have received the icterogenic agent in this way, but are destined not to develop clinical evidence of hepatitis; the possibility of such symptomless carriers cannot be excluded. Most patients who developed jaundice were given no intravenous injections until they had recovered and were thus not a source of syringe infection. As yet, little is known about the possible infectivity of the blood in patients who have had jaundice a few months previously. There is, however, no doubt that the really significant source of infection in venereal disease treatment centres during the war was the blood of men during the symptomless incubation period of the hepatitis.

MacCallum (1945) demonstrated that an icterogenic agent was, in fact, present in the blood of two icteric cases at two different venereal disease treatment centres and that the arsenical preparation *per se* apparently played little or no part in the production of hepatitis. The identity of the agent, whether that of infective hepatitis or homologous serum hepatitis, was not determined, but one of the icteric donors had completely recovered from an attack of infective hepatitis twelve months previously. Seventeen volunteers were injected intranasally and orally with nasopharyngeal and throat washings collected early in the pre-icteric and icteric stages from seven cases induced by the injection of one of the above sera. Two of the recipients developed jaundice after an interval of about 100 days. Faeces from the original two donors of serum and from the induced cases failed to produce hepatitis when given by the oral route to twenty volunteers.

That the arsenical preparation is a minor factor in the production of such cases has been amply demonstrated by the occurrence of cases in individuals being treated with penicillin in venereal disease treatment centres and surgical wards. In any particular case of suspected syringe-transmitted hepatitis there are always the possibilities that the agent may be that of either homologous serum hepatitis or infective hepatitis and that infection may have occurred either by injection of icterogenic blood or contact in the clinic or outside. The statistical probabilities in England and Wales have been discussed by Bradley (1946) who concluded that when hepatitis occurs 40 to 120 days after the administration of a human blood product, or other parenteral therapy, it is almost certainly homologous serum jaundice. The biochemistry and pathology have been shown to be essentially the same as in infective hepatitis but there may be immunological differences (Miles, 1944).

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APPENDIX

Royal Air Force (Total Force)

Infective Hepatitis (Catarrhal Jaundice)

Rates per 1,000 of Strength per Annum (Based on Annual Health Reports)

Year	Under 20	By age-groups						Total force	Officers		Airmen		Home	Overseas
		20–24	25–29	30–34	35–39	40–44	45 and over		G.D. branch	Other officers	Aircrew	Other airmen		
1939	1·9	1·3	1·2	1·2	0·4	0·1	—	1·5	5·8	2·8	0·9	1·3	0·7	6·9
1940	1·2	1·0	1·2	0·9	0·6	0·3	0·2	1·2	5·6	2·7	1·3	1·0	0·8	4·9
1941	4·4	3·0	2·6	1·3	1·2	1·2	1·2	2·4	10·6	4·7	2·1	2·2	1·3	10·3
1942	11·0	7·0	5·3	3·2	2·0	1·3	0·9	5·1	9·3	5·5	4·1	5·1	2·1	15·0
1943	9·7	16·1	13·1	8·1	5·7	3·7	3·0	11·6	22·2	16·0	10·0	11·2	3·0	29·9
1944	10·7	17·9	12·8	8·3	6·4	4·0	2·2	12·1	16·4	14·1	8·7	12·3	2·8	32·1
1945	15·1	11·3	5·2	5·8	4·4	2·2	1·0	7·0	8·4	9·6	8·9	6·8	3·1	15·5

NOTE: (1) The steadily decreasing incidence with age shown each year from 1939 to 1945.

(2) The increasing incidence up till 1944 affecting chiefly oversea personnel.

(3) The marked difference in incidence between the air crew (G.D.) Officers and the ground officers which is *not* shown in air crew airmen and ground airmen.

(4) The changing rates in the two Officer groups, during the early and later years of the war may be due to the fact that younger officers were in the later years returned to or retained in this country during the invasion of Europe, so that the proportion of the younger age-group to the older one oversea was changing considerably.

CHAPTER X

(i)

Neurology

Collated from various contributions

By V. ZACHARY COPE
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War on the modern scale subjects millions of men to the hazard of sudden and severe changes of climate and occupation, exposure to trying physical conditions and, on occasion, to severe restriction of diet and exposure to unwonted infections. All of these factors may directly or indirectly affect the central nervous system or the peripheral nerves and it was not surprising that many new features and facts were observed in the course of the war. These may briefly be considered under the following heads:—

Infections
- Virus infections
  - Poliomyelitis
  - Lymphocytic meningitis
  - Neurological complications of atypical pneumonia
- Bacterial infections
- Meningitis: pneumococcal
  meningococcal
- Polyneuritis: post-diphtheritic
  post-enteric
  post-dysenteric
- Neurological complications of relapsing fever
  and typhus fever

Localised neuritis of the shoulder-girdle

Heat stroke

Nutritional disorders of the nervous system in prisoners-of-war

(NOTE: The value of electro-encephalography in the diagnosis of epilepsy and of other cerebral lesions is discussed in the section at the end of the article on Neurosurgery in the volume on 'Surgery' in this series.)

VIRUS INFECTIONS

Poliomyelitis

Although the incidence of *acute poliomyelitis* did not increase in the United Kingdom, views on the mode and route of infection underwent a change. Previously it had been accepted that the disease passed from one to another by means of infective droplets. The primary focus of infection was thought to be in the nasopharynx from which part the virus passed to the anterior horn cells by axonal routes. There was experimental work to support the view that infection entered via the olfactory nerves and bulb. Yet the seasonal incidence of the disease—the late summer and early autumn—did not support this view since droplet-spread infections occurred in winter and early spring. It had been known for years (Ruhrah and Mayer, 1917) that the virus could dwell in the alimentary tract, and Toomey (1931, 1934, 1940) had more recently confirmed that the virus of the disease could be obtained from the faeces of infected persons. Just before the war and during its course several observers (Trask, Vignec and Paul, 1938; Trask, Paul, and Vignec, 1940; Melnick, 1943) not only confirmed this but isolated the virus from the sewage in the neighbourhood of local epidemics. These and similar observations showed that, though droplet infection might happen, one also had to reckon with the probability of infection via the alimentary tract. Bedson (1943) summed up this point of view as follows:—

> 'Contrary to our previous beliefs, poliomyelitis is acquired mainly if not entirely by the alimentary route, the virus reaching man indirectly through the agency of contaminated food, milk and possibly water. In any case the recognition of the importance of the alimentary tract as a portal of entry of infection necessitates a recasting of our views of the epidemiology of poliomyelitis and of the measures we may take for its control.'

On the other hand, there were many who took the view that alimentary infection was not quite so important. This view was well expressed by Seddon who (in 1947) wrote:—

> 'The poliomyelitis virus attacks the body either through the throat or the alimentary canal. This is what we call the portal of entry, but it must not be supposed that the inhalation or ingestion of the virus invariably causes the disease. It is usually spread by droplet infection, but it is conceivable that it might be contracted from the ingestion of infected food or fluid, such as water or milk.'

Some evidence has been put forward that flies may act as vectors of the virus.

In the Middle East and India the disease was of greater importance. In the latter country there was a mortality ranging from 18 to 30 per cent. Prodromal symptoms lasted from two to ten days. Sometimes the symptoms cleared up only to return again after two or three days. The prodromal symptoms were either of the influenzal, catarrhal, or gastro-intestinal types. In the majority of cases the lower dorsal and lumbo-sacral regions of the cord were involved and the muscles acting on the hip and knee were more affected than the distal muscles. Half the cases had temporary retention of urine. Some cases had localised paralysis, in one instance limited to the masseters and in another to the sterno-mastoid muscles. In about 5 per cent. of the cases the cerebro-spinal fluid was normal either during the meningitic or the paralytic phase of the disease. Pain was frequently felt in the paralysed limb and needed local heat and analgesics for its relief.

It was noteworthy that poliomyelitis was rare among Indian troops.

The incidence of poliomyelitis among the troops in India was significant. In 1941 one case only was reported. In the succeeding three years the incidence per 1,000 and the case fatality are shown (McAlpine, 1945) in the following table:—

Year	British officers	British other ranks	Indian troops	Case fatality per cent. (British)
1942	1·7	0·3	0·01	17·0
1943	0·5	0·1	0·01	33·0
1944	1·4	0·3	0·01	30·0

It will be noted that the incidence among British officers was almost five times that in other ranks.

Poliomyelitis was rife among the British, Dominion and American troops in Egypt between 1940 and 1943. The incidence among British troops in 1943 was 0·31 per 1,000 and in 1944 it rose to 0·42 per 1,000. There was no evidence that there was an increase in the number of cases among the Egyptian civilian population.

In Malta and Gozo an epidemic occurred in 1942–3, although for the previous forty years no similar epidemic had been reported. Nevertheless, for many years sporadic cases had occurred among the civil population, for between 1921 and 1941 as many as 61 cases of poliomyelitis were recorded in Malta. The first known cases of the epidemic occurred among civilians on November 15, 1942, in Malta, on November 21 in Gozo and on November 27 in the Services. The peak was reached in the week beginning December 20, and by March, 1943, the epidemic was over, though a few sporadic cases occurred later. There were 426 civilian and 57 Service cases. Of the civilians there were only 6 cases over the age of 10; only 4 Maltese adults were attacked. The civilian fatality rate was 3·7 per cent., but that among the Services was higher—19·3 per cent. (Seddon *et al.*, 1945). No Maltese troops were affected. (Bernstein, Clark and Tunbridge reported on the Service cases, 1945.)

Of the 57 Service cases, 2 were from the Royal Navy, 27 from the Army and 28 from the R.A.F. The incidence was proportionately higher among the R.A.F. than among the Army personnel. The duration of service in Malta appeared to bear no relation to the disease. The duration of the pre-paralytic stage varied from one day (or less) up to eight days with an average of 3·4 days. By routine examination of the cerebro-spinal fluid of suspected cases complaining of headache and fever during the peak period of the epidemic there were two definite cases recorded in which no paralysis ensued. The pre-paralytic symptoms were recorded by Bernstein, Clark and Tunbridge (1945) as follows:—

Pre-Paralytic Symptoms in 53 Cases

Headache	45	Anorexia	8
Muscle weakness	26	Vomiting	6
Pain in back	21	Lassitude	6
„ „ neck	14	Urinary symptoms	5
„ „ limbs	13	Abdominal pain	4
Malaise	14	Dysphagia	3
Sore throat and coryza	13	Weakness of eyes	2
Shivering attack	11	Miscellaneous	5

Pyrexia ranged from 98·8 to 104° F. and lasted up to a maximum of 8 days. About half the patients complained of weakness of a limb or other part of the body before admission, but the degree of paralysis was in many cases not maximal for some days.

Cases with Delayed Spread of Paresis

	Cases		*Cases*
2 days	2	6 days	1
3 „	3	9 „	1
4 „	3	10 „	1
5 „	2		

(In 8 cases, delayed 4 days and over.)

Respiratory paralysis occurred in 16 cases. The initial symptom was an inability to take a deep breath and the earliest sign was a weakness of the cough reflex. The later the development of respiratory symptoms the greater was the prospect of recovery. Nystagmus was noted in 10 cases, but, except in fatal cases, rapidly disappeared. The cerebro-spinal fluid findings, taken together with the clinical history and the distribution of the paralysis, were sufficient to establish the diagnosis. Convalescent serum and sulphadiazine were used in a few of the cases in Malta without any apparent benefit. Bernstein and his colleagues expressed the opinion, based upon their experience at Malta, that for a small outbreak it would be better to centralise treatment and if necessary transfer patients in the initial stages, if necessary by air, to a centre adequately supplied with respirators and full physio-therapeutic facilities rather than to transport respirators. (See the *Civilian Health and Medical Services*, Volume II, Part I, Chapter II.)

Among the troops of the British North African and Central Mediterranean Force many cases of poliomyelitis occurred in 1943–4. Here also the incidence was much higher among officers; in India the disease tended to spread among the young men who had served in the theatre for less than two years. In India and the Middle East many cases with mild symptoms but changes in the cerebro-spinal fluid occurred and were called abortive cases. Sometimes the virus was found in the stools of persons whose cerebro-spinal fluid was normal and who showed no symptoms. Various views were put forward to account for the greater incidence of the disease among the British officers than among the other ranks in India and the Mediterranean theatres of war. One reason suggested to account for the lower degree of immunity among officers was the possibility of their having been less exposed to infection in childhood in their (presumed) better social scale and environment. This view had little support. McAlpine (1945) came to the conclusion that the main reasons were the differences in the personal habits and feeding conditions between officers and other ranks. In the officers' messes under war conditions inspections were more irregular and perfunctory than in the messes of other ranks. Moreover the officers used restaurants and hotels and were more exposed to infection by visits to civilian establishments in which the sanitary conditions were often far from satisfactory. The occurrence of small focal outbreaks often seemed to result from simultaneous acute infection from one insanitary source, and gave support to the view that the alimentary tract was the usual portal of entry for the virus. If the above views be accepted the appropriate prophylactic measures are obvious.

An interesting light on the incubation period of poliomyelitis was furnished by the outbreak in the Island of St. Helena in 1945–6 (Nissen, 1947). Prior to that date there had been no recorded case for more than a hundred years. The last ship to call at the island before the epidemic was a transport which came from South Africa where poliomyelitis was common at the time. A corporal on board obtained permission to visit his fiancée who, one day later, developed a fatal attack of poliomyelitis. From this time the epidemic increased, reached a peak in two weeks and spent itself gradually over a period of six weeks. The symptoms were in most cases fairly typical but two noteworthy signs were observed. The first was the colour of the tongue which, though moist and clean, was of a bluish-grey appearance—a shade like that obtained by pouring milk into blackcurrant juice; round the margins were small macules which sometimes became confluent. This appearance was seen in all the paralysed cases and lasted for two weeks.

The other characteristic feature was the odour of the faeces which was said to be like that of rotting vegetables; the odour was independent of consistency and persisted for several days after the fall in temperature. The disease chiefly attacked those between the ages of 5 and 19 years. About 5·4 per cent. of the population were attacked but only about a fifth of those attacked were paralysed. There were 11 fatal cases out of the 217 patients.

Lymphocytic Meningitis

From 1941 onwards a considerable number of cases of meningitis of the lymphocytic type were seen in the Middle East. They presented the symptoms of malaise, fever, headache, vomiting and prostration with slight neck-stiffness but negative Kernig's sign. The fever lasted five days, recovery was rapid and no organic sequelae occurred. The cause and method of spread were equally doubtful.

Neurological Complications of Atypical Pneumonia

In 1943 Campbell and his colleagues recorded a case of ascending flaccid paralysis which occurred in the course of a fatal case of atypical pneumonia; at necropsy there was extensive perivascular necrosis infiltrated with polymorphonuclear leucocytes. There were fibrin thrombi in the vessels and overlying neutrophilic meningitis. Perrone and Wright in 1943 described a case of encephalitis which complicated a case of atypical primary pneumonia. Such cases were very exceptional.

BACTERIAL INFECTIONS

Pneumococcal meningitis. Perhaps the most remarkable advance in neurological treatment was the discovery that pneumococcal infection of the brain and spinal cord was capable of cure by means of penicillin. In 1944 Cairns and his colleagues published a record of 16 cases of pneumococcal meningitis treated by lumbar or ventricular, and intravenous or intramuscular injection of penicillin with 12 recoveries. Though some of the cases had also been given sulphonamides there was no doubt as to the predominant effect of penicillin, which was soon confirmed in other quarters. This hitherto almost invariably fatal disease was thus converted into a curable complaint.

Cerebro-spinal meningitis due to the meningococcus as it occurred in Northern Europe and the United Kingdom has been well dealt with in Chapter VI and the remarkably successful treatment by the sulphonamides has been described. In the Middle East and India it was seldom seen among British or Dominion troops but was common among the Indian and African troops. McAlpine (1946) mentions that during the first ten months of 1943, 1,700 cases were notified with a mortality-rate exceeding 15 per cent.

Meningitis and meningo-encephalitis also occurred, particularly in the Western Desert, in the course of tick-borne relapsing fever due to *Sp. recurrentis* or *persica*. The meningitis occurred from as early as the second to as late as the eighth relapse of fever. The cerebro-spinal fluid sometimes showed a paretic colloidal gold curve and a positive Wassermann reaction. A good account of these complications was written by

Dr. Allan S. Walker (1948) for the Australian History. It is included here by permission.

> 'The nervous system bore the brunt of most of the complications. Rigidity of the neck during the febrile stage and a degree of meningismus were regarded as part of the clinical picture; some actual involvement of the meninges was common. Cranial nerve affections were not uncommon; sometimes these were not seen till months after the original. The commonest was facial palsy which was occasionally bilateral. As a rule it resolved, but some permanent residual paralysis has been observed. Lesions of the 3rd, 4th and 6th cranial nerves were occasionally seen causing ptosis or affection of eye movements. The 5th and 8th have been affected too in some epidemics but there do not seem to have been any such lesions observed in Australian soldiers. The frequency of these complications varied considerably in different areas. Cooper (1942), out of 63 men treated for relapsing fever in Tobruk, saw 7 facial palsies, and in addition, 13 instances of meningeal involvement. Adler (1937) only found 2 patients with neurological complications out of 45 seen in Palestine before the war, but Scott (1944) in experiences with the R.A.M.C. found 9 out of 41. One of his patients was an Australian soldier who had right abducens palsy with meningitis; the man later had an upper motor neurone lesion affecting his left leg but some months later appeared to have made a complete recovery. Papillitis was seen in a few cases in association with encephalitic symptoms; it too resolved and no optic atrophy was observed.
>
> 'The predilection of the infecting spirochaete for the nervous system is shown by the observations on the cerebro-spinal fluid. Lumbar puncture during the febrile period frequently showed the fluid to be under increased pressure. A pleocytosis was observed in about half the cases, and was often associated with moderate increase in the protein content of the fluid. The cellular increase was due to lymphocytes but in some instances a small number of polymorphonuclear cells was found too. On a few occasions the cell-count of the fluid reached over 400 per cubic millilitre. Such changes were more frequently seen in patients showing signs of involvement of the nervous system. Occasionally spirochaetes were demonstrated in the cerebro-spinal fluid.'

Nervous symptoms very frequently occurred in connexion with mite-borne typhus fever. These were also well described by Dr. Allan S. Walker (1948) from whose account the following extract has been made by kind permission.

> 'Symptoms referable to the nervous system were universally present in all but the mildest infections. It was thought that even in the first few days the mental state of some patients was not normal being unduly euphoric. Towards the end of the first week the rather peevish apathy which characterised most patients at that stage gave way to depression or to a confusional state. Delusions and hallucinations were common. Seriously ill patients often were stuporous and inert, the chief problem of nursing being the administration of food, but others were constantly restless and trying to get out of bed. An increase of cerebro-spinal fluid pressure was commonly associated with headache and neck stiffness which were relieved

by lumbar puncture. The pressure was raised to over 150–160 millimetres in a small proportion and in a few instances cells and protein were also moderately increased. The chloride content was decreased below 700 milligrammes in more than half a series examined, which included some of the more severe infections. These abnormalities were more commonly found in patients in whom other neurological changes were present.

'Affection of the 8th cranial nerve was frequently seen, in about a sixth of the series. It usually took the form of nerve deafness, and rarely tinnitus; it was variable in degree and mostly bilateral. Recovery was practically always complete and rapid during convalescence though in one instance the deafness was complete and did not recover. Reflex changes were very common; both deep and superficial reflexes were temporarily in abeyance during florid illness. Peripheral loss of motor and of sensory function were both observed in a few patients. The latter appeared to be of the nature of a peripheral neuritis affecting cutaneous sensory nerves of the limb such as the ulnar nerve. Pareses of muscles were more difficult to evaluate, since a number of localised peripheral palsies were seen in troops especially at the time when the first large series was studied. Whether these were always due to typhus or were due to neuronitis possibly of virus cause is uncertain. Scapulohumeral and serratus magnus paralyses were seen among others; instances of these and other types such as peroneal were observed among men who had not had typhus.

'Muscular tremor, sometimes of the Parkinsonian type was prominent during the illness in a few patients. The condition was apparently of central origin and did not persist. Muscular fibrillation and wasting over a wide area of the body was observed in convalescence in a few patients. This state was slow in resolving. In several instances vascular accidents occurred in the cerebral and retinal vessels. The former caused hemiparetic signs with some disturbances of higher cerebral functions.

'In the brain round-celled infiltration was prominent but perivascular cuffing was unusual. Meningeal infiltration was seen in a few instances and occasionally thrombosis of small cerebral vessels. Small haemorrhages were sometimes seen in the brain. In general the changes of a meningo-encephalitis could be produced by this disease.

'A definite risk incurred in the care of a patient with scrub typhus was the production of a circulatory and particularly a cardiac neurosis. It is curious that this has been observed all over the world, no doubt because of the striking circulatory phenomena and the known histological changes seen in fatal cases. Where undue caution has been observed in regulating the patient's activities in the early days of convalescence, for example where graduated exercise after severe illness has been apportioned too meticulously, the result has been to produce some variant of the effort syndrome.'

Occasionally symptoms suggesting an encephalomyelitis were seen in sand-fly fever. Encephalitis also sometimes occurred in dengue.

Polyneuritis

Post-diphtheritic polyneuritis was not uncommon in the Middle East. Though infection of wounds with the bacillus of diphtheria was rare, it was quite common to find various skin lesions with a secondary infection of this nature, and in several hundred cases of post-diphtheritic polyneuritis among British and Dominion troops in 1940–3 the infection was in many cases traced to such lesions. The organism responsible for the paralysis was found on various occasions on desert sores, jungle sores, the lesion of scabies or even on an infected pile or ingrowing toe-nail.

Sometimes the first evidence of the paralysis was loss of power of accommodation. The patient complained of inability to read because objects became blurred. If only distant sight were tested this loss of accommodation might be missed and the sufferer might even be thought to be malingering. A careful ophthalmic examination including tests for accommodation was needed to demonstrate the lesion.

LOCALISED NEURITIS OF THE SHOULDER-GIRDLE

A neurological condition to which little or no attention had been drawn prior to the war came into prominence during its course; this was a syndrome in which pain in the region of the shoulder girdle was followed by weakness and wasting of one or more muscles in that region. In 1942, Burnard and Fox, of the New Zealand Medical Corps published an account of 9 cases, and in the same year J. S. Richardson described 9 examples of serratus magnus palsy. The first clear account of the condition was given by J. D. Spillane (1943) who analysed and commented on 46 cases to which he gave the diagnosis 'localised neuritis of the shoulder-girdle'. In 1944 J. W. Aldren Turner wrote a paper based on 36 cases to which he gave the diagnosis 'acute brachial radiculitis', a term which was also used by G. Joly Dixon and T. B. S. Dick (1945) in their account of 16 similar cases. After the war (in 1948) a comprehensive article dealing with 136 cases was published by M. J. Parsonage and Aldren Turner who considered that a better term to apply to the syndrome would be 'neuralgic amyotrophy'. A remarkable fact is that more than half of Spillane's cases (26) and 66 out of the 136 cases recorded by Parsonage and Turner, were in hospital for other conditions when the shoulder-girdle syndrome appeared, and others had recently recovered from illnesses. Sometimes it followed a comparatively minor operation for hernia, varicocele or the like, or was a sequel to malaria, dysentery or other infection. In the few cases in which there had been any trauma there was a considerable interval before any neuritic symptom developed and no causal connexion could be established. Though several of the patients had comparatively recently received injections (TAB, emetine, etc.) in very few was there any likely relationship of cause and effect, though similar cases have been known to occur seven to ten days after injection of serum. In one of Parsonage and Turner's cases there was a possible relationship. A man under treatment for non-specific urethritis was given intravenous TAB to cause protein shock. Two hours later he developed severe pain across the back of both shoulders which lasted a few days. On the day after the injection he developed a complete paralysis of the left serratus magnus.

The clinical features of the condition were sufficiently characteristic. It began with sharp pain about the affected shoulder, and this pain might radiate down the arm as far as the elbow, and occasionally down the forearm or up into the side of the neck. Weakness about the shoulder-girdle usually followed in four or five days. Rarely the weakness was noted as early as the second day or after an interval of a few weeks. The most striking feature of the illness was the wasting of the affected muscles. Those most commonly involved were the serratus magnus, spinati, deltoid and trapezius. The condition was afebrile and there were none of the symptoms (headache, malaise, etc.) commonly associated with a general disorder. Sometimes the condition was bilateral. Parsonage and Turner said that in 21 out of their 136 cases it was impossible to explain the muscle involvement in terms of a peripheral lesion only; they considered that the spinal cord must have been affected in these cases. If the circumflex nerve were involved there was some anaesthesia over the region of the deltoid; in cases with radicular distribution of muscle weakness there was some slight sensory change down the outer side of the arm, forearm or side of the neck.

As to the differential diagnosis Spillane wisely commented:—

> 'If these patients are seen for the first time some months after the acute phase the malady might be mistaken for poliomyelitis; the end-result can be identical in both diseases. Consideration of a few features, however, should lead to the exclusion of poliomyelitis.
>
> (1) There is a striking absence of general signs of infection (such as fever and leucocytosis) and of signs of meningeal irritation.
>
> (2) Examinations of C.S.F. so far as they go, have yielded normal results; but further information is needed.
>
> (3) Diffuse hyperaesthesia, so characteristic of poliomyelitis in the acute phase, was not encountered, whereas definite cutaneous sensory loss of peripheral distribution was detected in 10 out of 17 cases where a mixed motor and sensory nerve was involved (for example, the circumflex).
>
> (4) The distribution of the paralysis about the shoulder-girdle took on a peripheral rather than a segmental character. In 19 patients one nerve only was impaired while the deltoid escaped in no less than 29—a very unusual finding in cervical poliomyelitis.
>
> (5) In 26 patients the illness developed while they were convalescing from some complaint—again an unusual finding in poliomyelitis.
>
> (6) It would be unlikely to expect so many cases of atypical localised cervical poliomyelitis in the absence of typical examples of the disease at about the same time in the same locality.'

There was not much difficulty in distinguishing the condition from brachial neuritis, prolapsed cervical intervertebral disk and progressive muscular atrophy.

The aetiology of this condition remained obscure. Its clinical features did not tally with any particular form of infection, but it has been suggested that it might be due to a virus. No particular specific treatment was evolved but the general principles of giving analgesics, of seeing that the paralysed muscles were rested in relaxation, and prescribing physiotherapeutic measures, were usually adopted. Recovery of the muscles was very slow in many cases, but Dixon and Dick followed up 16 cases and found that 10 of them showed complete functional recovery in from eight to eighteen months.

The similar condition which occasionally followed the injection of serum was much rarer than neuralgic amyotrophy. It might be preceded by generalised urticaria and usually developed seven to ten days after the injection. Parsonage and Turner saw 3 serum cases in the same period as they observed the 136 cases of the amyotrophy. They were characterised by severe pain across the shoulder and upper arm lasting several days and succeeded by an atrophic palsy usually involving the muscles supplied by C5 and C6 roots. It is not known whether the lesion is due to a virus infection introduced at the time of injection or to a perineural oedema of the affected nerve-roots.

HEAT-STROKE

In the War of 1914–18 during the campaigns in Iraq there were many deaths from heat-stroke during the hot season of each year when shade temperatures of 120° F. or over were sometimes reached. During the early part of that war there were few facilities for preventing or treating that condition and the death-rate was high. During the War of 1939–45 there were considerable fighting in North Africa, Abyssinia, Syria and Iraq, but heat-stroke was seldom such a bugbear as in the previous war, and facilities for treating it were more readily available.

During the course of the war many experimental investigations were undertaken to determine the physiological changes which took place in a hot environment with varying degrees of humidity. The primary and most important adjustment depended upon cardio-vascular adaptation to the new conditions and was measured by a diminished accumulation of heat as indicated by the rectal temperature. Taylor and his colleagues (1943) found that, on the average, adaptation to high temperatures was well started by the second day. After four days in the heat, work was continued in the heat with a pulse-rate and rectal temperature not far different from that attained during work in the cold. Little further change in pulse or temperature occurred from the fifth to the eighth day, but it was noted that one-half of the total increase in the rate of sweating during work took place after all adjustments in temperature (as recorded rectally) had taken place. They did not confirm the view that an increased capacity to sweat played an important part in adaptation to high temperatures, for the average daily sweat loss was not affected. Though the rate of sweating during work tended to increase, the major part of the change occurred after the adjustments of temperature and pulse were completed. They found that a failure of the work-pulse-rate to improve after the first day was a sign of impending heat exhaustion, and in the same way a poor cardio-vascular adjustment to change of posture was a danger sign. They could find no certain variable factor which would enable them to predict the ability to become acclimatised to heat.

Bean and Eichna (1943) similarly found that in experimentally produced hot desert conditions most men became acclimatised in four or five days. In describing the effects of heat there is not general agreement as to the various terms used. One of the clearest accounts is that given by T. C. Morton (1944) who distinguished three effects of heat :—syncope, heat exhaustion, and hyperpyrexia or heat-stroke proper. Syncope was merely a temporary cardio-vascular collapse without any lasting effects or alteration of urinary chlorides. Heat exhaustion occurred chiefly in thin nervous subjects who had rather low blood-pressure and usually followed a sedentary occupation. Many were teetotallers. The usual symptoms were nausea, vomiting, dizziness, constipation, muscle cramp, sweating and diminished amount of urine.

Hyperpyrexia might be preceded by malaise but the onset was often sudden and devastating. It occurred more commonly in fat men with a high blood-pressure. Sepsis and the taking of alcohol were predisposing factors. The temperature might rise to 108° F. or 110° F. and delirium and coma were common. Vomiting and convulsion might occur. The knee-jerks were usually diminished or lost. There was diminution of the urinary chloride. It was noted that heat had a cumulative effect. The greatest incidence of casualties occurred on the third or fourth day of a heat wave. There were lesser grades of affection by heat corresponding to a gradual derangement of the body chemistry. Headache, giddiness, insomnia, mental dullness or irritability might be the prelude to more serious effects and put one on guard to prevent heat-stroke.

A fourth type of heat affection was described by Wolkin, Goodman and Kelly (1944), who characterised it as a failure of the sweat mechanism. The patients were in the desert army, and after exposure to sunlight with or without physical exertion were taken with sudden onset of general weakness, an uncomfortable hot feeling, dizziness and headache. From the neck downwards the skin was warm and dry like goose-flesh and did not sweat although the face and head sweated profusely. Even after pilocarpine injections there was no sweating in the dry area. The mouth temperature was 99° F. This interesting condition responded to rest in cool surroundings and salt-therapy.

The post-mortem appearances of fatal cases of hyperpyrexial heat-stroke have been described by Sachs (1944), who found important changes in the brain and meninges. There were peripheral congestion and petechial haemorrhages in the brain and beneath the serous membranes. There was also intense congestion of the stomach and upper intestine, and the lungs were haemorrhagic. In the brain there was oedema, perivascular and perineural; and the vessels were swollen and hyaline with many thrombosed capillaries.

A knowledge of many of the factors which conduce to heat-stroke pointed the way to its prevention. Prophylactic measures were largely hygienic, dietetic and protective. It was important to see that men did not overwork in a hot climate or in any close hot place, such as an engine room. Adequate rest was essential. Some recommended starting work early in the morning so as to avoid the burning heat of midday. Men needed special care on arrival in a hot climate. During the hot weather of 1942 three-quarters of the cases of general effects of heat among troops in Persia and Iraq occurred about the time of disembarkation. The period of acclimatisation required special care. In humid climates the danger point was reached when the wet-bulb temperature rose to 83° F.

Dietetic measures included the provision of a sufficient fluid intake and sufficient salt to make up for that lost in the sweat. Alcohol was better avoided or taken sparingly.

There was difference of opinion as to the need for protective topees and spine pads. Some called them relics of superstition, but there was a considerable body of opinion which maintained that a light hat which afforded some protection to the nape of the neck was a decided advantage when exposed to the hot sun's more direct rays.

As for the actual treatment of any effect of heat it was essential to increase the intake of fluid and salt, either by drinks or by intravenous administration and, when hyperpyrexia was a feature of the case, to adopt the usual methods of reducing the temperature.

(See also Chapter I (i).)

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(ii)

Nutritional Disorders of the Nervous System

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It was known, of course, for many years that defective nutrition could result in disturbances in the human nervous system. Pellagra and beriberi were acknowledged to be examples of such disorders, and in both affections various neurological symptoms and signs had been noted from time to time. But in tropical climates it was also realised by some observers, before the war, that neurological syndromes, which could not be labelled pellagra or beriberi, sometimes arose among native populations subsisting on poor diets. Amblyopia and ataxia of spinal origin had been described in West Africa and in the Far East. In Spain, also, during the Civil War of 1936–9, various nervous disturbances arose among the famished population of Madrid.

But until the war this knowledge was not widely appreciated and in European medicine nutritional disorders of the nervous system did not figure to any extent. During the war, however, thousands of captives in the Middle East and Far East developed neurological syndromes which were partly or wholly due to defective nutrition. No such syndromes were described among captives in the United Kingdom or Continental Europe. Starvation certainly occurred in innumerable camps in Germany, France, Poland and Russia, but distinctive neurological disorders such as arose in the camps of the Far East and Middle East have not been described. The first published indication that such neurological syndromes were arising came from the statements of medical witnesses repatriated to Canada from Japanese internment camps in the Philippines (Adolph *et al.*, and Whiteacre) in 1944. They recorded that in some camps there were outbreaks of pellagra, beriberi, ariboflavinosis, and obscure amblyopia with central scotomata.

Meanwhile, in the Middle East, other observers were studying the nature of certain neurological affections which arose among Polish refugees and among German and Italian prisoners-of-war. In 1942–3, among refugee Poles in Palestine, Spillane (1945, 1946 and 1947) noted the occurrence of nutritional polyneuritis and Wernicke's encephalopathy. In 1944, in a Middle East camp for German prisoners-of-war, such affections as amblyopia with central scotomata, deafness, sensory ataxia of spinal origin, ' burning feet' and laryngeal paralysis were all recorded (Spillane and Scott, 1945). It was concluded that these neurological disturbances were a result of defective nutrition.

Later, in the Spring of 1945, when the Allied Forces retook Rangoon and Manila, British prisoners-of-war were released and repatriated to the United Kingdom. Their numbers were not large, yet identical neurological disorders were encountered among them, and recorded by Spillane in September, 1945. Finally, with the surrender of the Japanese Forces in August, 1945, evidence rapidly accumulated that the prison camps were rife with disease and malnutrition. Besides the classical types of pellagra and beriberi there were thousands of cases of amblyopia, and many of ataxia, deafness, 'burning feet', laryngeal paralysis, Wernicke's encephalopathy and spastic paralysis of the lower limbs.

THE MIDDLE EAST

In the Middle East there were two groups of people who developed nutritional disorders of the nervous system: Polish refugees and German and Italian prisoners-of-war. The Poles were subject to polyneuritis and there were some cases also of Wernicke's encephalopathy. In certain German and Italian prisoner-of-war camps different cranial and spinal syndromes arose. In addition there was a curious outbreak of a nervous disorder in Aden which was traced to the ingestion of a poisonous weed.

Nutritional Polyneuritis in Polish Refugees

During 1942–3 Polish troops and refugees filled many of the camps and hospitals of Paiforce and Palestine on their evacuation from Russia. Most of them had escaped into or had been transported to Russia in the winter of 1939–40. For two years they endured considerable hardships there and after the German invasion many of them were transported across the Caucasus to Iran, Iraq and Palestine. Dysentery, malaria and typhoid were very common among them. Many were tuberculous. Malnutrition was widespread. Glossitis, oedema of the ankles, chronic diarrhoea and loss of flesh were commonly seen. A few had scurvy.

Many of them had polyneuritis. Two types of case were encountered. In the first and largest group symptoms dated back some six or twelve months. Difficulty in walking was the earliest complaint. Sharp pains in the soles of the feet and in the calf muscles would arrest progress and force the patient to rest. Affected individuals found difficulty in keeping their feet warm, painful dysaesthesiae distressed them, especially at night. Muscle tenderness, weakness, wasting, sensory loss and reflex disturbances subsequently made their appearance in many cases. In the second group the onset of paralysis was quite rapid. It almost always occurred during or shortly after an acute infective illness such as malaria, dysentery or typhoid fever. Polyneuritis among British soldiers with such infections was rarely encountered. Post-diphtheritic and acute infective polyneuritis among these Poles were readily excluded.

It appeared that a mild degree of chronic polyneuritis was common and that such infections as they frequently suffered acted as 'the last straw' and peripheral paralysis ensued. Some of these patients were already receiving vitamin supplements when they were studied and general dietetic measures were already started. Many others were observed from the outset. The results of treatment were not very dissimilar whether intensive vitamin-B therapy had been tried or not. Rest and a good nourishing diet were equally effective, as judged by return of power, reflexes and sensation. But thiamin was sometimes of value in relieving pain, dysaesthesiae and tenderness. In other cases it stimulated appetite and promoted a feeling of well-being. Thiamin did not presumably hasten the remyelinization of affected peripheral nerves.

Wernicke's Encephalopathy in Polish Refugees

There were also cases of Wernicke's encephalopathy among this group of Polish patients. Four of them also had symptoms and signs of polyneuritis. The classical type of case was uncommon (three cases confirmed post-mortem) but typical manifestations of the syndrome occurred. In 5 cases the onset of stupor, confusion and ophthalmoplegia was not acute. They tended to develop over a period of a few weeks and were invariably associated with vomiting with or without diarrhoea.

All four patients with this subacute form of the illness recovered, one of them without thiamin. They were all given a nourishing diet, supplemented with yeast, marmite and in two cases with nicotinic acid orally. Thiamin (100 mg. intramuscularly, daily) in three cases led to rapid improvement. Confusion lessened and the patient began to take note of his surroundings. Increase of the range of his eye movements was recorded in three or four days. Nystagmus, which was present in all these patients, subsided simultaneously. Some diplopia and blurring of vision persisted longer. Ataxia and inco-ordination of movement were inconstant signs and did not depend on the degree of any associated polyneuritis. Neither did it respond so significantly to thiamin.

Post-mortem examination in a few cases of this disease revealed characteristic vascular changes in the midbrain and hypothalmic region. The mamillary bodies were always affected.

German, Italian and Native Prisoners-of-War

As in the War of 1914–18 there were periodic outbreaks of deficiency diseases in refugee, internee, and prisoner-of-war camps in the Middle East. Beriberi was never encountered but periodically there were epidemics of pellagra, glossitis, stomatitis, scurvy and night-blindness. In the majority of the camps dysentery and malaria were common and deficiency diseases were usually well controlled. Nutritional neuropathy occurred in some camps and became a special problem in Camp 306 in the Canal Zone (Spillane, 1947). This camp contained about 10,000 German prisoners taken largely after the battle of El Alamein. Infective hepatitis and dysentery were widespread in the Afrika Korps and many of the prisoners were in poor condition when captured. In December, 1942, there was an outbreak of pellagra in Camp 306 and approximately 500 men were affected. Chronic oedema of the legs and polyneuritis were also observed. There was no further outbreak of pellagra in the camp during the years 1942–5, but sporadic cases cropped out. Scrotal dermatitis and glossitis were rare complaints. It was in this camp, during the following two years, that the type of nutritional neuropathy described by Spillane and Scott (1945) was observed. It was also seen in other camps—but to a small extent.

The first cases were seen in August, 1944, but investigation showed that symptoms began in the most chronic cases as early as June, 1943—about six months after the outbreak of pellagra. The illness was afebrile, chronic and in many cases progressive. The majority retained fair general health, although loss of weight and lack of energy were common. Heart and lungs were not affected. Apart from diarrhoea which was so prevalent there was no indication that the gastro-intestinal tract was seriously involved. In the majority the skin was normal, but in certain cases there was some degree of folliculitis. The majority of patients had been captive for more than a year, many of them for two years.

The illness began with failing vision; sometimes this was acute, but in the majority it developed over a period of months. Tinnitus and the gradual onset of deafness frequently accompanied the loss of vision, but in several instances they appeared later. Paraesthesiae of the lower limbs was another characteristic complaint which in some cases was followed by ataxia. There were other occasional symptoms such as trigeminal hypoaesthesia, loss of the senses of taste and smell, and paresis of the vocal cords. These neurological disturbances were combined as follows:—

Retrobulbar neuritis only	73 cases.
Retrobulbar neuritis and sensory spinal ataxia .	24 cases.
Retrobulbar neuritis and nerve deafness . .	12 cases.
Retrobulbar neuritis and nerve deafness and ataxia	10 cases.
Ataxia only (one deaf)	4 cases.
Retrobulbar neuritis and ataxia and vocal cord paresis	3 cases.

There were only 4 of the above patients who did not have retrobulbar neuritis; 41 showed abnormal neurological signs in the lower limbs and 23 had some degree of bilateral nerve deafness.

Retrobulbar Neuritis

The main complaint was of difficulty in reading. As a rule, the onset was slow, and was described simply as a blurring of the print. Others complained of 'shimmering', 'spots before the eyes', or of gaps in words. Frontal headache was a common symptom but was not severe. In most cases deterioration of vision was steadily progressive over a period of 6 to 10 weeks, until reading became extremely difficult or impossible. In about a quarter of the cases, however, the onset was sudden. In a few vision became severely impaired overnight, 'as if a grey shadow had come before the eyes', but in the remainder the failure, although rapid, took six or seven days before reading became impossible. The visual defect usually developed simultaneously in both eyes and to an equal degree, but occasionally the symptoms appeared first in one eye and then a week or so later, in the other. With a few exceptions the pupils were equal and normal in size and reacted normally to light and accommodation. Occasionally there was slight dilatation of the pupils with a sluggish reaction to light. The conjunctiva, cornea, uveal tract, and retina showed no abnormality. No pathological changes were seen at the limbus. The pathological findings consisted of: (1) impairment of visual acuity; (2) mild papillitis or temporal pallor of the optic disks; and (3) changes in visual fields.

(1) *Visual acuity.* The visual defect varied very considerably, some showing relatively little impairment while in others acuity was reduced to less than 6/60. As already mentioned, progressive deterioration tended to occur during the first six to eight weeks. Vision sometimes improved a little during the next two to three months, but thereafter the more serious cases tended to deteriorate whereas the milder ones either remained unchanged or improved slightly.

(2) *Optic disks.* (*a*) *Relation to visual impairment.* With visual acuity of less than 6/60, half the cases showed well-marked pallor, but even in this group 7 per cent. had normal disks, the remainder showing either slight hyperaemia or slight temporal pallor. While pronounced pallor was commoner, therefore, in those with severe visual defects it was also observed in the presence of relatively good visual acuity, and (as one would expect with a retrobulbar lesion) severe visual defect was sometimes associated with normal disks.

(*b*) *Relation to duration of symptoms.* Hyperaemia of the disks was quite common in the early stages of the disease and rare in the later stages. Thus it occurred in about 34 per cent. of cases seen within the first three months, in 9 per cent. seen at four to six months, but in none seen after seven months. Temporal pallor, on the other hand, was more common in the later stages. Thus slight temporal pallor occurred in only 20 per cent. of those examined within six months of the onset, the disks being normal in 40 per cent. and hyperaemic but not pale in the remainder.

(3) *Visual fields.* The characteristic defect was a central scotoma. This was bilateral and demonstrable in all cases, although in a certain number (with visual acuity 6/18 or better) it was impossible to plot out the scotoma with any accuracy when the examination was carried out at 1 m. The use of a Bjerrum screen at 2 m. was essential for accurate diagnosis and the scotoma could then be demonstrated even in the earliest cases. The scotoma appears first as a minute central defect, 0·5° in size to a 2/2,000 white test-object and 2° in size to a 5/2,000 red, the vision in such a case being 6/9 partly and Jaeger 3 or 4. As the vision deteriorates the central core becomes larger, as does the zone of relative defect around it.

The peripheral fields were normal in 65 per cent. of cases, moderately contracted (10–20° less than the normal field) in 13 per cent., much contracted in 7 per cent., and grossly so in 6 per cent.

Paraesthesiae of Legs and Ataxy

In the majority paraesthesiae and ataxy developed at about the same time as the loss of vision, Sometimes they preceded the visual symptoms by one, two, or three months, while in others they followed at similar intervals. In only three cases were the upper limbs involved. Paraesthesiae were usually prominent before ataxy developed but disturbance of gait sometimes appeared insidiously. Many patients with retrobulbar neuritis complained of paraesthesiae without becoming ataxic.

The paraesthesiae nearly always began in the feet, burning sensations of the soles being the most common complaint. Tingling, pricking, numbness, and sensations of heat and cold in the feet and legs appeared later. Formication was often worse at night, and some patients were forced to sleep with their feet exposed because warmth aggravated their discomfort. Walking sometimes eased the discomfort as did bathing the feet in cold water. Many said that if they sat down their legs would go numb. Pain was not a prominent feature, although transient cramps and periodic aching of the calves were not infrequent.

Ataxic symptoms developed over a period of weeks or months. Some patients were unaware of their unsteadiness until their attention was drawn to it by others. Failure to line up in a queue or to march without stumbling were often described. A few first noticed their ataxy at night or when washing in the morning.

On examination characteristic signs were noted. At an early stage there was usually little more than swaying on the Romberg test and exaggerated knee-and ankle-jerks. Later, the gait became unsteady and the patient would walk with his feet well apart, lifting them in steppage fashion and watching the ground intently. The Romberg test then resulted in falling and in some cases walking was only possible with the aid of two sticks. In only three cases was there any loss of power in the lower limbs, and there was no significant muscle wasting. When present, tenderness of the calf muscles was only slight, and the knee- and ankle-jerks usually remained exaggerated until the disease was advanced, though in a few patients these reflexes disappeared. An extensor plantar response was never encountered, and abdominal and cremasteric reflexes remained brisk. There was no clonus. In general, apart from hyperactive reflexes in some patients, no alterations were observed in the upper limbs.

There were characteristic alterations of sensibility in the lower limbs. At an early stage there was merely loss of vibration sense and of appreciation of passive movement in the toes, but later, alterations were observed spreading to the ankles and finally, in severe cases, involving the knees and hips. Occasionally the sense of vibration was lost or defective up to the level of the lower dorsal spines. Superficial sensibility did not appear to suffer so early in the disease, but later, considerable alterations were noticed. Hypoaesthesia and hypoalgesia below the waist line, or of stocking distribution, were common, as also were bizarre combinations of zones of decreased and increased sensibility to light touch and pinprick. A frequent finding was hyperalgesia of the feet and hypoalgesia over the shins and sometimes in the calves. Other patients had hyperaesthetic zones above the knees and general blunting of sensibility below the knees. Several of the severely affected ones had three zones of altered sensibility on the lower limbs—anaesthesia, hypoaesthesia, and hyperaesthesia—the grosser changes being at the periphery.

Tinnitus, Deafness and other Findings

Tinnitus was a common complaint at the time of onset of visual loss. It was often accompanied or followed by deafness which developed gradually. The deafness was usually bilateral and was of the nerve type and began as a feeling of fullness in the ears. It was severe in eight patients and slight to moderate in the remainder. Some complained that wireless music had become difficult to understand because they had difficulty in hearing the human voice against a background of other sounds. Tympanic membranes were normal, but bone-conduction was severely reduced, and, although no audiometric examinations were made, it seemed from tuning-fork studies that there was a greater degree of deafness for low-pitched tones. In some there was a discrepancy between the findings for whispered voice and musical tones. Appreciation of the latter was always the more defective.

Partial abductor paralysis of the vocal cords was found in three patients, all of whom had developed weak hoarse voices. Once developed, the condition remained stationary in all but one patient, who improved. In these three men the voice changed about three months after the onset of the illness and the change was associated with ataxia, deafness and retrobulbar neuritis. No other abnormality was found in the throat or larynx.

Treatment and results. Selected patients were placed on a full, balanced diet and were given courses of yeast, marmite, riboflavin, nicotinic acid and thiamin. There was slow but limited improvement. Many patients were little affected by treatment especially in regard to visual acuity and deafness. Ataxia usually improved slowly, but, so far as is known, none fully recovered. Therapeutic results did not indicate any particular vitamin deficiency.

An epidemic of Food-poisoning with Neurological Symptoms in Aden

An interesting clinical picture that arose as the result of food-poisoning among the natives of Aden in 1942 was reported by Brinton (1946). About 450 persons were affected over a period of one year. Dizziness, headache, tremors, lassitude, slurred speech and a staggering gait developed in the individual shortly after taking food made from a certain grain. The malady varied in severity according to the amount of poisoned grain ingested. Some patients were well in a few hours, others in a few days. All made good recoveries and there were no deaths.

The poisoning was found to be due to the contamination of Abyssinian wheat by a weed-seed known locally as 'miscara', which may be literally translated as 'tipsy'. The natives insisted that this miscara was a common weed in every wheat-field of the Aden peninsula and that the greatest care was always taken to remove the weed and its seed from the wheat crops. It had not proved troublesome in Abyssinia because it had always been properly removed by sieving devices before the wheat was milled. Aden had received unsieved wheat from Abyssinia after the fall of the Italian East African territories, but owing to the lack of proper sieving devices its inhabitants had milled miscara with wheat and become poisoned.

THE FAR EAST

The appalling conditions in the internment and prisoner-of-war camps in the Far East were quickly realised after the surrender of the

Japanese Forces in August, 1945. Overcrowded, insanitary and unequipped, they housed, for three long years and more, many thousands of men, women and children in conditions of wretchedness, slow starvation and disease. Savage brutality on the part of their guards added to the miseries these captives endured. Some languished for years in the same camp while others were marched off to the jungle, the dockside or the railway camp to toil by day and night or fall by the wayside. But wherever they lived or worked, tropical infections and malnutrition exacted a high toll of lives. Dysentery, malaria, tropical ulcers and infestations were everywhere encountered. Lack of food produced widespread debility and loss of flesh, and in the majority of camps in Burma, Thailand, Singapore, Malaya, Hong Kong, Batavia, Formosa and Japan subsequent reports indicated that deficiency syndromes arose and usually persisted until release came.

The Japanese scale of rations for prisoners-of-war was as follows:—

Rice	500 g.	Fresh vegetables	100 g.
Flour	50 g.	Canned milk	15 g.
Sugar	20 g.	Salt	10 g.
Cooking fat	5 g.	Tea	5 g.
Meat or fish	50 g.		

This scale, however, was not maintained and although the actual amounts of food received by prisoners varied from camp to camp there is little doubt that few received more than 1,500 to 2,500 calories a day.

The effects of malnutrition were not long in appearing. Subacute wet beriberi first appeared within eighty days in Hong Kong and in Singapore in about thirty days. Thereafter, dry and wet beriberi, pellagra, glossitis, scrotal dermatitis and hunger oedema waxed and waned in the various camps with the general conditions and with the ability of the inhabitants to obtain extra food or drugs or vitamin supplements. By the time they were released captive medical officers had collected information of great clinical and scientific interest and value. Their collected reports indicate that in addition to the classical deficiency syndromes there arose in many camps various neurological syndromes which appeared to be wholly or partly due to malnutrition.

The chief neurological syndromes were:—

Beriberi.
Pellagra.
'Burning feet'.
Nutritional retrobulbar neuropathy.
Spinal sensory ataxia.
Spastic paraplegia and quadriplegia.
Wernicke's encephalopathy.
Nerve deafness.
Laryngeal paralysis.

In many cases these affections overlapped or followed one another. Thus, a common combination was visual failure, burning feet and wet beriberi or hunger oedema. Wernicke's Encephalopathy and beriberi often coincided or pellagra was attended by polyneuritis. No doubt these conditions have much in common and the majority of reports seemed to incriminate some parts of the vitamin-B complex. Sometimes the unusual nervous syndromes seemed to be related to beriberi, at other times to pellagra, but there is no doubt that they could develop without active signs of beriberi or pellagra being present. The term 'Nutritional Neuropathy' suitably applies to them.

Beriberi

Wet beriberi was the first nutritional disease to appear in the Civilian Internment Camp in Hong Kong. It appeared in March, 1942, and soon reached epidemic proportions. As many as 219 cases were recorded and the epidemic was controlled by the prophylactic administration of synthetic vitamin B1 to the whole population. It recurred in 1944 and 1945 and in all 844 inmates suffered from the condition during the years of captivity. The onset was rapid and followed an attack of acute bacillary dysentery in 55 per cent. of all dysentery cases. There were thirteen deaths. Response to treatment with the synthetic vitamin B1 was satisfactory in all but moribund cases.

In this camp chronic dry beriberi was rare—only six cases were seen. Slow improvement followed treatment. The threshold vitamin B1/carbohydrate ration was found to be about 0·4 mg. per 1,000 carbohydrate calories.

In Changi Camp on Singapore Island there were two outbreaks of beriberi. The first occurred in the Spring of 1942 and the second in 1944. In the first outbreak the clinical manifestations were largely neuritic and improvement in the diet led to its control by November, 1942, and from then until May, 1944, there was a relative freedom from the disease. In the second epidemic oedema was observed and later famine oedema dominated the clinical picture.

In other camps there are reports of beriberi of the dry and wet form—but some officers record that they never saw classical dry beriberi and that oedema when it occurred was of the famine type, unassociated with signs of heart failure or vitamin deficiency.

Pellagra

As in the case of beriberi it is probable that many men who were said to have had pellagra were suffering, in actual fact, from one or other forms of the nutritional neuropathies mentioned. In many reports there are statements that pellagra was common and many repatriated prisoners stated that they had had pellagra, but figures are not available. Glossitis, scrotal dermatitis and the ataxic and painful feet were frequently labelled pellagra.

Pellagra did, however, break out in the civilian internment camp in Hong Kong in 1943 and throughout 1944 there were 20 to 30 fresh cases per month. It coincided with a drop in the intake of nicotinic acid and riboflavin in the diet and was eventually brought under control by the administration of rice polishings—a quarter to half an ounce daily. There was a simultaneous outbreak of glossitis and scrotal dermatitis. In Changi Camp at Singapore pellagroid skin rashes were sometimes associated with scrotal dermatitis in an outbreak in 1942 but there seems to have been no frank epidemic of pellagra. In work camps in the jungle there were many references to pellagra appearing, especially after attacks of dysentery or after any great exertion. In some camps it is said that pellagra was the most common disorder. (See Chapter III (Hong-Kong) and Chapter IV (Malaya) in Part I, Volume II of this Series—*Civilian Health and Medical Services.*)

'Burning Feet'

Various terms were applied to this condition in which pains and dysaesthesiae of the feet were the outstanding complaint. 'Painful feet', 'aching feet', 'sore feet' and 'happy feet' are some of them. It is probable that many were at first regarded as neuritic beriberi. The condition affected thousands of men in many camps, and the general reports agree that the malady arose as a result of malnutrition, and that a fairly constant clinical picture developed.

In Hong Kong Civilian Camp there were some 756 cases, in 35 per cent. of which dry beriberi was superimposed. It showed the same general outline as the incidence curves for pellagra and the orogenital syndrome. It bore no relation to the incidence of wet beriberi. In Singapore 30 per cent. also had scrotal dermatitis and 31 per cent. glossitis or stomatitis. In 42 per cent. there was no sign of associated deficiency disease. Some reports state that there were signs of vascular and vasomotor change in the affected limbs and in others there was said to be some rise of blood-pressure.

The development of the syndrome was usually with a tiredness or aching of the soles of the feet. At first it was present only at night when the patient was trying to sleep. The pain was variously described as aching, burning or throbbing. Later, sharp stabbing pains were complained of—and the burning pains became more constant. Walking, or even standing, became impossible and at night the suffering became extreme. Some hobbled around in their tents, others bathed their feet in cold water or rubbed them gently. In chronic or severe cases the dysaesthesiae spread up the calves to the knees and, rarely, there were complaints of similar sensations in the hands.

There were no constant changes visible in the lower limbs. Power, tone, sensation and reflexes were within normal limits in the majority.

Brisk and exaggerated reflexes, with some hypersensitivity of the feet to pin prick, were sometimes recorded. About 80 per cent. had shown evidence of previous deficiency syndromes—stomatitis, glossitis or defective vision.

In some instances ataxia of spinal origin followed the condition of burning feet.

Treatment, on the whole, was disappointing in its results. Vitamin B1 did not relieve the condition but most observers thought that nicotinic acid and riboflavin produced some improvement. The condition usually persisted for weeks or months and only slowly subsided after the introduction of normal diets.

Retrobulbar Neuritis, Nerve Deafness and Sensory Ataxia

Probably the commonest neurological manifestation of malnutrition in the Far East Camps was retrobulbar neuritis or neuropathy. It was just the same in its clinical features as in the Middle East—but it was much commoner in the Far East. It was acute or subacute in onset and characterised by the appearance of a central or paracentral scotoma in one or both visual fields. In the early stages treatment with vitamin B seemed to help—but the majority of men who had serious disturbance of vision after release showed no improvement. In the majority, too, there were no other neurological sequels, but occasionally nerve deafness or laryngeal palsy was recorded. As in the Middle East there were also cases in which ataxia of spinal sensory type was a serious disability.

Spastic Paraplegia and Quadriplegia

There was a small group of cases which presented a syndrome unlike those seen in any other theatre of war. By some they were referred to as 'pellagrous encephalopathy, or the spastic syndrome'. On release they were found to have marked spasticity of the lower limbs, and sometimes also of the upper limbs, with knee and ankle clonus and extensor plantar reflexes. Most of them were unable to walk unassisted. There was no sensory loss of any kind and the cranial nerves were normal. The onset of their illness seemed to have been abrupt, and in the majority there was some unconsciousness or amnesia. Some of them gave a history suggestive of Wernicke's encephalopathy. In their final stages they were not unlike cases of lathyrism in natives. Little or nothing is known of the cause of the syndrome except that it occurred in camps where other forms of nutritional neuropathy were rife.

Wernicke's Encephalopathy

One of the most interesting of all syndromes that arose in camps for prisoners-of-war in the Far East was that termed Wernicke's encephalopathy. In one camp there were at least 52 cases; 30 recovered. Loss of appetite, vomiting, nystagmus and emotional changes were the common early symptoms. Then there developed severe disturbances of vision and eye movement. Diplopia, blurring of vision, and photophobia were complained of and nystagmus was very prominent. Emotional disturbances, disorientation, loss of memory, confusion and confabulation were characteristic symptoms. Beriberi was also present in many cases (79 per cent.), and cardiac beriberi was the cause of death in four patients. Postmortem changes in the mammillary bodies and brain stem were recorded and were typical of the vascular lesions previously recorded in this condition. It was found that thiamin, even in small doses, was beneficial. It was certainly life-saving in some cases. Acute cerebral beriberi was thought to be the essential basis of the syndrome.

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CHAPTER XI

RESULTS OF EXPOSURE AFTER SHIPWRECK AND THE LIKE

By MacDONALD CRITCHLEY
M.D., F.R.C.P.

FROM time immemorial shipwrecked mariners have suffered from thirst, hunger and exposure, and many records published by survivors have given a vivid picture of the pitiable condition to which they may be reduced. In the War of 1914–18 the numerous torpedoings of vessels caused terrible hardships to the sailors and passengers from the abandoned ships, but no general account of the pathological or psychological results of such exposure was recorded.

More attention was paid to this subject in the War of 1939–45, where vessel-sinkings on a large scale again occurred. The first intimation of the clinical effects of severe exposure occurred in July, 1940, when there was admitted to a Royal Naval Auxiliary Hospital an officer who, a month previously, had been adrift for seventy hours in the Arctic without food, drink or protection from the biting cold. As the result of the subsequent attacks by enemy submarines on the ships and convoys in the Atlantic, many similar patients came for treatment and unfamiliar, if not new, physiological problems called for solution.

Following a medical report on the subject a special Shipwreck Committee was appointed (in 1941) to enquire into the physiological issues involved and the best means of relieving the effects of exposure. Much research work was done and in 1943 a most useful memorandum was issued as *A Guide to the Preservation of Life at Sea after Shipwreck*. In the meantime the Ministry of War Transport devoted attention to the improvement of lifeboat construction and equipment so that the chance of survival of the shipwrecked person was great in the later years of the war.

Persons who were shipwrecked usually got away either in a lifeboat, a raft, a Carley float or a flotanet (which is a rope net rendered more buoyant by a series of cork floats or buoys). Aircrew from aeroplanes made use of rubber dinghies. In the case of the flotanet and the Carley float the survivor was deeply immersed in sea water, the craft being awash or slightly submerged. The chances of survival in these various craft varied considerably. The maximum periods of survival reported were as follows—three and a half days on a Carley float, forty-eight days on a raft, and seventy days in a lifeboat. It should be mentioned that lifeboat voyages of longer than three weeks were exceptional; indeed if a lifeboat were not picked up within twenty-four hours, there was a 50 per cent. chance of its being rescued within five days.

GENERAL AND SPECIAL EFFECTS

These can be considered under five headings—excessive cold and wet, thirst, hunger, tropical conditions and psychological effects.

(1) *Excessive Cold and Wet*

In most cases of exposure after shipwreck the factors of low temperature, high wind, wetness and inadequate clothing existed in combination, very often to the extreme limit.

There is normally a considerable variation in the degree of resistance to cold, sailors and marines being relatively insensitive compared with the general population. Attempts to keep warm by various forms of exercise were not usually kept up for long. When exposed to extreme cold the usual train of clinical symptoms seemed to be—shivering, headache, increasing reluctance to move, an attitude of generalised flexion, drowsiness, torpor and death. The time-duration of each stage varied according to the degree of cold and the age, sex and size of the individual. The important factor in size was the relation of surface area to mass; large persons withstood cold immersion better than small, just as Arctic conditions favour the survival of the larger mammalian species. In an extremely cold environment death might occur within an hour or less. Sailors who died 'from exposure' during short spells adrift mainly succumbed to the effect of cold, which also increased the effect of any surgical shock from wounds or burns.

In addition to its general effects cold had special action upon the peripheral parts. Reflex vasoconstriction brought about a migration of blood from the extremities, which led to impaired sensibility and later to actual tissue damage—e.g. frostbite in the nose, ears or fingers and toes. Prolonged immersion of the legs in very cold water caused severe local pain followed by numbness to ordinary touch, although heavy contacts were felt and might be very painful. The feet used to swell and the boots had to be cut off. The time required to produce this state varied from a few hours to a few days. The numb and swollen foot was very susceptible to injury and sloughs readily appeared. The final stage of swollen, insensitive, powerless dead-white feet formed the picture of 'immersion foot'. The recovery stage from such a condition was accompanied by severe pain and a permanent state of partial incapacity often resulted. (See Chapter XX in the volume on Surgery in this series.) This complication was common; for example, out of a total of 279 survivors 110 showed symptoms of immersion foot.

The hands, even though not immersed, might become seriously affected. They became numb, swollen, painful and feeble. After the circulation had recovered they often remained hot and painful, were sometimes red and sweaty and, after the oedema had subsided, might show muscle wasting and impairment of sensibility. Sometimes in later stages a bluish-red, cold and claw-like hand resulted, somewhat resembling a Volkmann's contracture, though the radial artery was intact. The after-effects of immersion foot were more prolonged than those following trench foot or frost-bite.

(2) *Thirst*

Next to cold, thirst was the most distressing hardship suffered by exposed and shipwrecked persons. Men could not live long without a supply of drinking water; probably no one after shipwreck has ever lived longer than eleven days without any water, and few would survive anything like so long. Seldom or never could arrangements be made to carry a supply of drinking water adequate for many days on the crowded rafts and life-saving floats or boats. It was impossible to allow the 2½ pints daily per person which is requisite for health, and strict rationing was always necessary. When rescue did not take place for some days or even weeks those who were deprived of the necessary water became dried up or desiccated, or in technical terms dehydrated or anhydraemic. This anhydraemia inevitably led to thirst. The sensation of thirst was referred, at first at least, to the parched back of the tongue and the oro-pharynx, but thirst was by no means due to this dryness. The mucous membrane became dry, the saliva sticky, the tongue furred and the breath unpleasant, and difficulty was experienced in chewing.

As thirst increased, men sometimes tried to combat it by chewing tobacco, gum or seaweed, sucking a button or coin, or sniffing sea-water into their nostrils and blowing it out again. When thirst became overwhelming the victim sometimes soaked the head and face, or even the whole body, in seawater, but this had little effect. Some even drank urine, and if they lost self-control, would even drink sea-water. Experience showed that the drinking of undiluted sea-water was to risk delirium and death within a few hours. Sea-water poisoning was probably, next to cold, the commonest cause of death in shipwrecked sailors. The giving way to the temptation to drink sea-water occurred early in the case of Lascar seamen, much later in men of stout morale, particularly when they were in a position of authority within the life-boat. The drinking of sea-water was difficult to prevent, as it was usually carried out furtively, after nightfall or during the process of bathing the head and face. When sea-water was drunk by a dehydrated subject there was an immediate quenching, followed by an increase of thirst which demanded further draughts. The victim became silent and apathetic, within an hour or two quiet and later violent delirium set in, consciousness was gradually lost, froth appeared at the corners of the lips, and death—quietly or noisily—took place. Not infrequently the victim in his delirium went over the side into the sea. The mechanism of death after the ingestion of sea-water is not clear; probably the kidneys could not excrete the excess of salt which, being retained, would lead to dangerous and fatal osmosis from the vital body-cells.

The thirst of men adrift at sea differed from that suffered by men exposed in the desert, for in the latter case the air was drier and the surroundings warmer, there was no sea-water at hand and the wasting and desiccation proceeded to an extreme degree before death occurred. Severe thirst was sometimes experienced in Arctic regions (e.g. the North Russian voyages) where the low temperatures froze all available liquid, but generally speaking thirst was less in evidence in the colder climates. Exceptional thirst was said not to have been a prominent symptom among those adrift, but it is possible that in such cases memory may have been imperfect.

Allison and Critchley (1943) carried out an experimental investigation on three human volunteers for three days to ascertain the effects of progressive anhydraemia under moderate atmospheric conditions. One man was given no water, another 4 oz. and the third 8 oz. of water a day. In each case there was a loss of several pounds in weight, the pulse became smaller, there was a slight increase in the concentration of the blood, and, surprisingly, a slight increase in visual acuity. The most striking change, however, was the fall in urinary output which dropped to 20 c.cm. per hour. It was noteworthy that no great difference could be found in the physiological or mental concomitants of the three men, and for practical purposes there was little to choose between taking no water and taking amounts up to 8 oz. a day. It has indeed been found (K. Mellanby, 1942) that a person must take at least 18 oz. of water a day to avoid detrimental physiological changes in the body. Whether that amount would inhibit thirst has never been determined. An experimental attempt was made by Allison to conserve bodily fluid by inhibiting urinary secretion by the use of pituitrin snuff or vasopressin, but no reduction in urinary output followed.

(3) *Starvation*

When cast adrift with little or no water and food shipwrecked persons might have great thirst but often within a day or two developed an indifference or even an aversion towards food. It was undoubted that adequate water rather than food was the factor which determined survival, and among survivors many denied being hungry. The accounts of ravenous hunger described in early records of shipwreck have not been confirmed by modern experiences. It may be that a certain expenditure of physical energy was necessary for hunger to be felt. Nevertheless, whenever possible, provision was made for a store of food to be carried in lifeboats and rafts. The old-fashioned 'hard-tack' needed to be supplemented by foodstuffs which were more palatable and concentrated, such as bully beef, chocolate, nuts, dried fruits and condensed milk.

The physical effects of starvation are known to proceed gradually and include progressive loss of weight, muscular weakness, low blood-pressure, acidosis and improvement of visual acuity, but only the first three of these could be noted in war victims. Two other important results were, however, frequent in shipwrecked survivors—persisting constipation and mental changes. In only 19 out of 279 rescued persons had a bowel action been known to have occurred while adrift; 3 persons went for 41 days without an action.

Mental changes were usually affective in nature and comprised depression with irritability. Later there was a tendency to fantasy-building and even hallucinosis and special sense-distortion.

(4) *Exposure in the Tropics*

Exposure in tropical latitudes was much better tolerated since the important factor of cold was absent. In a hot climate anything up to two weeks in a boat was borne well, despite minimal food and water, and men could remain almost entirely submerged for several days and yet survive. There were however additional hardships such as heat-prostration, severe sunburn, salt-water sores and the like.

It was surprising to note that sweating was rare among men adrift in the tropics. Blistering was common, and salt-water boils were frequent as they have always been among seafaring people. In tropical seas persons who were on rafts and dangled their feet in the water were liable to be bitten by sharks, by the barracuda—a carnivorous fish—or by the voracious 'bluefish'. Jelly-fish also caused painful stings with consequent severe constitutional symptoms.

(5) *Psychological Aspect of Prolonged Exposure*

It would indeed have been strange if the exciting and often terrifying experiences of shipwreck and prolonged exposure did not affect the mental condition of the victims.

With a well trained and disciplined crew the anxiety associated with the abandoning of the ship was sometimes masked by the almost automatic acts required for the release of rafts and lifeboats, and after the event there might follow amnesia with regard to that period.

While in the water, prior to rescue, a man was first intensely preoccupied with vital attempts to keep the head and face clear of the surface and to keep warm. If in the water for a long time and hope of rescue faded, the mind began to wander and various fantasies often developed. Rescue was often succeeded by a state of excitement but this usually subsided, and as the many discomforts increased there followed sometimes psychogenic disorders. Taciturnity, increasing egocentricity and irritability with slight depression were followed (as thirst increased) by fanciful thoughts of food and drink, but purely intellectual impairment seldom occurred as the result of hunger or thirst. Among small groups of survivors there ensued an increasing feeling of loneliness and interdependence, accompanied by marked suggestibility, so that ideas, feelings and even physical sensations appeared to be shared.

Later still, as towards the end of a long lifeboat voyage, there might develop increasing depression or even despair, and loss of morale. The most important single influence in preserving confidence, hope and mental integrity was that of the leader, whether he were an officer or merely a leading hand or senior rating. With a good leader who could preserve confidence and discipline, conditions were better and survival rate higher.

In the trials of shipwreck the Anglo-Saxon as a rule behaved with greater equanimity than some other races.

Simple anxiety was comparatively rare as a mood-disorder while adrift, but after rescue there was often acute anxiety lest the rescue-vessel should itself be attacked.

In the matter of survival there is little doubt that the will to survive had a considerable influence. This might be found in two different classes of persons: the simple, stable, unimaginative person who instinctively clung to life; and the intelligent, stable, individual, who regarded it as a duty to maintain the spark of life to the utmost.

As the hardships piled up and exhaustion increased, the victims slowly lost touch with the environment and torpor was added to a progressive mental haziness. Orientation became uncertain and this was noticeable first as regards time. Disorientation as to place came late but might be conspicuous, and the sailor might imagine himself back in the ship, at home, or in his depot. Severe cold by itself might be followed by some warping of judgment followed by incoherence, confusion and maybe unconsciousness; this, as Grow (1940) suggested, might be due to cerebral anoxia.

Fantasy-building began to develop soon after the sensorium became clouded and might even occur in the waking but drowsy state—usually being concerned with day-dreams of relief of the physical distress. Delirious confusion and vivid imagination might occur as the person was going off to sleep or awaking.

Among the most striking features of the psychological state of men adrift was the occurrence of hallucinations in a comparatively intact sensorium; sometimes there was a contrast between the vividness of hallucination and the relatively slight degree of confusion. In a few cases the hallucinations were shared among a group; as E. W. Anderson (1938) has shown, this depended upon physical exhaustion, hyper-suggestibility, the breakdown of personality-barriers and the persistence of hope and expectancy among the hallucinated.

Late psychiatric reactions after rescue sometimes occurred. Whether there was a true exhaustion-neurosis was doubtful, but since severer neuroses were commoner after the longer lifeboat voyages there may have been some relationship between the magnitude of the physical stress and the psychological after-effects.

Hysterical features were not rare. They were characteristically seen in an exaggeration or perpetuation of the symptoms of an immersion foot, making it difficult to determine where the organic element ended and the functional began.

THE CONDITION AT TIME OF RESCUE

The condition of rescued survivors naturally depended upon the duration of exposure, the climatic conditions and the amount of deprivation of food and water. Usually they were unkempt, unshaven and dirty, and often were suffering from wounds, burns or scalds. The degree of emaciation, exhaustion and dehydration varied within great limits. That many men had considerable stamina was shown by the following instance:—

Four merchant seamen, aged 21, 23, 24 and 29, were adrift in an open boat in the tropics for 41 days with a bare minimum of water and practically no food. For 11 days they had no water at all but a thunderstorm provided them with a meagre ration which lasted till the final 3 days. Food consisted of a very occasional biscuit. When picked up they were able to climb unassisted over the side of the rescuing craft. Though wasted to skin and bone, with an average loss of 5 stone in weight, their mental condition when interviewed 12 to 24 hours later, was entirely normal. They had many low-grade boils and pressure sores but no oedema nor signs of scurvy. They had been without bowel action for the whole 41 days. Their tongues were dry and furred and blood-pressures were about 90/50. Starting with small hourly feeds of milk and water they were able to take a reasonably soft diet within 3 days.

Surgeon Lt.-Commander E. M. Buzzard who looked after these men might well comment, 'My general impression of the four men was of their amazing endurance, the absence of any serious complication and of their speedy recovery'.

Quite often, however, the survivor, on being rescued, suffered a mental reaction and might collapse for a time ; he could not at first take food and might suffer from physical restlessness and insomnia. Solid food could usually be taken within a few days and many survivors had a strong craving for sugar or sweetstuffs at this stage.

Although dehydration might, *a priori*, be thought likely to lower bodily resistance to infection it was remarkable how seldom there were cases of acute respiratory infection, of infective disorders, or even of rheumatic, fibrositic, neuritic or nephritic symptoms, apart of course from such conditions as immersion foot; bronchitis and pneumonia were rare.

PREVENTION AND TREATMENT OF THE RESULTS OF EXPOSURE

At the beginning of the war precautions to mitigate the results of exposure at sea were inadequate, but as the war progressed some improvements occurred. In 1940 arrangements were made to carry water in Carley floats, and in 1941 it was enacted that all life-floats should be provided with a double grating to hold containers for water and concentrated food. Later, further improvements were made, e.g. the carrying of first-aid dressings and the means to keep floats in touch with each other. Regulations were made as to lifeboat drill and launching, and to the carrying of flares. Legal provisions were made as to the carrying of increased amounts of water and food and the providing of massage-oil to prevent immersion foot.

It was of course impossible to provision a lifeboat fully for a long voyage, but the Ministry of War Transport laid it down that all lifeboats should carry 112 oz. of drinking water per person which would suffice to satisfy the bodily requirements for at least three or four days. This supply was sometimes increased by the collection of rain-water which could be caught in empty tins or sail-cloth. Occasionally the distillation of sea-water was performed. In a small boat containing officers and men of the Royal Marines, adrift between Crete and Libya, petrol cans were used for this purpose; and on another occasion, when a lifeboat containing seven Norwegian sailors and two American nurses was adrift in the North Atlantic for nineteen days, the first engineer rigged up a still out of the motor-boat engine and some cans. No practicable method of chemical treatment of sea-water was found satisfactory for rendering it fit to drink. The injection of sea-water per rectum was not recommended, and in general the conclusion was reached that it was unwise to take sea-water in any form, even diluted.

Though in some cases, when water failed, the men had recourse to drinking their own urine, little satisfaction of thirst resulted and it was therefore forbidden except possibly where absolutely no drinking water was available and where the urine passed during the first twenty-four to forty-eight hours of being adrift (which is not so concentrated as that passed later) had been able to be stored.

With regard to food, as the war progressed the usual emergency ration of hard biscuits was replaced by malted milk tablets, chocolate and better biscuits, but, as said earlier, hunger was not such a trouble as thirst among those adrift.

To prevent immersion foot it was considered wise to practise active movements of the foot, and to keep out of the wet as long as possible by wearing loose top-boots which had to be taken off at the first sign of oedema. It was doubtful if massage had any definite effect.

When an acute state of immersion foot came for treatment the first requisite was gentleness in dealing with the affected parts. An Admiralty Fleet Order issued in October, 1941 pointed out that it was important to avoid attempts at standing or walking, massage or rough handling of any kind, and even to prevent any warming up of the legs and feet. Indeed the acute case needed to be treated more on the lines of a burn or scald. The feet were raised, the blisters and sores gently cleaned with spirit and flavine or dusted with sulphonamide powder, and the whole limb was kept cool by cold air from an electric fan or by applying ice-bags. Morphine was sometimes needed for the pain. Very gradually the cooling application was discarded and active movements of the toes and ankles encouraged. The later or neuritic stage was treated by graduated exercises, Buerger's vascular exercises, massage and radiant heat.

In abandoning ship it was the rule to advise the taking of plenty of warm clothing, including, if necessary, sea-boots and duffel coats. When at sea in dangerous waters the sailor turned in fully dressed with extra clothing at hand in case of emergency. Many layers of thin material, loosely fitting, were better than a tight heavy garment; thus three cotton vests were regarded as better than one woollen vest three times as heavy. If possible the outer layer of clothing was waterproof, e.g. an oilskin.

In stocking the lifeboat with food and drink it was found better to cut down the number of occupants, when possible, rather than to stint the equipment of water, blankets and food. In cold environments fats and carbohydrates were found more suitable than proteins, being of higher calorific value. Alcohol had no scientific claim to be carried in lifeboats, for the vasodilation, after taking it, might prove dangerous in causing loss of heat. In view of the fact that it sometimes induced sleep and made people feel a little better it was considered justifiable, on occasion, to give it to the badly wounded or the moribund.

With regard to the treatment of survivors immediately after rescue the following special points had to be regarded:—

> The warming up of the victim was not applied to the lower limbs until it was certain that no degree of immersion foot existed.
>
> The dehydration which accompanied the state of shock forbade blood-transfusion. Glucose-saline injections were more suitable.
>
> Inhalation of oxygen and carbon dioxide was beneficial.

Since the mental states of the victims were often unstable, sedatives were needed for a few days, but, since those exposed to severe cold were specially sensitive to morphine and other hypnotics, only small doses of these drugs could be used with safety.

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CHAPTER XII

THE HAZARDS OF TOXIC GASES IN WARSHIPS, EXCLUDING AGENTS OF CHEMICAL WARFARE

BY SURGEON LT. COMMANDER F. P. ELLIS
O.B.E., R.N.

NUMEROUS incidents occurred during the War of 1939–45 where men lost their lives through the direct action of poisonous gases, generated by explosions or fire, by damage to or misuse of refrigeration machinery or fire extinguishers containing volatile chemicals, or from gases generated by internal combustion engines. Some of these accidents could not have been avoided, but in many cases the adoption of preventive measures and a general awareness of the potential hazard would not only have saved lives but at times would have entirely averted tragedies.

The insidious nature of certain of these gaseous poisons is perhaps their most menacing feature. Nitrous fumes, generated by the incomplete combustion of cordite; carbon monoxide, evolved in huge volumes by the detonation of many explosives, by fires in enclosed spaces and in the exhaust gases of internal combustion engines; methyl bromide, used as a refrigerant and in fire extinguishers, are all practically devoid of a distinctive smell, and, in the presence of smoke or oil or petrol vapour, they will often be unrecognised until too late.

The crews of warships are probably more exposed to these hazards than the land forces, and the dangers were probably greater in the War of 1939–45 than they were in the War of 1914–18, because of the greatly increased use of poisonous chemicals in refrigerators and fire extinguishers, and the greater numbers of shipborne aircraft and petrol-driven power boats; furthermore, the importance of ensuring watertightness of ships in dangerous waters resulted in reduction of the ventilation below decks to the minimum consistent with the maintenance of reasonable efficiency. When a vessel is damaged, all the ventilation to the damaged area is at once shut off to prevent the flooding of the ship through the ventilation trunking. Thus gases liberated or generated by explosions cannot escape easily. Compartments are frequently crowded and it is rarely a simple matter to evacuate battened down spaces when damage occurs, even if such action is permissible, and this will rarely be the case when fires must be fought, flooding controlled, or wounded assisted.

The toxic features of most of these gases are well known. Descriptions of their pathology, signs, symptoms and treatment are given in the *Manual of Chemical Warfare* (1943), but there is still a widespread unawareness, not only among naval officers and ratings, but also among medical officers, of the true incidence of the dangers, the ways in which they occur, of the value of the Service respirator in prevention and rescue work, and of the death-roll that has been exacted.

From a review of the literature, it appears that these intoxications form a chapter in naval warfare out of all proportion to their importance in the other Services (with the exception of carbon monoxide poisoning). This is not the place to discuss clinical features, but attention should be drawn to the considerable frequency of these incidents in wartime, and to discuss their prevention rather than their cure.

NITROUS FUMES

Since the close of the last century, Legge (1934), Irvine (1916) and Schubert (quoted by Wood, 1944), have reported numerous cases of nitrous-fume poisoning in the British and German munitions and mining industries. In warships during the War of 1914–18 Symons (1916) reported seventeen cases with eight deaths when H.M.S. *Russell* was mined in 1915, and Fairlie (1920) described fifty-six cases with ten deaths in H.M.S. *Britannia* following a torpedo attack in 1918, and six others with two deaths at the Battle of Jutland.

No further incidents were reported during the years of peace, but with the outbreak of war the hazard was recognised early, and soon assumed formidable proportions. Desmond and Frazer (1943) described ten cases with three fatalities due to the blow-back into a gun-turret of gaseous products of cordite combustion from the breech of a gun. Ellis (1944) described fifty cases admitted to hospitals in Alexandria after the bombing of H.M.S. *Orion*, when evacuating troops from Greece in 1941. Fifteen of these patients died and nitrous-fume poisoning was the only obvious injury sustained by eight of the fatalities. In the United States Navy, Charleroy (1945) reported cases due to an unusual cause. Blasting gelatine, which was used for boosters in hand depth-charges, caught fire and gave off thick yellowish-green fumes. Nine of the twenty-three men affected by the fumes were seriously ill and two died.

Many other cases reported by medical officers have not been published. On December 5, 1940, five men in H.M.S. *Caernarvon Castle*, who had been in close proximity to burning cordite charges, were reported as suffering from burns and 'bronchopneumonia'. After the torpedoing of H.M.S. *Aurania* on October 21, 1941, four men, who inhaled irritant fumes in the vicinity of the explosion, developed pulmonary oedema, and one died. On December 13, 1941, H.M.S. *Puckeridge* was struck by a delayed-action bomb in the region of the after gun-turret, which then exploded in a mess deck. It was found later that the depth-charge store and the four-inch ammunition in No. 2 magazine were burnt out. A petty officer, who had the presence of mind to wear his gas mask, was the last man to get out of the crater alive, the man behind him falling back unconscious. Five of the survivors died of nitrous-fume poisoning, and forty-one of the ship's company were dead or missing. On May 15, 1942, H.M.S. *Hecla* was damaged by an underwater explosion, due to a mine or torpedo, and fourteen men, diagnosed as suffering from pulmonary oedema due to 'irritant gases', were probably suffering from nitrous-fume poisoning. H.M.S. *Phoebe* was torpedoed on October 23, 1942, six miles off Pointe Noire in French Equatorial Africa, and eighteen men died from typical pulmonary oedema following nitrous-fume inhalation, while the bodies of thirteen others were recovered where the cause of death might also have been attributed to this factor, although blast effects and carbon monoxide probably contributed to the death roll. In discussing the treatment of these cases, the medical officer commented on the paramount importance of a good supply of oxygen and efficient methods of administering it. Another incident occurred at Algiers in August, 1943, when a phosphorus-smoke bomb burst into flames in the forward hold of S.S. *La Montée*, which also contained howitzer and mortar bombs. H.M.S. *Arrow* came alongside, and shortly afterwards there were several explosions which ignited ready-use ammunition on the upper deck of the destroyer. It was reported that: 'Most of the injured brought up copious frothy sputum and exhibited other signs and symptoms of oedema of the lung showing that they were suffering from lung lesions due to the action of "phosphorus"'. They were probably suffering from a mixed intoxication, but of the several possibilities nitrous fumes were the most toxic, though they would be less irritant than phosphorus at first.

Lastly, H.M.S. *Albatross* was holed forward by an underwater explosion on August 11, 1944, while lying in the anchorage of the British Assault Area off Courseulles, Normandy. The area of the damage was filled with a dense grey-white smoke which spread to adjacent compartments. The medical officer, who had previous experience of nitrous-fume poisoning in H.M.S. *Phoebe*, attributed most of the deaths to nitrous-fume poisoning, carbon monoxide poisoning, or a combination of both. Many casualties were shocked or affected by immersion and blast, but few showed signs of physical injury. Four of the sixty-two injured died before the wounded were evacuated six hours after the explosion, and fifty-eight bodies of sixty-one missing men were recovered a week later. Evidence of nitrous fume poisoning was not so convincing as in H.M.S. *Phoebe*. Casualties in the rescue and repair parties were less numerous, and frank pulmonary oedema occurred in a small proportion only of the gassed men before they left the ship.

These are instances which can be picked out of reports ready to hand. Many suspicious cases occurred elsewhere, and it is certain that many other men who died under similar conditions were killed by nitrous fumes.

Symptoms and Signs

The clinical features are well described in the *Manual of Chemical Warfare* (1943), in the *Royal Naval Medical Bulletin No.* 2. and in the published accounts referred to above. The following abstract from the report of the medical officer of H.M.S. *Sirius*, who attended cases in a cruiser after it was torpedoed in 1944, is illustrative of a typical incident:

> 'Thick yellowish fumes pervaded the atmosphere in the vicinity of the explosion. Rescue parties toiled to succour the injured, and repair parties were busy. . . . By early afternoon [the torpedo struck at 0715] several casualties [of nitrous-fume poisoning] had occurred, most of whom were in the affected compartments at the time of the explosion. But from evening onwards, casualties began occurring amongst those who were not involved in the explosion area, but had worked in the rescue or repair parties in the morning and carried on with their ordinary duties in the afternoon. They felt perfectly well until evening, when they developed slight tightness of the chest and an irritating cough, some also had a headache. Within four hours of reporting to the doctor the majority were dead. When the patients reported they appeared normal, pulse and respiratory rate only very slightly raised, and auscultation revealed rhonchi throughout the chest, particularly the lower portions. The next state, in about one hour, appeared to me very similar to toxaemic shock, definite apathy, facies pale, pulse rapid and thready, respirations quickened and laboured and small. The third stage was one of venous congestion, the patient being more or less moribund. The pulse was full and bounding, facies congested, and lips cyanosed and frothing slightly. There was much coughing of tenacious sputum, the patients became comatose and died.'

This was generally the story. The latent period of practically complete freedom from symptoms varied in length from thirty minutes to twenty-four hours. The fumes were not recognised at the time of exposure, rescue and repair parties later became victims; gas masks, which would give good protection for about five minutes in fairly heavy concentrations, were rarely worn; men worked on after exposure to the fumes, and those who worked hardest died first. It is of interest to observe that those who recovered often recovered remarkably quickly despite the severity of the initial lesions. If death does not occur, or infection supervene, the oedema fluid is absorbed from the alveoli, recovery is fairly quick and not usually associated with pulmonary disability later.

Diagnosis

The diagnosis will generally be dictated by the circumstances if cordite is known to have been exploded or burnt. In practice it was frequently missed, and bronchopneumonia, irritant gas poisoning, phosphorus poisoning, and 'blast lungs' were alternative diagnoses selected at different times. Some of the cases from H.M.S. *Orion* were considered to be due to blast at one hospital, and considerable persuasion, based on the results of necropsies, was necessary before the diagnosis was altered. So dramatic was the clinical picture at the time that it was hard to believe that it could be other than that of a well recognised syndrome. Underwater explosions or magazine fires are particularly dangerous. The treacherous latent period means that it may be disastrous to await the onset of symptoms or signs. When mixed with smoke, nitrous fumes are difficult to identify and lethal concentrations may not possess an identifiable odour. Reliance on the colour of the smoke, which has been variously described in the above accounts as 'brownish', 'greyish-white' and 'yellowish-green', may be misleading.

Treatment

In the treatment of these cases complete rest in a sitting position, morphine in moderate doses to allay restlessness, and efficient continued administration of oxygen if moist sounds can be identified at the lung bases, are probably all that can be done. Intravenous transfusions of any kind are absolutely contra-indicated. Antispasmodics, such as atropine, while not likely to do harm, are considered to be of little value by most observers, but venesection has been said, by others, to give dramatic relief to cyanosed patients with full bounding pulses. Prophylactic chemotherapy is of value in preventing secondary infection and bronchopneumonia.

Prevention

The prevention of nitrous-fume poisoning lies first in remembering that when cordite in a torpedo, mine, bomb or shell is either detonated or burnt in turrets or magazine fires, this hazard will probably exist to a lesser or greater degree, and the fumes will probably extend beyond the compartment where they are initially generated. Secondly, the use of gas masks at the earliest possible moment will give ample protection for the time required to escape, or for rapid rescue work. The period of full protection will depend on the concentration present. Rescue and repair parties should be equipped, if possible, with closed breathing apparatus such as the Proto, Salvus, Davis Submarine Escape Apparatus or the Naval Breathing Apparatus Pattern 230, which will all give complete protection. However, it will often be found that the attitude of the British sailor to what he thinks is a 'hypothetical danger', when there is urgent work to be done, is a factor of importance. It is too late to teach men about these hazards when accidents occur, and thorough instruction in the possibilities should be part of the training of naval officers and ratings, and so guide them to do the right thing instinctively in an emergency.

CARBON MONOXIDE

The lethal effects of this gas are known to most laymen and to every medical student, yet, through a neglect of the hazard, casualties continue to occur. The clinical features are described in many text books, and are summarized in the *Manual of Chemical Warfare* (1943).

In modern mechanised warfare carbon monoxide poisoning has caused anxiety in each of the Fighting Services in turn wherever internal combustion engines have been used. In the Army, tank crews were poisoned from defective exhausts. High concentrations in the cockpits of aircraft were a menace to aircrews, and in the Navy, cases occurred among the crews of the motor craft of coastal forces and later, in the hangars of aircraft carriers when engines were revving up.

Carbon Monoxide as a Hazard of Explosives

Reference has already been made to the way in which varying concentrations of carbon monoxide will accompany nitrous fumes generated by underwater explosions due to mines or torpedoes. It is also evolved in very large volumes when shells and bombs are exploded or burnt. Lewes (quoted by Hill, 1915) estimated that the 400 pound charge of a 15-inch gun gave off 2,500 cubic feet of carbon monoxide when the gun was fired.

The importance of carbon monoxide poisoning in the causation of death after aerial bombing has been stressed by the Germans, and although it is not a naval communication, the *Report of the United States Strategic Bombing Survey on the Effects of Bombing on Health and Medical Care in Germany* contains relevant and important facts. The Germans concluded that carbon monoxide poisoning was a major cause of death after aerial bombing, and referred to typical 'shelter or cellar death' occurring in rooms where the exits were blocked by rubble. So serious was the official view of the danger that the High Command of the Luftwaffe ordered a statistical survey of the incidence of carbon monoxide poisoning to be made. In Hamburg, 70 per cent. of the total casualties, excluding those due to mechanical causes or burns, were caused by carbon monoxide. According to Schoen, 0·5 per cent. carbon monoxide can cause death in one hour, and death is known to occur even in the open air. Two conclusions stressed as a result of these surveys were that carbon monoxide should always be kept in mind in treating casualties from aerial bombing, and that preference should be given to the treatment of unconscious victims before those with physical injuries. Public prominence was not given to the hazard because of possible adverse effects on morale.

These observations lead one to consider whether unrecognised cases of carbon monoxide poisoning have occurred in aerial attacks on warships where, as we noted earlier, optimum conditions for gas poisoning may be found when prepared for action. No accounts come readily to hand, but others may report cases in retrospect. The diagnosis may be far from obvious. When H.M.S. *Birmingham* was torpedoed forward on November 28, 1943, gas casualties were reported, and Pattern 230 Breathing Apparatus and the Salvus equipment were said to be of inestimable value. The gas was colourless, acrid, heavy and sweet. The carbon dioxide cool room in the vicinity was destroyed. Pyrene fire extinguishers had been used liberally; thus, with the addition of carbon monoxide, nitrous fumes and blast, was posed a pretty diagnostic problem. The clinical features were not typical of nitrous-fume poisoning. Many men were asphyxiated, many unconscious, and there was no latent period followed by pulmonary oedema. Thirty-seven men were unconscious and twenty-nine of them required artificial respiration from hastily assembled first-aid teams. Some cases took three hours to regain consciousness, and when artificial respiration was stopped, breathing frequently ceased also, and further efforts were required. Those less severely affected complained of dizziness and loss of co-ordinated locomotion, and many were deeply cyanosed. Afterwards, varying degrees of mental confusion were the main convalescent symptoms. The consensus of expert opinion, when the incident was reviewed, was that carbon monoxide was the principal toxic agent. Forty cubic feet of carbon monoxide may be evolved by one pound of T.N.T., and recent American experiments have shown that the air near to a torpedo explosion may contain 60 per cent. carbon monoxide. Death may be produced by 5 per cent. in a few minutes, and 1 per cent. of the gas in air will give 50 per cent. blood saturation in fifteen minutes at rest, and with ten minutes' light work, or five minutes' hard work. It was gratifying to record that so many recovered with adequate artificial respiration given by first-aid parties. The closed-breathing sets gave full protection to the rescue party.

Carbon Monoxide in Coastal Craft

The carbon monoxide hazard in coastal craft was investigated for the Royal Naval Personnel Research Committee in June and July, 1943, by Surgeon Lt.-Commander H. E. Holling, R.N.V.R., and members of the Medical Research Council Staff at the Armoured Fighting Vehicles School, Lulworth. Illustrative incidents given in their report as occurring in the first half of 1943, were as follows:—

1. Shortly before an action, a flotilla staff officer could get no response from the engine room staff of his boat. They had been overcome by exhaust gases escaping from the defective packing of a joint.

2. Within a fortnight of the above incident, the engine room staff of another boat were asphyxiated by exhaust gases after an action. The leak was the result of the penetration of an exhaust by an enemy missile.

3. A stoker was found unconscious in the engine room of a motor launch, suffering from the effects of carbon monoxide poisoning. There were small exhaust leaks, and the margin of safety in this boat had been reduced by the unauthorised removal of one of the four cowl ventilators to allow free bearing for a gun-mounting.

4. Six ratings from a motor torpedo-boat were transferred to hospital suffering from carbon monoxide asphyxiation. The exhaust leak in this case was from a sluice box, the aluminium cover of which had been corroded by salt water. The hole was obscured by a brass plate bearing the name of the makers.'

These are typical instances which were repeatedly encountered among coastal forces. The investigating team emphasised the importance not only of the dramatic intoxication by large doses of fumes, but also the effects on efficiency and the danger to the ship of the minor symptoms, such as headache, dizziness, nausea, anxiety, mental retardation and confusion, which undoubtedly occur more frequently. They found, however, that under normal conditions the average concentrations in engine rooms would not exceed 0·01 per cent. carbon monoxide, and that the concentrations in the blood of engine-room crews did not exceed 10 per cent., both figures well within the limits of safety. It is necessary, however, to allow for the danger of leaks, and as the gas is both odourless and colourless, the need for an efficient indicator is apparent. An efficient simple carbon-monoxide indicator was not available for use in coastal craft during the war. Canaries or red polls, birds which are sensitive to low concentrations of the gas, were suggested as engine-room pets which might give warning of dangerous concentrations to the watch-keepers, but the former were apparently all required for research on anti-malarial preparations, and the latter were never used in practice. Towards the end of the war the M.S.A. Indicator was used in landing craft-carrying vehicles.

Submarine Accidents and Carbon Monoxide

However frequent cases of carbon monoxide poisoning may be, there is always an element of surprise and doubt when cases occur, and wrong decisions are often made. A torpedo motor, started up by accident when the torpedo tube of a submarine was being loaded at Malta in May, 1941, filled the torpedo compartment with exhaust fumes. An officer entered the compartment to rescue one of his men, who had collapsed and who died later, lost consciousness and was exposed to the gas for six to ten minutes. He was delirious after recovering consciousness, and suffered from mental confusion for a long time. For days he was completely blind. Then his vision gradually returned, though he was still unable to write two months after the incident, partly because of incoordination of fine movements, and partly because of loss of memory and word patterns. Thus, it is seen that in certain individuals the effects of the poisoning may be of quite long duration as opposed to the transient story given in most cases. Later, he made a complete recovery. A similar incident followed the firing of a practice salvo of torpedoes at Malta later in the same year, when several of the torpedo party were overcome by a 'non-irritant' gas.

Treatment of these cases consists of artificial respiration, complete rest in fresh air, and the administration of oxygen. The Service respirator gives no protection against carbon monoxide. Complete breathing apparatus should therefore be worn by men working under circumstances where this gas may occur. Once again, the greatest importance should be attached to the education of naval officers and ratings, particularly those of motor craft, aircraft carriers and submarines, in the recognition of the factors causing carbon-monoxide poisoning and of the symptoms, signs, and ways of protecting oneself against the hazard.

LESS COMMON HAZARDS

Undoubtedly, nitrous fumes and carbon monoxide have contributed a formidable page to naval medical history. It is now necessary to refer to certain volatile organic poisons used as fuels or refrigerants or in fire extinguishers, especially in view of the greatly increased installation of domestic refrigerators, water coolers and air-cooling plants in warships, and the large numbers of shipborne aircraft used in modern warfare.

PETROL VAPOUR

The increase in numbers of shipborne aircraft which occurred between the wars and during the War of 1939–45, and the addition to warships of petrol-storage tanks and control compartments, added petrol-vapour intoxication to the list of atmospheric hazards which might beset the unwary.

Petrol vapour is a powerful anaesthetic which will produce loss of consciousness when breathed in high concentrations. The margin between the fatal and the anaesthetic dose is small, and delay in rescue work or in adopting measures for self protection may prove fatal. The higher the air temperature, the greater will be the concentration of petrol in the atmosphere. Thus the hazard is likely to be more prominent in the tropics. Furthermore, the vapour is heavy and will be more concentrated at the deck level than elsewhere in a compartment. Thus the rescue of a collapsed man is a matter of urgency.

Incidents of mild intoxication have been of frequent occurrence in aircraft carriers. These effects were summarised in a report from H.M.S. *Victorious* in 1943, 'The effect of the vapour is to put all but a few hardened cases in a condition similar to alcoholic drunkenness; most men having to be sent up within half an hour [from the petrol-control compartment]. For example one man was found busily engaged in catching non-existent flies on the bulk-head . . .' More serious incidents have occurred. An officer and two naval ratings working on a valve in a petrol-control compartment in H.M.S. *Activity* were rapidly incapacitated following a gush of petrol from the valve. The officer was dead and the others comatose when they were removed from the compartment. Similar fatal accidents to individuals occurred in the petrol-control compartments of H.M. Ships *Glenroy* and *Empress*, and in H.M.S. *Arbiter* seven men, including unprotected members of a rescue party, were rendered unconscious and one man died. Those who were not fatally poisoned sustained severe skin burns where their clothes were soaked with petrol.

High concentrations of vapour, while they are very dangerous, are so irritant to the upper respiratory passages that men exposed will always try to withdraw from a compartment. A slowly rising concentration from a leak may prove more dangerous in effect, for the sense of smell tires after working in a petrol-ridden atmosphere for some time, so that workers will miss this warning sign, may be unaware of their danger, and pass through a phase of intoxication and impaired judgment to collapse later.

Complete protection will be afforded only by a total breathing apparatus such as the Salvus, but the Service respirator affords almost complete protection for at least ten minutes in an atmosphere saturated with petrol vapours, and should therefore always be carried by those who work in petrol-control compartments and used when danger appears to be imminent. The respirator is adequate for most rescue work.

General measures directed towards reducing this hazard are to provide petrol-control compartments with adequate exhaust fans and to ensure that the ventilation system receives careful maintenance, with special regard to the frequent and adequate cleansing of the gauze filters on the exhaust trunking, where these are fitted.

METHYL BROMIDE

Methyl bromide may be used in fire extinguishers or refrigerators, and is also used occasionally for disinfestation or as a fumigant. Since 1939, twenty-two cases of poisoning with this substance have been reported in the Navy, and excellent accounts are given by Holling and Clarke (1944), Gray (1944), and Clarke, Rowarth and Holling (1945). The last-named emphasised the importance of investigating the fire-fighting apparatus whenever a number of simultaneous poisoning cases occur in a small ship, and classified cases as follows:—

1. Acute cases with irritation of the upper respiratory tract and eyes, followed by pulmonary oedema, which is frequently fatal.

2. Patients with symptoms delayed until 2–16 hours after exposure, and occasionally until 48 hours, who pass through a phase of mild intoxication, dizziness and drowsiness into coma, which may be

interrupted by epileptiform convulsions, a sign of grave prognostic significance.

3. Patients with symptoms arising during convalescence, such as diminished capacity for physical work, melancholia, nervousness and neurasthenia.

Gray (1944) called attention to the less dramatic but unpleasant burns that may be sustained by repeated or continuous skin-contact with the vapour or fluid or by exposure to large amounts of methyl bromide.

The insidious nature of the systemic poisoning by this colourless and practically odourless gas, which can permeate apparently intact bulkheads, suggests the necessity of combining a distinctive warning smell with these preparations if they are to be employed in devices in general use in the Services or industry. This problem was carefully considered at the Chemical Defence Experimental Station, Porton, and it was found that either citronella or *p*-dichlorobenzine would be suitable for this purpose. The ordinary Service respirator (Type E. Mark VI) affords protection for only ten minutes, and the light Mark III container will only protect for three or four minutes.

On common-sense grounds it would appear that the measures for preventing poisoning are first to forbid the use in H.M. Ships of fire-fighting or refrigerating equipment containing methyl bromide, or failing this a distinctive smell should be incorporated with it. Service respirators may be used for short periods in emergency, but the limitations of the gas mask in affording protection should be made known. For all repair work the use of a total oxygen-breathing apparatus is essential. Once again well-planned ventilation systems with good exhaust arrangements will greatly reduce the likelihood of accidents.

The treatment of cases of poisoning is largely symptomatic, oxygen being given if pulmonary oedema develops.

METHYL CHLORIDE

Methyl chloride is used as a refrigerant in domestic refrigerators installed in certain British warships. In January, 1939, Gimlette drew attention to this as a naval hazard when he reviewed cases which had occurred in an Italian submarine fitted with a methyl chloride air-conditioning plant. Subsequently, during the war, methyl chloride intoxication is known to have embarrassed the crews of enemy submarines on several occasions, and once caused a submarine to surface with most unsatisfactory results from the enemy viewpoint. This serves to emphasise the importance of selecting an innocuous refrigerant, such as 'freon', for use in ships, and methyl chloride refrigerators in warships should be avoided. The symptoms are similar to those of methyl bromide intoxication: progressive drowsiness, apathy, nausea, possibly vomiting, abdominal pains, coma, convulsions and death; and again treatment is symptomatic.

Typical instances showing the poisonous effects of methyl chloride were reported in the early years of the war, chiefly among technical personnel. In May, 1940, an engine room artificer developed a headache and became drowsy after repairing leaks in a methyl chloride refrigerator in a ship, and then retired to bed with severe headache, dizziness, vomiting and diarrhoea for five days, after which he recovered. Another rating in the vicinity was less seriously affected. In June of the same year an engine-room artificer in H.M.S. *Express*, when working on a refrigerator which was suspected of leaking, lost consciousness and was revived by the use of a Novox machine. In 1941, a rating working in the forward cold store of H.M.S. *Harvester*, where the refrigerator was leaking, suffered from sickness and vertigo after ten minutes' exposure, and two men wearing respirators were similarly affected after about twenty minutes, while other workers equipped with the Salvus apparatus were completely protected. No distinctive smell was reported by any of these men. A few months later, a rating, who had worked on a leaky refrigerator on three consecutive days in H.M.S. *Impulsive*, became unsteady on his feet, was mentally confused, lost his appetite, and began to hiccup, subsequently becoming delirious, cyanosed and semi-conscious. Then convulsions supervened and he died twenty-four hours after reporting sick. This case emphasised the enhanced danger of repeated exposure.

The moral of these accidents is obvious and important. Ratings whose duties include the maintenance of refrigeration machinery, and officers who are responsible for such machinery, should be fully conversant with the hazards of refrigerants; and men who are required to investigate or repair leaks in domestic refrigerators, watercoolers or air-conditioning equipment, should wear a Salvus or some other form of complete breathing apparatus, unless assurance is given that the refrigerant employed in the machine is non-toxic. The virtues of 'freon' (dichloro-difluoromethane) in this respect are widely known, but even here a query arises when there is a fire risk. The thermal decomposition products of 'freon', which may be encountered at temperatures above 500° C., include small amounts of phosgene and fluoro-phosgene. The advice of the Chemical Defence Experimental Station, Porton, however, is that these substances, though highly poisonous, are unlikely to be present in toxic concentrations, and this view is borne out by the lack of reported incidents, despite the fact that 'freon' was widely used throughout the war by the American and British Fleets.

CARBON TETRACHLORIDE

The low incidence of carbon-tetrachloride poisoning in the Navy is of interest, because it is widely used in Pyrene fire extinguishers, and not infrequently as a cleansing agent or for the degreasing of metal parts. In addition, of course, it is an effective anthelmintic and is widely used in the treatment of hook-worm disease. Carbon tetrachloride possesses, however, a characteristic ethereal chloroform-like odour. Thus, workers exposed to toxic concentrations will be aware of the danger, and, provided they are informed that the chemical they are using is poisonous, this is an important factor in their protection.

A minor accident happened in 1940, when five men working in the engine room of a motor torpedo-boat suffered from mild intoxication and discovered that the fire extinguisher had leaked into the bilges. Smarting of the eyes, nausea, vomiting and lassitude were the main complaints, and they all made an uneventful recovery. The way in which the excellent properties of this chemical as a cleansing agent may lead to its irregular use has been described by Forbes (1944). French petty officers in a submarine depot-ship mess discovered the virtue of carbon tetrachloride, contained in Pyrene extinguishers, for cleaning their uniforms before going ashore. They used about four pints on different occasions over a three-month period and the work was generally carried out in a small space with indifferent ventilation. After a few weeks several of them complained of feeling unwell and eventually three men were admitted to a naval hospital acutely ill. They all showed signs and symptoms of toxic damage to the kidneys, and a post-mortem carried out on the one fatal case revealed a central lobular necrosis of the liver and a tubular nephrosis of the kidneys. Sherman and Binder (1944) described four cases in the United States Navy, which all occurred when men were using comparatively large quantities (1–3 gallons) to clean guns (2 cases), a bomb sight and a carburettor. One man died. The main symptoms were considered to be those of an acute toxic hepatitis. Corcoran, Taylor and Page (1943) described a single case where the predominant lesion was acute toxic nephrosis. The more chronic form of poisoning by this chemical, which has been reviewed by Stewart and Witts (1944) and Elkins (1942), is unlikely to be encountered in the Navy as it is not in constant use in naval workshops.

The need for good ventilation arrangements in compartments where carbon tetrachloride is frequently used requires special attention, but once again, it would appear that prevention of poisoning would be most satisfactorily achieved by employing innocuous compounds in fire extinguishers or as cleansing agents. The thermal decomposition products of carbon tetrachloride include phosgene and chlorine, but no instance of poisoning due to this cause was reported during the war.

HAZARDS OF FIRE FIGHTING IN ENCLOSED SPACES

In addition to the obvious dangers of getting burnt and exposure to high concentrations of the chemical vapours referred to above, carbon monoxide, carbon dioxide, oxygen depletion and heavy smoke will always be dangerous factors when there is a vigorous fire in an enclosed space; and if ammunition is ignited, or the fire follows cordite detonation, nitrous fumes may be a further danger. The ordinary anti-gas respirator will not give protection against either carbon monoxide or carbon dioxide, and the protection afforded against nitrous fumes and the chemicals of fire extinguishers is limited. Obviously, it is quite ineffective in the prevention of oxygen shortage. A complete breathing apparatus, such as those described above, should always be worn by the more active members of fire parties. At the same time in acute emergencies when complete breathing apparatus is not available it should be remembered that the Service respirator will give considerable protection against nitrous fumes and smoke.

SMOKE CLOUDS

It is widely believed that the smoke clouds which may be used to conceal the movements of ships or of bodies of troops, or to camouflage objectives, have no injurious action *per se* on man. Under the open-air conditions where they are generally used, this is reasonably true, unless a man is exposed to the full delivery of a generator. In enclosed and poorly ventilated spaces, however, smoke clouds may be very dangerous, and numerous deaths and cases of serious incapacitation have been reported from smoke poisoning in places such as dugouts, tunnels and huts, when combat troops were training in this country.

Smoke may have been a contributory factor in the causation of the casualties in S.S. *La Montée*, and H.M.S. *Puckeridge*, and other clear-cut incidents of smoke poisoning have been reported in ships elsewhere. The spontaneous combustion of a smoke float, containing hexachlorethane and zinc oxide mixture in H.M.S. *Lothian* in 1945, partially asphyxiated a number of the ship's company and one of them died. Similar incidents have been reported in the U.S. Navy, and 85 per cent. of the personnel in one ship were reported to have raised temperatures, rapid pulse rates, sore throats, pains in the chest and muscular pains after exposure to a smoke cloud, although they recovered in twenty-four hours. Smoke was found to be most effective for clearing Japanese out of caves, when the lethal effect was again observed. Latterly the use of smoke in exercises was prohibited.

A serious incident which illustrated the dangers, occurred in the Corradino Tunnel at Malta in 1943, when a fire broke out among smoke-making canisters stored in the tunnel, and numerous dockyard workers who were sheltering there from enemy air-attack were asphyxiated by smoke (Evans 1945). Seventy persons were exposed to the smoke, the longest exposure being for twenty minutes. Four men died from asphyxiation while still in the tunnel, and others died later from broncho-pneumonia and pulmonary oedema, which were directly attributable to the irritant effects of the particulate zinc chloride cloud which formed the smoke. One man who died later was well enough to discharge himself from hospital after preliminary treatment, and walk home.

Service respirators, which were not worn, would have given complete protection during the time of exposure.

CONCLUSION

Atmospheric hazards are not uncommon in naval warfare and are likely to become more numerous if more machines employing diverse chemical substances are introduced into ships. The casualties due to these causes will be reduced by the improved education of all who might be exposed to the hazard, and of the medical staff, in the potential dangers.

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CHAPTER XIII

TUBERCULOSIS IN THE ROYAL NAVY

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TUBERCULOSIS has been, for many generations, a major naval medical problem. In war-time the disease has been specially significant as an impediment to naval operations, for it has consistently been a leading cause of disability, has regularly required the time and efforts of a large number of naval medical personnel, and has added to the problems of transport in every theatre of war. The position was assessed by Dudley (1938) when he showed that over the whole period during which accurate medical statistics at the Admiralty were available the invaliding rate for this disease has remained approximately constant at two per thousand of the entire force per annum; and this, despite every change and improvement in naval architecture, and in the conditions of service in His Majesty's Ships and Establishments. He brought forward, in this article, epidemiological evidence which strongly supported the view that pulmonary tuberculosis in sailors arose as a result of infection incurred in the course of their service, and discussed the value of radiological methods for the exclusion of the disease in order to reduce its incidence.

In 1936, d'Abreu, in Brazil, had, as a result of many years of work, made possible the practical application of fluorography (the photography of the fluorescent screen image) whereby rapid, efficient and relatively inexpensive examination of the chest could be carried out in such a way that a permanent film record of its existing state was obtained. Dudley strongly advocated the application of this method in the Royal Navy for the detection of unsuspected tuberculosis. The enthusiastic support of the then Medical Director General (Sir P. Nicholls, K.C.B.) and the approval of their Lordships were obtained so that the first such apparatus was installed and began its work in the Royal Naval Barracks, Chatham, in 1939. The experience of nearly two years' work of this kind was thus available (and was indeed freely given) when the Royal Air Force began to use the method in 1941.

With the outbreak of war, the mobilisation of large numbers of men rapidly led to a flood of recruits in the three main naval barracks and, indeed, a steady flow continued there, and in other admission centres set up throughout the country during the whole of the war. Fluorography was admirably adapted to deal with the problem of the exclusion of tuberculosis in all these recruits. They had, of course, as had been the case in peace-time and in the War of 1914–18, previously been examined clinically at the recruiting centres, and this examination had, in fact, resulted in the exclusion, at this stage, from service of approximately one per thousand of those examined on account of pulmonary tuberculosis. The available apparatus, however, in that year, and, indeed during the next two years, was in such short supply that many tens of thousands of recruits, of necessity, had to be admitted to the Royal Navy without the advantage of this procedure. It was not until some seven units were in operation in 1944 that all recruits were so examined before they were allocated duties in the Royal Navy. The prevalence of pulmonary tuberculosis in male recruits over the period of the war, as revealed by fluorography is set forth, by age and year, in Table I, while in Table II are presented the corresponding percentages of these cases which a full investigation in hospital had shown to be of active disease.

TABLE I

Incidence of Pulmonary Tuberculosis in Apparently Healthy Naval Recruits as revealed by Fluorography

Age	1940	1941	1942	1943	1944	1945	1946
15–19	4,858 (4·98) 24	33,219 (4·67) 155	49,414 (8·86) 438	86,803 (10·88) 944	19,385 (7·53) 146	33,399 (5·84) 195	20,453 (5·43) 111
20–24	8,470 (4·84) 41	19,393 (5·52) 107	10,874 (9·56) 104	12,236 (15·28) 187	4,917 (7·12) 35	5,918 (9·80) 58	4,799 (6·67) 32
25–29	5,205 (6·92) 36	9,324 (11·37) 106	4,748 (16·85) 80	6,464 (19·03) 123	1,596 (11·90) 19	1,139 (12·29) 14	339 (11·80) 4
30–34	2,471 (7·69) 19	6,582 (12·15) 80	4,018 (13·94) 66	6,565 (23·61) 155	1,916 (14·10) 27	433 (18·01) 8	158 (12·66) 2
35–39	918 (18·52) 17	3,724 (18·26) 68	3,824 (19·87) 76	4,311 (27·14) 117	995 (19·50) 19	168 (17·86) 3	29 0
40	191 (20·94) 4	953 (9·44) 9	2,256 (32·80) 74	2,018 (37·16) 75	569 (21·10) 12	39 (25·65) 1	34 0
TOTAL	22,113 (6·38) 141	73,195 (7·17) 525	75,134 (11·15) 838	118,397 (13·52) 1,601	29,376 (8·78) 258	41,096 (6·79) 279	25,812 (5·77) 149

Figures in parentheses represent numbers per 1,000 with fluorographic evidence of tuberculosis.

It will be seen that, as in other surveys of the apparently healthy, the incidence of the disease rose with age, but in addition *and at all ages* a quite remarkable increase was observed in 1942, 1943 and 1944, with a peak in 1943. The fact that after 1943 the incidence fell makes it difficult to believe that diet or the stresses of war in the civilian population were the factors concerned. It may, however, be significant that sanatoria

TABLE II

Recruits to the Royal Navy: Active Pulmonary Tuberculosis expressed as a Percentage of Total Cases

Age	1940	1941	1942	1943	1944	1945	1946
15–19	41·1	43·6	40·8	39·5	51·4	59·5	43·2
20–24	42·7	40·4	39·5	36·9	51·4	56·9	50·0
25–29	31·8	38·8	39·0	41·5	26·3	28·6	25·0
30–34	39·8	33·0	36·1	48·0	33·3	25·0	50·0
35–39	35·8	34·4	35·3	39·2	21·5	33·3	0
40+	25·0	33·3	36·9	44·6	8·3	0	0
TOTAL	40·7	39·1	38·7	38·2	43·4	55·9	44·3

were for the most part emptied and largely used for other purposes during the period 1939–42. Many more infectious patients than was usual thus remained at home, and the 'shelter-life' of the time enhanced the hazard of widespread infection. The usual slow development of the disease after infection, the increasing return of tuberculous patients to sanatoria after 1942, and the steady dwindling of the intensity of aerial bombardment during and after that year, were all factors which may well have combined to give rise to this fluctuating curve of the incidence of the disease revealed by fluorography during these years.

The proportion of these recruits found at fluorography to have pulmonary tuberculosis in these years, whom full investigation in hospital showed to have active tuberculosis, remained remarkably constant at all ages at 40 per cent. approximately.

It was from the first decided to examine not only recruits but also regular personnel, and to make an attempt to re-examine the entire force, if possible, at yearly intervals. It was with this aim in view that the first three available fluorographic units were stationed at the Royal Naval Barracks at Chatham, Portsmouth, and Devonport through which nearly all naval personnel recurrently pass. This object has since the war been attained; but during the war, for a variety of reasons, the most important of which was the lack of adequate apparatus and personnel, the ideal was never in practice even approached, and the older methods of clinical examination with subsequent radiological investigation, when signs and symptoms were suggestive, was, in fact, for some years the most important method of exclusion of pulmonary tuberculosis and of its diagnosis within the Royal Navy.

The increasing use of fluorography, however, led to the need to define the proper method of its application. It was decided to use fluorography as a 'sieve'. Anyone with any abnormality detected at fluorographic examination of the chest was submitted to a routine radiological examination. At this stage, the radiologist in charge of the Fluorographic Unit had authority to return, forthwith, to duty those men whose radiographs showed anatomical abnormalities, such as dextrocardia; and also those with pathological signs which were clinically insignificant, such as wholly calcified primary foci of tuberculosis. Those with apparently significant disorders were sent to the adjacent Royal Naval Hospital, were fully investigated, and as a result, their appropriate treatment or disposal was arranged.

The following conditions were regarded as incompatible with full duty:—

1. Any evidence of re-infection (adult type tuberculosis) other than entirely calcified minimal lesions or thin fibroid strands.

2. Evidence of active primary tuberculosis, or of pleurisy with effusion.

3. Evidence of fibrous or serofibrinous pleurisy in excess of slight diaphragmatic or costo-phrenic fibrosis.

4. Other significant non-tuberculous abnormalities in the lungs, heart, or thoracic parietes.

Calcified primary tuberculosis was not regarded as being incompatible with active service.*

Those who, at the first or subsequent examination in hospital, showed evidence of active tuberculosis of the lungs were given appropriate treatment in naval hospitals, and later, as soon as transfer could be arranged, were invalided to civilian sanatoria. Those who, at investigation in naval hospitals, either on the first occasion or as a result of repeated examinations after an adequate period of observation, were found to have arrested disease, were returned to full duty, to be re-examined, as far as possible, annually with the rest of the Royal Navy.

The shortage of man-power at all stages throughout the war, and, in particular, the shortage of trained naval personnel led, from the first, to the necessity for conserving every man who was fit to serve. It was quickly realised that there were many with minimal adult-type pulmonary tuberculosis, which could not be regarded as completely arrested, in whom a full clinical investigation failed to reveal any evidence of active disease. It was thought likely that such lesions were essentially unstable and likely to progress unfavourably under the condition of active service in the various and widespread theatres of war. These men were given special duties at home in shore establishments, and arrangements were made for extra leisure and abundant food, and for repeated full clinical and radiological investigation in hospital at three-monthly intervals. At one time, in 1943, there were more than two thousand so employed, and, in this way, a considerable saving in man-power resulted.

Table III indicates the results of the investigation of 1,836 cases of

* The earliest results of fluorography in the Royal Navy were published by Dudley (1941), and Brooks (1942) gave a detailed account of procedure as well as an analysis of the results of the first 200,000 examinations.

TABLE III

Minimal Pulmonary Tuberculosis (Adult Type) in Men of the Royal Navy: Cases of Apparently Inactive Disease Observed on Selected Shore Service at Three Ports from March 1942 to March 1944

Age group (years)	Depot	Period of Observation							
		0–6 Months		6–12 Months		12–18 Months		18–24 Months	
		Population at risk	Relapsed	Population at risk	Relapsed	Population at risk	Relapsed	Population at risk	Relapsed
10–19	A	256	20 (7·8)	116	7 (6·0)	37	2 (5·4)	10	0
	B	23	3 (13·0)	16	4 (25·0)	4	0	2	0
	C	124	12 (9·7)	71	5 (7·0)	32	2 (6·3)	13	0
	Total	403	35 (8·7)	203	16 (7·9)	73	4 (5·5)	25	0
20–29	A	343	22 (6·4)	180	13 (7·2)	66	1 (1·5)	27	0
	B	77	5 (6·5)	63	2 (3·2)	44	2 (4·5)	26	0
	C	196	26 (13·3)	101	8 (7·9)	36	1 (2·8)	22	0
	Total	616	53 (8·6)	344	23 (6·7)	146	4 (2·7)	75	0
30–39	A	282	11 (3·9)	167	6 (3·6)	63	1 (1·6)	22	0
	B	80	0	69	4 (5·8)	48	0	28	0
	C	146	8 (5·5)	81	5 (6·2)	38	2 (5·3)	21	0
	Total	508	19 (3·7)	317	15 (4·7)	149	3 (2·0)	71	0
40–49	A	117	5 (4·3)	62	0	25	0	14	0
	B	47	2 (4·3)	39	2 (5·1)	25	1 (4·0)	4	0
	C	86	6 (7·0)	55	2 (3·6)	31	0	15	1 (6·7)
	Total	250	13 (5·2)	156	4 (2·6)	81	1 (1·2)	33	1 (3·0)
50–59	A	24	0	17	0	11	0	4	0
	B	13	0	11	0	11	0	3	0
	C	12	0	4	0	3	0	1	0
Total all ages	A	1,002	58 (5·7)	542	26 (4·8)	202	4 (2·0)	77	0
	B	240	10 (4·2)	198	12 (6·1)	132	3 (2·3)	63	0
	C	564	52 (9·2)	312	20 (6·4)	140	5 (3·6)	72	1 (1·4)
GRAND TOTAL	All	1,826	120 (6·6)	1,052	58 (5·5)	474	12 (2·5)	212	1 (0·5)

Figures in parentheses are percentages of the corresponding population at risk.

minimal apparently inactive pulmonary tuberculosis so observed on home shore service during two years (Brooks, 1944).

These cases, disclosed at fluorography, had not been found to be active at first examination in hospital, nor were the first radiological or other investigations suggestive of arrested disease.* The patients were re-examined in hospital at three-monthly intervals. Of the 1,836 cases observed, 120 (6 per cent.) had relapsed during the first half year, 58 during the second half year, 12 during the third half year, and only 1 during the fourth half year. The frequency of relapse was highest in the younger age groups, after which it declined. In other words, the older a patient was and the longer a lesion remained apparently inactive the less likely was it that relapse would occur.

The invaliding rates for pulmonary and other forms of tuberculosis had, prior to the war, always provided a satisfactory index of the known level of the disease within the Royal Navy. It had indicated in practice the proportion of men who developed symptoms and signs of the disease, and so reported sick, and since following diagnosis the delay before transfer to the civil authorities for further treatment had been short, the death rate from the disease in any of its forms had always been very low. In Tables IV, V and VI, there are presented the invaliding and death rates for pulmonary, and other forms of tuberculosis over the period 1938–48.

It must be emphasised, however, that both rates were modified and fluctuated considerably as a result of extraneous and changing factors, some of which had not existed before the war. They were:—

1. The considerable and increasing delay in the transfer of patients from the naval hospitals to civilian sanatoria (for it was usually, at this stage, that invaliding took place). This tended to increase the death rates.
2. Fluorography of recruits after they had been admitted to the Royal Navy, and of regular personnel, increased the invaliding rates by revealing unsuspected tuberculosis.
3. Changes in policy as regards invaliding; thus, for the first three years of the war, unless the man was untrained, only active tuberculosis, as a rule, implied invaliding.
4. Late in 1943, a major change took place after the decision to regard the treatment of those found to have active tuberculosis as a naval responsibility. Although such treatment usually took place, for the most part, in civilian sanatoria this postponed invaliding

* The diagnosis of active tuberculosis depended on a synthesis of the following:— The case history, physical examination, temperature, pulse, respiration, weight, haemogram and blood sedimentation rate; at least six direct sputum examinations, including concentration methods, or if these were negative, at least three cultures of existing sputum, and if there was no sputum, at least three cultures of the fasting gastric juice. In some doubtful cases guinea-pig inoculation was used. The investigation in hospital lasted, on the average, ten days.

TABLE IV

Annual Invaliding Rates per 1,000 Strength by Age Groups (Officers Excluded)

Age	1934–8	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948
Under 20	1·03	0·82+	1·43	2·26+	2·49++	2·47++	2·54++				
20–24	1·81++	1·27	1·28	2·06++	2·64++	2·39++	2·25++				
25–29	2·05	1·48	1·79	2·10	2·84++	2·13	2·76++				
30–34	1·72	2·27	2·28	2·55	3·00	2·35	2·34				
35–39	1·94+	2·27	2·85	2·40	4·18+	3·14	2·72				
Over 39	2·36	2·36	2·47	2·76	3·96++	3·87++	3·75++				
40–44	2·05	1·82	2·32	2·87	—	—	—				
Over 44	3·33	2·96	2·61	2·66	—	—	—				
Total crude rate	1·74	1·54	1·79	2·26++	2·93++	2·54++	2·55++				
Total age—adjusted rate	1·74	1·58+	1·87	2·27++	3·01++	2·52++	2·57++	2·16+	2·89++	7·54++	7·08++

Notes on Table showing the Annual Invaliding Rates per 1,000 Strength by Age-groups (Excluding Officers)

1. + indicates a significant difference from the corresponding rate for 1940. ++ indicates a highly significant difference from the corresponding rate for 1940.
2. Age adjusted rates are the rates which would have been observed had the age composition of the Navy remained constant at the average for the period 1934–8.
3. As in civilian experience the rates do not differ greatly over the age-range concerned. Consequently age adjustment makes very little difference to the crude rates.
4. There has been a striking increase in invalidings due to pulmonary tuberculosis in 1941 and again in 1942. In 1943 a fall occurred. The difference between the rates for 1942 and 1943 is highly significant.
5. A possible indication that fluorography has begun to affect the figures is the high rate in 1942–3 among those over 39. It is older men of high resistance, with symptomless but nevertheless active disease, whom, it may be expected, fluorography would particularly detect. It is also they who provide sources of infection in their ships and whose removal may perhaps lead to improvement in the figures for the Navy as a whole. At present, however, this should not be regarded as more than speculation.

till finality of treatment was attained. Those cases of apparently inactive tuberculosis in which the stability of the lesions was questionable were still, for the most part, retained under supervision.

5. A further change took place at the end of the war, in 1945, when once more it became the usual rule to invalid those with apparently inactive pulmonary tuberculosis to the supervision of their local Tuberculosis Officers.

TABLE V

Invalidings Due to Pulmonary Tuberculosis and Non-Pulmonary Tuberculosis. Annual Rates per 1,000 Strength (Officers)

Year	Pulmonary tuberculosis	Non-pulmonary tuberculosis
1934–8 . .	0·84	0·19
1939 . .	0·84	0·15
1940 . .	1·09	0·04
1941 . .	0·87	0·00
1942 . .	1·46	0·07
1943 . .	1·52	0·05
1944 . .	2·08 + +	0·07

NOTES

1. + indicates a significant difference from the corresponding rate for 1940. + + indicates a highly significant difference from the corresponding rate for 1940.
2. Invalidings due to pulmonary tuberculosis rose in 1942–3. The difference between the periods 1934–41 and 1942–3 is significant.

TABLE VI

Annual Rates per 1,000 Strength (Officers Excluded) of Deaths Due to Pulmonary Tuberculosis

Year	Rate
1934–8 . .	0·12
1939 . .	0·12
1940 . .	0·10
1941 . .	0·15
1942 . .	0·14
1943 . .	0·08
1944 . .	0·10
1945 . .	0·10
1946 . .	0·14
1947 . .	0·43
1948 . .	0·42

The very high rates for 1947 and 1948 are the result of these last two factors, as well as the invaliding of those cases diagnosed during the war and then attaining finality of treatment, and most of all to the marked fall in the total numbers of men then serving.

During the period 1940–5, exceptionally valuable and skilled members of the Royal Navy whose active tuberculosis was minimal in extent, and in the opinion of the consulting physician of relatively good prognosis were, with the permission of the Medical Director General, retained in the Royal Navy while undergoing therapy in the expectation that, in due course, they might be able to return to duty. Though the total number concerned was statistically insignificant, this group was important not only because the great majority did return and remain well while on active service, but also because they were exceptional individuals whose contribution to the war effort could ill be spared.

The results of initial fluorographic examinations in the Royal Navy are recorded in Table VII and represent an aggregate of these examinations over the whole war period to June 30, 1945.

TABLE VII

Incidence of Pulmonary Tuberculosis (Adult Type) Disclosed in R.N. Males and in W.R.N.S. Females at First Fluorography

Age	Males			Females		
	No. examined	No. with P.T.	Per cent.	No. examined	No. with P.T.	Per cent.
10–14	325	2	0·62	5		
15–19	246,888	1,952	0·79	13,996	86	0·61
20–24	189,048	1,765	0·93	17,931	133	0·74
25–29	88,165	1,098	1·24	5,502	77	1·3
30–34	61,976	1,002	1·62	2,556	34	1·3
35–39	40,008	883	2·21	1,436	26	1·8
40–44	22,968	658	2·86	872	12	1·3
45–49	9,766	335	3·43	342	3	0·95
50–54	5,928	187	3·15	67		
55–59	3,153	95	3·01	8		
60	458	14	3·06	1		
TOTAL	668,683	7,991	1·20	42,716	371	0·86

It will be seen that the incidence of the disease so disclosed (12·0 per thousand for the males) rose steadily with age to a maximum of 34 per thousand at 45 years and thereafter stayed approximately constant. In women, the incidence was less (except between the ages of 25 and 29) and the incidence fell after the age of 40. It must be realised, however, that throughout the war the W.R.N.S. was a highly selected force, and it is likely that the bulk of the recruits came from sections of the population less severely affected than others by the disease. More exact analysis, simultaneously, by age and duration of service, revealed that pulmonary tuberculosis in apparently healthy sailors in the Royal Navy had an incidence related only to the former, and this finding, which was unsuspected, can be compared with that of Dudley (1938) who, from invaliding rates for symptomatic active tuberculosis prior to the war found no evidence that service in the Royal Navy gave rise to increasing immunity to the disease, or to any process of selection whereby the more highly immune tended to be retained. As was the case in recruits, the proportion with active tuberculosis disclosed by fluorography was very constant at all ages at about 4·6 per thousand fluorographed, of whom 3·0 per thousand were found to be excreting tubercle bacilli.

Dudley had emphasised that, if tuberculosis in adult life is preponderantly the ultimate result of infection in childhood, routine repeated fluorography could do nothing to reduce its incidence in the Navy; and if not, it was still necessary to reduce the number of infective cases serving in the Navy below that critical level which is necessary to ensure the perpetuation of the disease. The first of these questions is still a matter of academic controversy, though it became evident among sailors that a considerable proportion of those cases of pulmonary tuberculosis discovered in adolescents and young adults were either examples of active primary tuberculosis or cases in which continuous progression to adult-type disease had occurred shortly after primary infection. Important evidence furthermore, accrued within the Service, that adult-type tuberculosis developed apparently as a result of re-infection by contact with 'open' cases. Thus, it was not infrequent to encounter localised epidemics of tuberculosis in ships at sea for long periods, for example destroyers concerned with Atlantic convoys, and many of the cases showed radiological evidence of calcified residua of past infection.

The second question requires some knowledge of the critical level of infection, of the actual level of infection, and of the optimum practical interval between fluorographic examinations required to keep the latter below the former. The critical level was and is quite unknown, but the actual level of unsuspected infective cases within the Royal Navy was very closely measured by the number of those cases found at fluorography which were demonstrated to be excreting tubercle bacilli in their sputum. Those with symptomatic disease were, as a rule, removed swiftly enough from contact with their fellows as a result of the available clinical facilities to prevent their contributing appreciably to the risk of infection incurred by their messmates. Of those with unsuspected disease, however, approximately 3 per thousand of the entire force had sputum containing tubercle bacilli (Brooks, 1945).

Light was cast upon this problem by the results of repeated fluorography. In Tables VIII and IX these results are shown. They demonstrate that the incidence of new disease disclosed by fluorography in

TABLE VIII

Age (years)	Interval since First Fluorography (Months) 0–11	12–23	24–35	36+	Total
10–14	4	5	2		11
15–19	5,245 11* (2·10)	14,380 35* (2·43)	753 2* (2·92)	26	20,404 48* (2·35)
20–24	5,916 12* (2·03)	29,162 82* (2·81)	15,868 73* (4·60)	3,176 15* (4·72)	54,122 182* (3·40)
25–29	2,580 9* (3·44)	10,648 37* (3·47)	5,641 23* (4·08)	1,663 10* (6·01)	20,532 79* (3·85)
30–34	1,691 3* (1·77)	7,254 29* (4·00)	3,796 20* (5·03)	1,217 10* (8·21)	13,958 62* (4·44)
35–39	1,031 5* (4·85)	4,943 22* (4·22)	2,778 13* (4·68)	861 7* (8·13)	9,613 47* (4·89)
40+	1,221 6* (4·91)	5,683 24* (4·22)	3,283 30* (9·14)	1,013 8* (7·89)	11,200 68* (6·07)
TOTALS	17,688 46* (2·60)	72,075 229* (3·18)	32,121 161* (5·01)	7,956 50* (6·28)	129,840 486* (3·08)

Figures in parentheses represent numbers per 1,000 of new cases of pulmonary tuberculosis.
R.N. MALES, second fluorography, normal.
* R.N. MALES, second fluorography, new cases of pulmonary tuberculosis.

those who were previously normal to this examination rose steadily with the interval since the first fluorography. At an interval of less than one year, 2·6 per thousand (of whom 0·8 per thousand were excreting tubercle bacilli) developed evidence of disease, and this proportion rose to 6·3 when the interval had increased to three years. It was certain, therefore, that the steps taken as a result of repeated fluorography disturbed the natural balance of tuberculosis in the Royal Navy, but as the intervals between examinations increased there was a tendency for the old balance to be restored. Whether, with annual re-examination, the level of the infectious cases among the apparently healthy will be sufficiently low continuously to reduce the number of new infections, is a problem for the future, and, in this respect, it is significant that with the interval held constant the incidence of new disease falls steadily at third, fourth and subsequent fluorographic examinations.

TABLE IX

Age (years)	Interval since Second Fluorography (Months) 0–11	12–23	24*	Total
10–14	1	—	—	1
15–19	282 2* (7·09)	328 1* (3·05)	9	619 3* (4·84)
20–24	1,522 11* (0·66)	4,438 12* (2·70)	1,204 2* (1·66)	7,164 15* (2·09)
25–29	707 1* (1·41)	2,345 2* (0·81)	611	3,663 3* (0·81)
30*	1,410 4* (3·84)	3,938 9* (2·29)	1,092 3* (2·75)	6,440 16* (2·48)
TOTALS	3,922 8* (2·04)	11,049 24* (2·17)	2,916 5* (1·71)	17,887 37* (2·07)

Figures in parentheses represent numbers per 1,000 of new cases of pulmonary tuberculosis.

R.N. MALES, third fluorography, normal.

* R.N. MALES, third fluorography, new cases of pulmonary tuberculosis.

As the war progressed, and, in particular, as operations in the Mediterranean and in the Far East became increasingly of marked significance, facilities for the treatment of cases of tuberculosis discovered oversea were provided in widely scattered areas over the world. Difficulties of transport and the large numbers concerned led to the necessity of retention of cases of tuberculosis for a considerable time in the Royal Naval Hospitals, for example, in Ceylon, South Africa, and, later in the war, in Australia. At the same time, the increasing difficulty of transferring cases to civilian sanatoria at home had, as a result, enforced the utilization of more beds and medical personnel in the greatly increased number of naval medical hospitals in England. So pressing had this problem become that, by 1943, a special Royal Naval Auxiliary Hospital for the treatment of cases of pulmonary tuberculosis was opened at Southport, and within it full facilities for the surgical treatment of the disease were made available.* In addition, surgical therapy was developed, to a limited extent in the three main naval hospitals of Chatham, Haslar and Plymouth. Finally, transport

* H. Morriston Davies, M.Ch., F.R.C.S., acted as Regional Surgical Consultant.

difficulties being considerable, full sanatorium facilities were made available through the co-operation of the South African Government (and were shared by all three Services) for cases of this disease at Baragwanath near Johannesburg. Naval cases going thence were received at the Royal Naval Hospital, Durban, where selection was made of those suitable for the surgical or sanatorium therapy.

Though statistical evidence is lacking, there is strong reason to believe that a higher proportion of those with unsuspected tuberculosis broke down, indeed often relapsed catastrophically, under the conditions of tropical service, than in those serving in home waters or establishments at home. Certainly, the numbers of cases with far advanced active disease entering the Royal Naval Hospitals in Ceylon, Australia and Durban were significantly higher than in other Royal Naval Hospitals. For the most part, transport of these cases from distant theatres was done by hospital ship, though occasionally air-transport facilities, when available, were used and were found to be quite satisfactory in the great majority of cases.

Early in 1944, the facilities for controlling and dealing with tuberculosis within the Royal Navy had been perfected and were capable, despite difficulties in the transport and transfer of cases, adequately to meet the problem in a force then consisting of nearly a million men scattered widely over the world. Seven fluorographic units were at work respectively at Chatham, Portsmouth, Plymouth, Lowestoft, Liverpool, Skegness, and Greenock. Full diagnostic facilities, as well as those for the therapy of the disease were available in Royal Naval and Royal Naval Auxiliary Hospitals widely scattered over the world, and this implied the provision in each of these of radiologists and medical personnel skilled in the diagnosis of the disease and in every aspect of its treatment.

The clinical records, both of the Fluorographic Survey and of cases of tuberculosis disclosed at clinical examination were transmitted to the Admiralty and were, to this extent, centralized. In the instance of the Fluorographic Survey, however, it was realised from the beginning that dispersal of records had many advantages, not least of which were the comparative safety from aerial bombardment and the maintenance within reasonable bounds of the size of stores of accumulated films and indexes. A system, therefore, was elaborated whereby each unit kept its own records and stored its own fluorographic and routine films. The ease of reference (particularly when repeated fluorography necessitated re-scrutiny of previous films), permitted by relatively small peripheral collections of records, far outweighed any disadvantage which dispersal may have entailed. These records have repeatedly been found to have, for the Admiralty as well as for the individual, a practical as well as an academic value, for their medico-legal and their clinical significance is great. The British Tabulating Machine Company were responsible for sorting and statistical compilation in various categories of those found to be normal at fluorographic examination. Those found to be abnormal and, in particular, those showing evidence of tuberculosis were hand-sorted and tabulated centrally.

At the end of the war, demobilisation once more implied increased pressure upon all the facilities for the diagnosis of tuberculosis, and the efficiency of fluorography was of high order. The great majority of those demobilised were fluorographed and when abnormality, and, in particular tuberculous abnormality was found, investigation was, in every case, undertaken. It was thus ascertained whether the disease was active and requiring treatment, or arrested, in which case the individual was demobilised forthwith. If the category was that referred to above as apparently inactive pulmonary tuberculosis, the individual concerned was invalided to the supervision of his Tuberculosis Officer to whom a full record of the investigation was sent.

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CHAPTER XIV

(i)

BORNHOLM DISEASE

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In 1930 Sylvest described a clinical condition, characterized by the sudden onset of severe pain in the lower chest and abdomen and a brief febrile course, to which the name Bornholm disease was applied because the aetiology was obscure and the cases upon which he based his article occurred in the Danish island of Bornholm. Clinical conditions, which probably indicated the same disease, had been described previously by others, notably by Daae in Norway in 1872, but little notice had previously been taken of the syndrome until Sylvest's paper appeared. Many other names were given to the disease—for example, epidemic myositis, epidemic myalgia, epidemic pleurodynia, and 'the devil's grip', each name emphasising one or other of the salient clinical features, but the pathology remained obscure.

During the War of 1939–45 and in the year after its conclusion several epidemics of what appeared to be Bornholm disease occurred among Service personnel. In 1943 and 1944 an outbreak occurred in the Suez Canal area and a careful study of 20 cases occurring in officers was made by J. G. Scadding (1946). As in the case of infective hepatitis there was a greater incidence among officers than among other ranks. The cases arose in units scattered over a rather extensive area, and in only one instance was there a significant number at the same time from one unit. Prodromal symptoms were rare and the onset was usually sudden and was ushered in by severe pain which was entirely confined to the chest, abdomen and shoulder, situations in which it could reasonably be attributed to a pleural origin. The pain was pleuritic in character, being aggravated by respiratory effort. In some cases the severe abdominal pain simulated an acute abdominal condition. Fever varying from 99·2° F. to 104° F. lasted for 3 to 5 days. Cutaneous hyperaesthesia was noted in 8 cases; it was generally confined to areas on the abdominal wall supplied by the 9th, 10th and 11th thoracic nerves. A notable feature in Scadding's series was the occurrence of pleural friction in 11 out of the 20 cases; the friction was always localised over the extreme base of the lung and appeared three to nine days after the onset of symptoms. Radiological examination showed no pulmonary lesion and only occasional slight limitation of movement of the diaphragm. Total and differential leucocyte counts were as a rule within normal limits.

In diagnosis, amoebic hepatitis, pneumonia, tuberculous pleurisy and acute abdominal conditions had to be considered, but were fairly easily excluded. In general the symptoms and signs suggested an infection causing dry basal and diaphragmatic pleurisy, with little evidence of muscle involvement; it differed from some of the recorded outbreaks in that there was little tenderness or objective change in the muscles, in the frequency with which pleural friction was heard, and in the total absence of evidence of involvement of the central nervous system.

In 1943, T. Howard and his colleagues recorded a considerable epidemic which occurred in Brooklyn in the previous year; in this outbreak several cases developed frank encephalitis.

In the year following the war an interesting series of cases of Bornholm disease occurred at Singapore Naval Base and was observed by Surgeon-Commander J. Vincent-Smith, R.N., from whose report the following account has been abstracted.

On June 8, 1946, 42 men in the barracks at Singapore reported sick with complaints of pain in the chest, fever and prostration. It was feared that this might be the beginning of a serious epidemic, so a suitable empty building was rapidly fitted up as an emergency ward and part of the barracks was similarly prepared. On June 9, 28 more cases were received into hospital and on the following day a further 23 were admitted. Thereafter the numbers rapidly declined until by June 21 only an occasional solitary case occurred. At first the exact nature of the disease was doubtful but by the third day of the outbreak it was clear that the cases constituted an epidemic of Bornholm disease. In this epidemic 125 cases were seen. The clinical signs and symptoms were fairly typical but some features were unusual.

Pain was usually on one side of the chest, but it was sometimes felt substernally or even in the epigastrium. Occasionally it was felt around the neck and shoulders. Pain on respiratory movement was always present, but varied much in severity; one or two patients had to be given morphine, others felt little more than a 'tightness'. The degree of prostration was difficult to assess as the predominant characteristic was fear of moving at all. One lad could only breathe when sitting up; when he lay flat pain was very severe round the neck and shoulders. It was noticed in all cases at the onset that breathing was mainly abdominal. Fever accompanying the pain was also variable, from the maximum record of 104° F. to a hardly perceptible rise. The initial fever might last from one to four days. In 77 cases there were one or more bouts of fever, with return of pain, after the temperature had once returned to normal. It is perhaps more accurate to call these exacerbations rather than relapses. Faucial and conjunctival injection was seen in most cases at the beginning, but there was no marked catarrh. Pinprick hyperaesthesia was elicited over the lower chest and upper abdomen, but bore little relation to the site of the pain. Some tenderness was found over the descending colon of early cases but not as a regular feature. Diarrhoea had occurred in one patient and several complained of nausea and loss of appetite, but these symptoms, like the frontal headache and general body pains also reported, were regarded as due to the fever. Pleural friction was not heard during the acute phase of the attack, but a painless pleural rub developed later in 33 cases; in 20 of these the rub was on the same side of the chest as the pain had been. Herpes around the mouth was observed in 10 patients. Four cases of mild orchitis were seen. White-cell counts and estimation of the blood-sedimentation rate were made in 56 cases, and were discontinued when no constant or suggestive variation was found. In 9 cases eosinophils formed 6 per cent. or more of the total white cells. In 19 cases the B.S.R. was between 10 and 30 mm. in one hour; in 9 cases it was 10 mm. exactly, in the remainder below 10 mm. These observations were of necessity somewhat empirical. With such a large number of patients, and the laboratory staff at the Asiatic Hospital hard-pressed by other commitments, it was not practicable to repeat investigations and follow up those which showed some deviation, so that other possible causes were not excluded. A few patients in the acute stage were X-rayed; no abnormalities were detected. There was nothing in available literature to suggest that significant variations would be found in the above investigations, and, similarly, it was felt that subjection of patients to lumbar puncture would not be justified.

At Singapore nobody was able to offer any helpful suggestions regarding virus experiments; no suitable animals were available on the spot and the explosive nature of this outbreak left no time to arrange for material to be collected and flown to Australia. Some observers have assumed a primary involvement of the thoracic muscles themselves. There was no evidence of this in the cases seen at the Naval Base except for one patient whose 'pleural rub' was not only audible and palpable but actually visible.

This particular outbreak appeared to be food-borne in the first instance, and that would not be surprising since the place at which it occurred had been for some weeks remarkable for its low standard of hygiene, and adverse reports had been made from time to time by the Principal Medical Officer and the Health Officer. Various sanitary defects were noted in an attempt to trace the origin of the outbreak. The disease had not previously been recognised as endemic in Malaya, though a Dutch doctor who had worked for some years in the Netherlands East Indies said that the syndrome was familiar to him. Nobody could recall any particularly suspicious cases being treated at the Asiatic Hospital, though when it occurs sporadically anywhere in the world the disease is seldom recognized and must usually be passed off as 'pleurodynia', 'muscular rheumatism' or as an episode in some prevalent complaint—dengue, influenza, tuberculosis, malaria. However during the outbreak of poliomyelitis in Singapore earlier in 1946, cases sent to the Middleton (Infectious Diseases) Hospital for observation had included ten in which a tentative diagnosis of Bornholm disease had been made. It was mention of this at a clinical meeting that had put the possibility of such a diagnosis into the mind of the medical specialist at 69th Indian General Hospital.

The Singapore outbreak was remarkable for its large numbers (125 in all), its explosive beginning suggestive of infection by food, the few cases of orchitis, and the relative frequency of the highly problematical 'pleural rub'.

Cases of anterior poliomyelitis were being disseminated by H.M. ships from Singapore as far as India and Ceylon, and later in the year it was reported to the Principal Medical Officer that there were being received at the R.A.F. Hospital, Aden, patients homeward bound from Singapore who were suffering from that disease. The fact that anterior poliomyelitis and epidemic myalgia sometimes occur in simultaneous epidemics has led some to enquire if there might be any relationship between the two diseases. In 1941 F. Wolter considered this question and concluded that, though similar circumstances might favour the development and spread of both epidemics there was no common causative factor.

An account of the epidemic at Aden was recorded by Jamieson and Prinsley. Between August 17 and October 25, 1946, there were 35 cases, nearly all treated in the R.A.F. Hospital at Aden. The outbreak was confined to the British Services with the exception of one Arab who contracted the disease. Nearly half of the cases complained of soreness of the throat in the initial phase and inspection showed a generalized inflammation of the fauces without exudate. Only one patient developed a pleural rub. An unusual feature was the development of orchitis in 12 out of the 30 male cases; it was always unilateral, affected the right and left side equally, and developed at times varying from the end of the first week to as late as the middle of the sixth week after the onset of the disease. X-ray examination showed a normally mobile diaphragm in every case. As a rule there was a moderate leucocytosis, and the sedimentation rate was increased in all of 24 cases examined. It was considered likely that the spread of the disease at Aden was by droplet infection. In view of the frequency of orchitis in this epidemic the author recorded the interesting fact that, while the medical staff of the Indian Hospital at Aden saw no cases of Bornholm disease they noted an outbreak of mumps among Indian personnel at that time; the Indian authority had several cases admitted with orchitis which they presumed to be complications of 'missed' cases of mumps.

(ii)

Note on Bornholm Disease

By Major General Sir HENRY TIDY
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Bornholm Disease is an infectious disease characterised by the sudden onset of severe pain involving the lower respiratory and upper abdominal area on one side. It is a benign infection and complete recovery is uniform. It possesses a considerable degree of infectivity and often occurs in local epidemics. It has been described in Scandinavian literature for over 200 years but attention was more definitely drawn to it by a full account by Ejnar Sylvest in 1932 who gave it the name 'Bornholm disease'. Pickles described an epidemic in England under the same title in 1933.

Many epidemics have been recorded in British and American journals under a variety of titles but in spite of the severity of the pain and the unusual character of the 'rub' which may be present the disease remains curiously unknown to the general medical profession and is rarely correctly diagnosed. As recently as 1944, a typical epidemic was described in a medical journal under the impression that it was a new syndrome.

The physical sign which often gives rise to an erroneous diagnosis is the occasional but not invariable presence of a loud rub audible over the painful area. The various titles under which epidemics are described illustrate the difference of opinion as to whether the rub is pleural in origin or due to some muscular change such as friction between the muscle and its sheath. One group includes epidemic pleurodynia, epidemic pleurisy and benign dry pleurisy, and another group includes epidemic myalgia and epidemic myositis. Many authors assume that it is pleuritic in origin. Sylvest, however, came to the conclusion that it was muscular. It may be noted that there is no cough, no pulmonary changes other than the rub either on physical or radiographic examination and pleural effusion does not develop. The rub is often strikingly loud and it may be extraordinarily coarse, and in such cases is quite unlike any pleural friction. The muscles in the affected area are extremely tender to pressure and may be swollen. After the severe pain subsides there may be aching for two or three weeks. The evidence seems to support Sylvest's conclusion.

An epidemic in the Suez Canal area in 1943–4 was described by Scadding under the title 'acute benign dry pleurisy'. This is almost the only reference to the disease in the literature during the war. Nevertheless, there was undoubtedly an extensive epidemic in 1941–2 among troops in the United Kingdom and cases were seen over a wide area.

At that time the admitting diagnosis remained as the permanent official diagnosis, and, as the diagnosis was never made before admission, the epidemic did not receive official recognition. But there is no doubt that a large number of cases occurred.

It has recently been discovered as the result of a chance laboratory infection that the causal factor is one of the group of Coxsackie viruses.

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CHAPTER XV

PSYCHOLOGICAL MEDICINE

GENERAL INTRODUCTION

THE introduction of conscription had the effect of bringing into the Services large numbers of unsuitable individuals who, on a purely voluntary system of recruitment, might have been very largely excluded by self-selection. The Services were composed of individuals of all mental levels and types. It was therefore to be expected that the various forms of psychiatric disorder occurring in the civilian population would also be found in comparable proportions among the men and women of the Services. It was primarily to deal with the problems created by these conditions that psychiatrists were drawn into the Services.

In 1922, the Southborough Committee surveyed the psychiatric problems of the War of 1914–18 in its 'Report of the War Office Committee on Shell Shock, 1922'. The report stressed, in particular, the importance of proper selection procedures in preventing psychiatric illness.

The scope of the psychiatrist varied considerably from one Service to another. This was due to the different kinds of problems which arose in the respective Services, to the differences in the categories and grades of personnel which each Service employed, and to variation in Service organisation and environment.

In the Navy and Air Force, psychiatry and neurology were regarded as two aspects of one subject closely linked with general medicine. In the Army there was a separate Directorate of Psychiatry within the Army Medical Department. The Medical Directors-General of the three Services and of the Emergency Medical Service were advised by the consultants in psychiatry or neuropsychiatry.

The Service psychiatrist worked in a team in collaboration with psychologists, other medical officers and scientists, and especially with the executive. As a member of this team his concern was with the relationship of the individual to his job and environment. His function was thus to advise the executive authorities when matters of mental health and adjustment were in question.

The magnitude of the psychiatric problem in the Services may be illustrated by the number of psychiatric cases which had to be discharged. About 118,000 such cases (men and women) were discharged between September, 1939 and June, 1944. Between one-third and one-half of all medical invalids, men and women alike, were discharged from the Services on psychiatric grounds. This ranged from about 4 to 10 per

1,000 of average strength per annum. About one-third of such cases in the Navy and about one-quarter in the Army served less than one year. It was clearly desirable, therefore, that these individuals should be more closely examined at entry.

Of the 118,000 discharged from the Services on psychiatric grounds between September, 1939, and July, 1944, the proportions discharged under four diagnostic heads were as follows:

	Per cent.
Psychoneurosis and effort syndrome	64·3
Psychoses	21·2
Mental defect	6·4
Psychopathic personality	8·1
Total	100·0

Predisposition was of importance in determining psychiatric breakdown, though this does not imply that hereditary causes were of necessity predominantly operative. A survey, based on experience of the previous war, came to the conclusion that the 'constitutional' factor could be regarded as predominant in about 75 per cent. of those psychiatric cases who served at home only, and in about 25 per cent. of those who had served oversea; about half of the latter percentage had served oversea less than six months. There is no doubt that those who broke down showed a much higher concentration of ominous signs, such as poor occupational record, than those who did not break down. Thus, in the Navy, enquiry showed that about 50 to 60 per cent. of psychiatric patients showed these ominous features as compared with about 15 per cent. in a normal group of sailors. The high proportion of such cases who returned to duty in the Navy and did not relapse may be attributed to the good material which was self-selected by expressing a Naval preference at recruitment. Although those with predisposition tended to break down without adequate exciting cause, it was generally recognised that there was a point at which almost any man would break down. Given conditions of severe and prolonged stress the soundest constitution gave way.

The Service activities to which psychiatrists contributed may be conveniently classified under the following five headings:—

(i) Selection of Personnel
(ii) Training
(iii) Morale
(iv) Treatment and Disposal
(v) Research and Validation

It was the special function of psychiatrists to detect or recommend placement, treatment or rehabilitation for the following classes of mental disability, each of which was highly heterogeneous in itself and might overlap with another: neurosis, psychopathic personality, psychosis and mental dullness or defect. In the early stages of their milder forms, these disabilities were difficult to distinguish from healthy variations within the normal.

Special emphasis was laid, in all three Services, on the early detection and treatment of mental abnormality and on the avoidance of hospitalisation. The reason for this was to prevent the spread by contagion of conditions, such as those of an hysterical or depressive nature, to other members of a unit. It was shown that the longer the delay in treatment the less favourable was the prognosis for return to Service duty.

Psychiatric treatment in the Services embodied and amplified purely clinical methods customary in pre-war practice. As in civilian life, Service psychiatrists were concerned with the treatment and welfare of their patients so as to hasten their recovery. In the newer procedures the task of readjusting the patient to his environment figured prominently. There were special difficulties with neurotic Service patients, partly because they often tended to resist treatment designed to fit them once again for their war duties, and partly because social considerations tended to be subordinated in the neurotic mind to purely personal motives. In individual therapy, continuous narcosis, insulin treatment, electric-shock therapy and other forms of physical treatment were used together with established methods of psychotherapy. Apart from such purely clinical methods of treatment, psychiatrists also employed occupational therapy, remedial training, educational lectures, gymnastics and recreations. Group therapy was also used. Some importance was attached to social case-work to deal with problems of the familial background, and to vocational guidance in which psychological testing and technical training might play a part.

TRAINING OF SERVICE PSYCHIATRISTS

Most naval psychiatrists had preliminary experience of conditions at sea. After several months of training they began serving as juniors under a senior naval psychiatrist.

Army psychiatrists, after completing their first four weeks of initial training were posted to a field force unit as 'trainees' to live for four weeks in the atmosphere of fighting units. During this period they acted neither as medical officers nor as psychiatrists, but as observers of, and participants in, the unit's activities. The 'trainee' then became apprenticed to an area psychiatrist for a period of not less than three weeks and his suitability for various types of military psychiatric work was assessed. Army psychiatrists did not have the responsibility of treatment or disposal until they had had a minimum of three months' training in the special conditions obtaining in Army psychiatry. A series of technical memoranda on military psychiatry was issued to each new psychiatrist, and finally he attended a seven-day course at the Royal Army Medical College on administrative aspects of his duties.

In the Royal Air Force, neuropsychiatric specialists were, on entry, attached to the Central Medical Establishment for training in the general principles of neuropsychiatry as applied to the R.A.F. Subsequently, they were attached for a period to a neuropsychiatric centre for acquiring practical experience under a Service specialist. During the period of training they were attached for two or more weeks to a station from which squadrons operated in order that they might become acquainted with the conditions of station life and obtain flying experience.

INSTRUCTION OF MEDICAL OFFICERS IN PSYCHIATRY

Medical Officers (General Duty) in the Navy, prior to service in aircraft carriers or Naval air stations, were given a brief course of instruction, by lecture demonstrations and attendance at medical boards, on neuropsychiatry in relation to flying duties. All Army medical officers received general lectures on psychiatry during their initial period of training at the R.A.M.C. Depot. In addition, all unit medical officers received instruction on the diagnosis and handling of acute psychiatric cases occurring in action. In the Royal Air Force medical officers were instructed by lectures and memoranda on measures for the prevention of psychological disorder and fatigue and on the detection of early signs of breakdown. The staff of the E.M.S. Neurosis Centres worked in liaison with the Army, and in the case of ground personnel, with the R.A.F. The work of E.M.S. psychiatrists was directed primarily towards meeting Service requirements and, wherever possible, to fitting men for military duties after a period of psychiatric breakdown.

SELECTION OF PERSONNEL

The advantages of a joint psychological and psychiatric contribution to selection were many. The intellectual resources and personality of individuals were assessed so that each could be directed to the position where he could be of greatest use to the Service. Moreover, individuals were no longer liable to be allocated to duties much above or below their capacity, with the result that wastage of training time was much reduced. For example, up to the end of 1940 one in five of the Infantry intake and one in two of Pioneer Corps intake were capable of more skilled work than that to which they were posted; one in two of the intake to Tank Regiments and one in five of Infantry intake lacked the capacity to cope with the tasks they were expected to perform. Again, introduction of psychiatric selection helped to exclude from the Army many thousands of dullards and defectives; such individuals were formerly nothing but a burden to their units, training staffs and medical and disciplinary authorities. Finally, a psychiatric selection reduced the intake of individuals with predisposition to psychiatric disorder, who, had they entered the Army, might have required discharge shortly afterwards.

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(i)

Psychiatry in the Royal Navy

BY DESMOND CURRAN
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ORGANISATION AND STAFFING

In the War of 1914–18 there was no formally organised psychiatric section existing as a separate entity in the medical service of the Royal Navy. But as the war went on it became necessary to cope with many cases of psychiatric breakdown, and such cases were examined and treated by Naval medical officers having psychiatric qualifications. No figures of incidence or of invaliding rate from this cause exist.

The two decades between the wars saw not only technical advances in the study and treatment of psychiatric disorders but a vastly increased public awareness of factors affecting mental health, whether in civilian life or in the Services. As a natural corollary of this attitude, the Medical Director General of the Navy set up the machinery for a naval psychiatric service in September, 1939, immediately on the outbreak of war. Two consultants and some half a dozen psychiatrically trained medical officers formed the cadre. Numbers expanded in the course of the war, and at its end there were some fifty naval medical officers employed in psychiatric work in Great Britain and oversea. But numbers consistently lagged behind need, partly because of the shortage of trained men, partly owing to difficulties in providing suitable courses for interested medical officers, and partly owing to the difficulty of establishing claims in the face of the relatively small naval sickness and invaliding rates. Nevertheless the psychiatric problem bulked quite large in naval medicine, and by August, 1943 it was established that neuropsychiatric disorders had accounted for rather more than 1 in 5 of all invalidings. At the same time, while in the Army references for psychiatric examination were running at 12 per cent. of all new entries at initial reception centres, in the Navy the number referred at this stage was negligible. One main reason for this was self-selection. Far more men expressed a naval preference at call-up than that Service could take, and therefore only the best entrants could be accepted, though initially the selection procedure was rough-and-ready.

In January, 1940, it was suggested that selected naval medical officers should take a postgraduate course in neuropsychiatry at Mill Hill Emergency Hospital, London, working there for two months and following up with a month at R.N.H. Barrow Gurney, near Bristol. However, even two years later there remained a serious shortage of trained staff. At the end of 1942 the Navy had only 26 medical officers engaged on neuropsychiatric work in the British Isles compared with 147 in the Army and 47 in the R.A.F. In February, 1943, it emerged that a course at Mill Hill could only be provided if six officers were available at a time. But since only two could be released at a time it was suggested that they should be trained within the Service, taking a course averaging two months at Barrow Gurney, with chief emphasis on clinical matters, and the major part of the time spent on case taking. During the later war years recruitment for naval psychiatrists was obtained in this way from naval medical officers who had served at sea.

A report on psychiatric work done in the first six months of 1943 showed that at the four hospitals, Chatham, Barrow Gurney, Kingseat and Knowle, 12 medical psychiatrists had dealt with something over 2,500 admissions and roughly 1,500 consultations. At the barracks at Chatham, Portsmouth and Devonport and the bases at Lowestoft, Glasgow and Lyness, 8 officers had dealt with over 4,700 new cases and a large but indeterminate number of old cases. In June, 1944 it was reported that nearly 20,000 men were being referred annually to neuropsychiatric specialists, and that a stringent invaliding policy (in the interests of morale) had resulted in the passing for full sea service of many 'doubtful risks'.

In February, 1945, the consultant in psychological medicine to the Royal Navy furnished the following statistics to M.D.G:—

(*a*) At least 10 per cent. of beds in main naval hospitals are needed for neuropsychiatric cases.

(*b*) About 10 to 15 per cent. of a convoy of sick from an operational theatre are probably suffering from neuropsychiatric disorders.

(*c*) Some 3 to 4 per cent. of all men passing through a main naval depot are referred for a psychiatric opinion. At least 8 per cent. of all offenders are also referred by the Commodores.

These various figures indicate the dimensions of the problem that confronted the naval psychiatric service. The shortage of staff was a matter of grave concern not only in respect of psychiatrically trained medical officers but also in respect of ancillary personnel. In 1941 a scheme was instituted for training of W.R.N.S. petty officers of high educational calibre, who were used to assist the normal recruiters in selection. Their work (which is described in a later section) proved potentially valuable. For the actual nursing of in-patients recourse was had to sick-berth attendants trained in hospitals for nervous and mental disorders, but these, like the trained psychiatrists, were always too few.

Conditions did not improve as the war dragged out its six years. The Navy had the highest casualty rate of all the Services in proportion to its size. War weariness became manifest, as did the effects of overwork and insufficient leave. At the end of the war the number of patients treated annually as in-patients for neuropsychiatric disorders had reached the impressive figure of roughly 1 per cent. of the whole of the naval personnel, and it was not far short of this throughout the war.

FUNCTION OF A NAVAL PSYCHIATRIC SERVICE

Not only psychiatrists but also psychologists were used for various purposes by all three arms during the Second World War. In the Navy psychologists were introduced in 1941. Some of the main subjects on which they were to advise were the design and use of training and operational equipment, interviewing technique, job analysis, and the assessment of fitness of personality for various Service rôles and duties. In co-operation with the psychiatrists and the executive their task was to allocate personnel to those duties for which they were most fitted by temperament, physique, education, general aptitude, civilian work and social background.

In homely metaphor, the psychologist's business, or the main part of it, was to 'help choose the football eleven'. The psychiatrist, on the other hand, was not faced with this choice as a main task, but had rather to deal with unstable elements, weeding them out at an early stage as far as possible, diagnosing and treating psychoneurotic cases as they arose, and following up with rehabilitation, and recommendation for modified duty as necessary. Ideally, psychologists and psychiatrists should have worked in close concert, but in practice, for various reasons, real integration was never effected, and it was not until 1944 that psychiatrists were found carrying out selective work at training centres. Only one psychiatrist was ever employed whole time on such duties. The function of the psychiatric service may be divided into five main headings :—

(*a*) Discovery of predisposition to neurosis at the selection stage. The ideal would have been to eliminate bad psychiatric risks at the start (so far as they could be detected by examination and selective procedure), but in practice both trained staff and time were inadequate in numbers for the full implementation of this policy.

(*b*) In co-operation with the psychologists, the allocation of personnel for duty in accordance with temperament, background, aptitude and physique.

(*c*) Diagnosis and treatment of psychiatric casualties as they arose during service, whether ashore or afloat. Disposal of cases after treatment for (i) full sea service, (ii) modified duty, or (iii) invaliding.

(*d*) Examination of such a proportion of delinquents as were referred by the Commodores on suspicion of psychoneurotic abnormality.

(*e*) Follow-up and rehabilitation, with a view to the highest possible percentage of return to normal duty, or, failing that, to the best measure of social recovery and useful employment, either in shore jobs or in relevant civilian jobs after invaliding.

GENERAL CONSIDERATIONS

The basic principle of the naval psychiatric service was to consider psychiatry and neurology as two aspects of one subject, and to link both as closely as possible with general medicine. Its broad aim was to minister to the maximum possible overall efficiency of the Service. It strove to avoid 'putting square pegs in round holes', to predict cases likely to break down under Service conditions, and to treat psychiatric casualties so that a large proportion of them would be fit for return to normal duty. There proved to be a constant stress between two mutually antagonistic principles. On the one hand there was pressure from the executive not to exempt too many men; on the other, the psychiatrist lost credit if he recommended a man for redrafting and that man broke down a second time. It was also found that there was an initial underestimation of how much a man can and will endure, and experience tended to show that far more men could be passed fit for sea duty than had been supposed.

The better type of rating, if he broke down at all, usually did so in an affective state of anxiety or depression, but though the Navy was subjected to great stress, the number of breakdowns leading to invaliding was comparatively small. Various factors contributed towards this result: (*a*) self-selection, as we have seen, operated strongly in this Service; (*b*) selection procedure (but more doubtfully, perhaps) may have contributed; (*c*) the group spirit and community life of a ship, the feeling that crew were literally 'all in the same boat' made for high morale; (*d*) naval stress was different *in kind* from that experienced by the Army, since danger was met by all *together*, whereas soldiers often had to face it in isolation.

Cases of general paralysis of the insane and of delirium tremens or other alcoholic troubles were rare; they had become so in civilian life before the war; true hysterical conversion syndromes were likewise rare, because they were fundamentally unnecessary when other forms of substitution constituted good grounds for reporting sick. The head and the stomach were the most popular foci of complaint; as a German psychiatrist put it, 'in this war, it is the stomach that shakes and not the hand'.

Several *a priori* pre-suppositions of the layman were invalidated by experience. In the first place there was no greater pre-disposition to psychoneurotic disorder among intelligent and emotional types than among others. The incidence was similar among officers and ratings (though there were fewer hysterics among the officers). Secondly, claustrophobia was rare among submariners as was breakdown in general, no doubt partly owing to self-selection and partly because the main weight of the situation lay on the commander. Thirdly, little psychoneurotic disturbance was directly attributable to noise. And fourthly, sexual deprivation had no more than a minimal effect.

ADMINISTRATIVE PLAN

In consonance with the general principles laid down at the outset, the clinical and administrative sides of the naval psychiatric service were closely bound up with one another. Following out the plan, already adumbrated, of close linkage between psychiatry and neurology and general medicine, neuropsychiatric units were established as integral parts of the main naval hospitals, and specialists were appointed to the main naval depots and bases. Ideally, psychiatric advice was to be available as near the centres of operation as possible (though in practice there were obvious limitations arising from the extremely scattered interests of the Navy and the serious shortage of trained specialists). Neuropsychiatrists in hospitals, besides controlling their own units, were called upon to see patients referred by other medical officers in their own hospitals or by naval establishments nearby. These cases were provided with a medical and executive report covering conduct, character, morale and stress experienced.

Work at depots was mainly confined to out-patients, but might also include charge of a limited number of beds in the local sick quarters. A primary aim was to avoid hospitalisation by establishing an out-patient filter at barracks and naval bases. It was found that time and care spent in eliciting histories facilitated sound prognosis.

New cases were men reporting sick in depots, or men referred by medical officers in neighbouring ships (or establishments) or by the executive because of training or disciplinary trouble. There was also a large attendance of old patients, many of them discharged from hospital for a period of shore service and for further observation and treatment while at duty in the depot. The main port divisions were in effect clearing-houses for the Navy. From them redrafting took place, and psychiatric units maintained close liaison with the drafting and other executive branches.

The in-patient accommodation available for psychiatric cases towards the end of the war comprised in Great Britain :—

	No. of beds
Royal Naval Auxiliary Hospitals:	
Barrow Gurney	96
Knowle	220
Kingseat	80
Cholmondeley Castle	220
Royal Naval Hospitals:	
Chatham	80
TOTAL	696

At Knowle there was a separate section of about 100 beds at which psychotics from the Navy as a whole could be collected and treated prior to discharge. Cholmondeley Castle was for men of good morale and prognosis, who required a graduated and hardening course between ordinary hospital treatment and duty: the average duration of stay was about six weeks. In addition to these there was H.M.S. *Standard* (Kielder Camp), for the rehabilitation of men of poor morale who had proved incapable of ordinary naval service. For these men no grounds for invaliding could be found, and their discharge on other grounds was deemed undesirable in the interests of discipline and morale. The routine at this camp is described in a later sub-section.

Roughly 3 per cent. of the personnel passing through a naval depot tended to be referred for a psychiatric opinion; about 90 per cent. were kept at some form of duty. The turnover of in-patients was quick, and unless a man proved to be a psychotic he was generally returned to some form of duty after three weeks or, alternatively, invalided after four weeks. About two-thirds of all neuropsychiatric cases admitted to hospitals were returned to some form of duty, but at Knowle, owing to the large proportion of psychotics, the figure for returns to duty was only about 50 per cent.

SELECTION OF RECRUITS

At the beginning of the war there was no system of psychological or psychiatric selection in use for recruitment in the Navy, but in June, 1940, instructions were given for the rejection of men suffering from nervous instability. In the same year Desmond Curran and W. P. Mallinson investigated the incidence of different forms of psychiatric disorder in 100 admissions to the neuropsychiatric unit of a naval auxiliary hospital. They estimated that 39 per cent. of the breakdowns might have been predicted by previous psychiatric examination. Fifty surgical patients were used as controls, and it appeared that the proportion of positive past histories was high among the predictable cases and the proportion of positive family histories was high among the unpredictable cases. This confirmed the need for a preliminary 'screening' procedure to pick out recruits for whom a psychiatric interview was desirable.

In March, 1941, the Admiralty appointed a committee to study the selection and allocation of 'hostilities only' recruits, and on its recommendation there was established the post of Senior Psychologist to the Navy. Thereafter new schemes were instituted at recruiting centres and entry establishments.

In the late summer of 1941 it was decided to appoint selected W.R.N.S. petty officers of high educational standard, to assist the naval recruiters. These Wrens were given a fortnight's intensive training in interviewing, testing technique and record keeping, and in an initial experiment were set to interview cases from the neuropsychiatric unit of a naval hospital, together with surgical and medical cases to act as controls. They were not, of course, told which of the men were neuropsychiatric patients and which controls, and they were instructed to confine their inquiries to matters of fact preceding enlistment and to ignore any volunteered information about Service careers. Questions put by the Wrens covered general health, digestion, sleep, powers of endurance and whether the subject considered himself sensitive or 'highly strung' or had 'had any trouble with his nerves'. In the result 3 out of 7 controls classified as positive on mental grounds were found to be positive on psychiatric examination. From 53 neuropsychiatric cases referred on mental grounds, 22 were picked up, while out of 56 controls only 4 were judged positive without this finding being substantiated on psychiatric examination. A second experiment was then carried out on a larger scale, using 97 neuropsychiatric in-patients, 50 neuropsychiatric out-patients, 77 in-patient controls from surgical and medical wards and 98 controls from among the normal ratings. Combining the results of the two experiments, and considering only the 'mental' pick-ups of the first experiment, out of 200 psychiatric patients there were positive findings in 107 (53 per cent.). Out of 231 controls only 35 (15 per cent.) were classified as positive, and out of 28 of these, subsequently examined psychiatrically, no fewer than 15 presented some evidence of appreciable psychiatric abnormality.

Interviews rarely lasted more than eight minutes each, and it was found that, except in a very small number of cases, no resistance or resentment was manifested by those examined.

Some development of this selective system took place, and experienced psychiatric social workers were engaged to travel round the country, supervise the work of the Wrens, and train others in these duties. There were originally three of these supervisors, but the number was soon reduced to two and finally to one. Though the potential value of this selective procedure was manifest, it was never put into operation on a arge scale. Again, it must be borne in mind that the psychiatric invalidity rate was always well under 1 per 1,000 which scarcely justifies a high initial rejection rate on psychiatric grounds.

CLINICAL WORK

(*a*) *Physical Disorders and Constitutional States*

In a number of cases presented for psychiatric examination physical disorders were found to have influenced, in greater or less degree, the causation and prognosis of reactions. The significance varied from case to case. Concussion and influenza were often the direct precipitating causes of a breakdown. In an investigation conducted by Curran and Mallinson (1941) on *Depressive States in War* it was found that prognostically, arteriosclerosis and head injury were the most unfavourable of the physical factors encountered.

In spite of preliminary examination a considerable number of unstable and psychopathic persons were taken into the Navy and gave rise to serious problems of treatment and disposal.

(i) *Epilepsy*. Since an epileptic afloat is a constant potential danger, rapid diagnosis was highly desirable. Suspects were admitted to hospital, and every effort was made to arrive at a diagnosis while they were there. If indications were positive the patient was invariably invalided. Between September, 1939, and September, 1941, some 260 patients were admitted to hospital for investigation of fits, vertigo and other paroxysmal disorders. A careful history was taken, a full clinical examination was made, and the possibility of malingering was borne in mind. In every case an electro-encephalogram was taken by Grey Walter, whose views at that time have historic value. He said: 'The only completely trustworthy abnormal appearance in E.E.G. records is a series of waves at a frequency of less than about seven per second (delta waves)', and further: 'Any patient with a history, however unconfirmed, of some sort of attack, who has an abnormal E.E.G. either while resisting or during overbreathing, can confidently be regarded and treated as an epileptic, provided of course that the possibility of an expanding lesion has been ruled out.' (Grey Walter and Golla, 1941.) The conclusions reached from this survey were that electro-encephalography should always be supplemented by clinical findings.

(ii) *Schizophrenia*. In the Navy schizophrenia tended to come under notice much earlier than in civil life because of oddities, unpunctuality and minor offences which involved punishment, and because the simple environmental adjustments tended to be difficult or impracticable. Sometimes hysterical reactions or a falling off in performance were early symptoms. Service routine appeared to affect the patient in one of two ways. If the illness was progressing very slowly, difficulty in adaptation might produce a pseudo-neurotic reaction of anxiety or depression or an hysterical avoidance, or a more profound disturbance, such as stupor or a Ganser state. If the course was more rapid the illness was recognised more quickly. The general policy was to invalid all cases diagnosed as schizophrenia. The progress of such cases was much better than in civilian practice. In 1946 Garmany reported a series of beneficial results from treatment of schizophrenia by insulin shock-therapy, the quality of the remission seeming better than without it.

(*b*) *Psychoneurotic Disorders*

(i) *Hysteria*. In the War of 1914–18 hysteria and 'shell-shock' (an equivocal and unsatisfactory term) accounted for 5 per cent. of the naval neurotic casualties. Beaton found the relative infrequency of hysteria in the Navy, as compared with the Army, to be due to the less automatic obedience and greater personal responsibility encouraged in naval ratings. In the two-year period, September, 1943—September, 1945, out of 4,988 new neuropsychiatric out-patients at the main naval barracks, 15 per cent. were diagnosed as hysterics. This increased incidence of hysterical reactions (or the more frequent use of this diagnostic label) as compared with 1914–18 deserves examination. Pure conversion syndromes were probably rarer than in the First World War, largely owing to the gradual yielding of the Charcot tradition to the psycho-biological approach to the subject, and the reorientation of psychiatric opinion and practice. Moreover the earlier diagnosis of borderline deviations from normality, and their correct psychological management, led to better selection and placing, with a consequent avoidance of positions in which conversion syndromes might arise. Simple hysterical dissociation, both immediate and delayed, was uncommon. When paralysis came on immediately after an incident, the outlook for return to duty was good if the ship's doctor took the matter in hand at once and reassured the patient by explanation and persuasion. Cases in which the symptoms were delayed were not of such good prognosis. The hysterical prolongation and exaggeration of real physical or psychological disorder were difficult in diagnosis. When after an injury improvement ceased with physical methods of treatment it was wise to suspect hysterical motivation and to use psychotherapy and occupational therapy.

Secondary hysterical reactions constituted both numerically and therapeutically one of the major problems of naval psychiatry. One of the common underlying disorders upon which these reactions tended to arise was mental backwardness. Fugues and amnesias were at first fairly frequent, and a claim to loss of memory was often made by arrested deserters or men returning to depot after a period of absence without leave. But when it was made known that amnesia itself, whether genuine or spurious, would not be acceptable as a reason for exoneration in disciplinary cases, the incidence of the cases fell considerably. Hysterical delirium and stupor were very uncommon and always of bad Service prognosis. Auditory hallucinations were occasionally recorded, and occurred in dullards who, finding themselves in situations of danger or uncertainty, obtained guidance and reassurance from absent and even deceased relatives. Collective hallucinations occurred in stable personalities who spent a period of sixty-five hours in Carley floats. The visual sense-deceptions described by these men included hallucinatory impressions of land and ships. The part played by the medical officer in helping to maintain morale was nowhere more important than in his firm handling of the hysteric and his unremitting effort to ensure that justice should not only be done, but should seem to be done, to every man who reported sick. 'Lead-swinging' and exploitation were discouraged when it was generally known that neurotic complaints and disabilities would receive the same careful and impartial evaluation as physical ones. The great thing to avoid if possible was hospitalisation.

(ii) *Anxiety and depressive states.* Anxiety states caused the breakdown of many naval personnel, but these often manifested themselves not during action, but ashore, after it was over. From an investigation of post-operational strain in the Navy, Curran and Garmany (1944) endeavoured to show that men at sea developed a state of tension that resulted in an increased responsiveness which was both physiological and appropriate. But if the same reaction persisted on coming ashore it would be considered pathological. It was found that certain men of a good type who on shore presented persistent anxiety symptoms sometimes asked permission to return to sea despite clinical signs which appeared prohibitive; and when permission was given the experiment was often successful. In general, mental tension could be dealt with by rest and sedation, or by raising the tempo by an early draft to sea before habituation.

The main factors leading to an anxiety state were found (in a survey by Stephenson and Cameron, 1943) to be separation from home, lack of privacy, uncongenial company, monotony, unsuitability of employment, and physical threats to life. Symptoms might be psychic or somatic. Under the first heading were fear, sleeplessness, loss of confidence and a feeling of tiredness. The somatic symptoms were chiefly palpitation or indigestion. Complaints of headache and other pains were common. Treatment was chiefly by sedation, and sometimes by continuous narcosis. Psychotherapy and occupational therapy were also used. Depressive states are frequent in war, and in a survey made late in 1940 Curran and Mallinson found that such conditions constituted 13 per cent. of all admissions to a naval neuropsychiatric unit over a period of several months. The cases ranged from certifiable intensity to quite mild reactions showing excellent insight, a high degree of reactivity to their environment, and no evidence of such 'endogenous' symptoms as retardation and self-reproach. No justification for a clear-cut division into 'neurotic' and 'psychotic' types was discovered. It was argued that a more fundamental distinction would be between affective disorders and hysterical reactions (in which the 'escape' element predominates). Men of fine type and excellent morale, who for various reasons were deficient in adaptability, were, as a result of prolonged stress, prone to develop reactions which lay at the depressive end of the affective series. Reactivity was better than in civilian life, and out of 88 consecutive cases observed, 29 per cent. were able to return to duty after a brief period of treatment, and only 6 per cent. needed further hospital care.

(iii) *Psychiatric study of delinquents.* Crime is defined legally as 'an act or omission forbidden by law under pain of punishment', but, as every ex-Serviceman knows, 'crime' in the Services is a far wider term, ranging from the merest peccadillo (outside the cognisance of civil law, but punishable in the Service as a breach of discipline) to the very grave offences which are universally condemned as criminal. Petty offenders were seldom referred to the naval psychiatrist, and there is no reason to suppose that the vast majority are in any way mentally abnormal. On the other hand there is no direct relation between the severity of an offence and its origin from some medical cause. Of serious offences landing men into Detention Quarters, 95 per cent. are desertion and of the remaining 5 per cent. most are petty larceny. A substantial number of offenders were referred to naval psychiatrists, amounting in one main naval depot to 5 per cent. and in another to 8 per cent. Depot psychiatrists independently arrived at strikingly similar results; and 90 per cent. of such references went for punishment, while in 10 per cent. mitigating circumstances were put forward or (less frequently) hospitalisation was recommended. It has to be realised, as Anderson (1942) has pointed out, that the psychiatrist should not form a weak link in the chain of justice out of consideration for the individual as against the community. On the other hand (as emphasised by Blacker) the assumption of an all-pervasive cynicism is often the cloak for ignorance and stupidity on the part of the examiner. Case history (and especially work record) is of first importance. Diagnosis of a significant degree of abnormality can seldom be deduced from the nature of a criminal act, but depends upon the determination of associated symptoms. In an examination of 1,000 cases under detention, made by Prewer (1944), 773 were found to be approximately normal and 227 abnormal, the 'abnormality' ranging from mental retardation (59 cases) to psychopathic personality (87 cases). Latham (1946) investigated a series of 300 repeat offenders—185 of them serving their second sentences and 115 serving their third or later sentences. All were under 26 years of age, and intelligence (tested by Raven's matrices) was equal to the average. Of the total, 1 per cent. were sent to hospital (two mental defectives and one case of delusional insanity), 4 per cent. referred for further attention to the depot psychiatrist, 7·6 per cent. were recommended for executive discharge, and the rest (87·3 per cent.) were considered fit for normal duties after sentence. This review showed that psychiatric assessment could contribute to the task of distinguishing those who could not make good and ought to be discharged from those who could do better but by bad conduct hoped to gain release out of turn.

SPECIAL ESTABLISHMENTS

(a) H.M.S. Europa

The Royal Naval Patrol Service, known as H.M.S. *Europa* and centred on Lowestoft, was organised in 1938 so that fishermen of the Royal Naval Reserve could be drafted to their ships for minesweeping duties in the event of war. H.M.S. *Europa* was purely a training, drafting and accountant depot, with no accommodation. A psychiatrist was appointed there in October, 1941, and six (later twelve) beds were provided in the local sick quarters. Out of a figure of some 85,000 men serving in the Patrol Service during the war the total referred on psychiatric grounds was over 5,000, i.e. between 6 and 7 per cent. From 1942 to June, 1945, there were 3,772 new cases and 25,137 interviews were given. During this time 495 men were invalided on psychiatric grounds.

Treatment consisted of sedation and comparatively simple and superficial psychotherapy—explanation, reassurance, persuasion and indirect rather than direct suggestion. The psychiatrist was able to help in choosing the environment in which the patient would have to serve on his return to sea; and in about 60 per cent. of cases recommended modification of the draft. The main types of case seen were: anxiety states, psychopathic personality, mental backwardness, schizophrenia and depressive states.

Among the aetiological factors the chief was stress of war experience in a vessel usually without protection and with no power to fight back. Moreover the confinement, lack of recreation and general discomfort in isolated bases contributed to the general strain, particularly when long continued. Domestic worries were common factors. Head injury and other organic conditions often played a part in the breakdown.

As regards the prognosis, out of the whole 295 cases specially investigated, 77 men (25·8 per cent.) were invalided. Roughly 45 per cent. gave good service after treatment, a further 23 per cent. were worth retaining in modified duties, and 32 per cent. did badly.

The general invaliding rate among neuropsychiatric cases was higher in the Patrol Service, accounting for 1,264 men out of a total of 5,235 from all causes (24·1 per cent.). Taking 85,000 as the approximate total serving, 1·49 per cent. were invalided for psychiatric disorders.

(b) H.M.S. Standard

Kielder Camp, known as H.M.S. *Standard*, was situated in the Cheviot Hills, thirty miles from any town. It was an experiment, intended for men of low morale, unemployable as combatants, who were both culpable and to some extent abnormal, without being frank criminals or mentally deranged. Neither a concentration camp nor a hospital, Kielder was a rehabilitation centre for borderline psychiatric cases, under executive, not medical control. Though it was not a penal establishment, discipline was strict, and there was little respite in a day beginning at 6.45 a.m. and ending at 10 p.m. The men sent there ranged from the 'old lag' to the immature youth who had not been able to adapt himself in the Navy.

Work done included physical training, tree-felling, land-drainage, assisting in the building of a dam for a reservoir, farm work (in summer), sawing logs, as well as the general fatigues necessary for running the camp. Occupational therapy, games, drill, route-marches and discussion groups were other activities; and the school (obligatory for all except very backward dullards) did an immense amount of good.

About 100 was the usual strength. Personal influence played a great part in the scheme, and every rating had several interviews with the commanding officer, schoolmaster, chaplain and medical officer—as well as with the psychiatrist. The various officers pooled their knowledge, and in this way a common policy was attained. Every man had his intelligence quotient tested when he joined the camp, and, though defectives were not sent to Kielder, there were a number of dull men. In school the ground covered comprised chiefly current affairs, the elements of citizenship and a modicum of mathematics (useful for inducing concentration). Occupational therapy—including woodwork, plastic work, painting and drawing—fulfilled a useful purpose in providing both outlet and interest for certain men who would otherwise have 'stuck' or deteriorated.

The average stay in the camp was between three and a half and four months. Four months after a rating had left, a follow-up letter was sent to the medical officer of his ship or establishment. Only about half these forms were returned completed (largely owing to the rapid movements of ships), but the results obtained, considering the nature of the material, were on the whole satisfactory. Expressed statistically they were as follows:—

Total number joining camp in three years	842
Drafted to various kinds of service (232 good reports on follow-up; 105 bad reports)	680
Discharged, 'services no longer required' (i.e. incorrigible)	22
Discharged, 'unsuitable' (i.e. unlikely to make an efficient sailor)	22
Invalided out of Service (physical grounds)	7
Invalided out of Service (neuropsychiatric grounds)	60
Miscellaneous disposals (deserters, civil prisons, etc.)	37
Retained in the camp	14
TOTAL	842

A number of psychotic patients had been retained in hospital for treatment.

GENERAL SUMMARY

A considerable number of cases of neuropsychiatric disorder came under observation and many needed to be invalided out. The invaliding figures were as follows:—

Year	Rate per 1,000 Ratings	Officers
1939	1·65	2·52
1940	3·68	5·11
1941	5·0	3·34
1942	3·46	2·55
1943	2·76	3·01
1944	3·48	4·56

In summarising the advances in psychiatry during the war, Surgeon-Commander E. W. Anderson (1946) stated that the real fruits of the War of 1914–18 were increased awareness, professional and lay, of the need for psychiatry and a more enlightened attitude towards its treatment in general. At the same time, though it was too early to make final judgments on the advances in the War of 1939–45, there was a more sober assessment of the claims of psychotherapy, at least of individual psychotherapy, and every day in the Services brought fresh confirmation of the rôle played by heredity and constitution. One-third of the naval psychiatrist's time was taken up with the problem of the 'second class citizen' who had no will to health. Perhaps too much emphasis was placed on disorders of conduct among these men, and too little on the validity of their symptoms. This particular group of men were often asthenics, and though no definite detailed physical or biochemical peculiarities have been proved to be associated with this condition, it is possible that future research may find some association.

An impressive fact is that, despite continued severe stress to which the Navy was exposed, the invaliding rate for neuropsychiatric disorders compared favourably with those in the other Services. It cannot, however, be claimed that naval psychiatry made more than a small and modest contribution to this result, which was clearly due to factors such as leadership, tradition and morale that lie mainly outside medical or psychiatric method.

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(ii)

(a) Psychiatry in the Army

By Brigadier R. J. ROSIE
A.M.S.

At the outbreak of war there was a very small number of regular R.A.M.C. officers who had acquired psychiatric qualifications and experience, and these were serving in various parts of the world. Just before the outbreak of war a consulting psychiatrist to the Army was appointed. It became increasingly apparent, however, that methods of recruitment were causing serious psychiatric problems in the Army. Many men suffering from psychiatric breakdown were mentally defective, and these formed a fairly high proportion of those invalided from France in 1940. In April, 1940, a specialist in psychiatry was attached to each Command at home. Very soon, however, one specialist in each Command was quite unable to deal with the volume of work, and additional psychiatrists were subsequently authorised for all Commands. Gradually a system of regionalisation was developed by placing psychiatrists in various Areas within the Commands. Some idea of the volume of work involved in seeing cases referred as out-patients may be gathered from the total of 342,729 out-patients examined between April, 1941, and October, 1943. At first, psychiatrists were attached to military hospitals whenever possible, and a close teamwork developed between psychiatrists and their other specialist colleagues which was in most cases far more intimate than that seen in civil life. Many recruits, however, were referred from training centres, and consequently routine visits to these centres were initiated, and the psychiatrist was thus able to discuss individual cases with the unit medical officer, the unit officers and N.C.Os. He was thus able to form a judgment of each individual soldier on the basis of the evidence of independent observers, and at the same time to advise the medical officers and officers in charge of training units on how to handle particular cases. A certain amount of out-patient treatment was undertaken, but this of necessity had to be confined to such psychotherapy as could be given in a few visits.

The scope of Army psychiatry extended considerably during the war in response to Service needs. It was directed primarily at the mental well-being and efficiency of the group, and was interested therefore in the soldier not only as an individual but, in a degree at least equal, as a member of the group. By reason of this emphasis on the group, Army psychiatry was more concerned with preventive measures than is civilian psychiatry.

The Service activities to which psychiatrists contributed may be conveniently classified under the following four headings :—

(i) Selection of Personnel.
(ii) Training.
(iii) Morale.
(iv) Treatment and Disposal.

SELECTION OF PERSONNEL

Experience showed that when men were inappropriately placed within the Army they were particularly liable to psychiatric breakdown. During the early days of the war it was obvious to Army psychiatrists that many of their patients were misfits, fit only for civilian jobs, or were wrongly employed within the Service. Since the correct placing of men is considerably easier and less time-consuming than the treatment of psychiatric disabilities once they have developed, Army psychiatrists devoted much work to preventing such misplacements, and became concerned with procedure for large-scale selection.

Recruit Intake Selection

The first main group of potential psychiatric cases requiring correct placing within the Army consisted of those whose intelligence was subnormal. Experience showed that such men, if placed in jobs beyond their mental capacity, easily became prone to delinquency or sickness, and proved incapable of attaining any high standard of military efficiency. The dullard, among men of higher intelligence, began quickly to feel himself inferior, and from this developed anxiety and often became a disciplinary problem to his unit. He was a consumer of man-power rather than a contributor. On the other hand, if placed in simple jobs within their capacity, dullards frequently proved useful members of their units. For this reason all recruits whose intelligence test results indicated that they were of subnormal intelligence were referred for examination by military psychiatrists for advice as to disposal. Many were recommended for transfer to the Pioneer Corps. Certain sections of this Corps were unarmed and limited to men whose capacity to learn was so low that they were not safe to be armed and trained for fighting. The results obtained in these unarmed sections were remarkable. Men who would have been a grave liability in fighting units were now efficient, well-disciplined and of good morale.

The second group of potential psychiatric cases consisted of men of normal intelligence, who, because of emotional instability or defect of character, were only suitable for Service duties in a limited sphere.

Because of shortage of psychiatrists, all recruits could not be interviewed individually, and a screening process had to be used whereby those who appeared doubtful from a psychiatric point of view were referred to military psychiatrists. Approximately 15 per cent. of the total recruit intake was so referred. This aspect of the military psychiatrist's work made a definite contribution to the economic use of man-power since the psychiatrist's recommendations for disposal enabled the Army to retain the services of many men who would undoubtedly otherwise have broken down and had to be discharged if care had not been taken in finding them correct employment.

Selection of Officers

In peace-time the Army chose its officers with some care; those who selected them knew the types of young men coming through certain schools; they knew and understood their background and were reasonably well able to assess their quality. A long and careful training and adequate supervision produced a fine type of officer who grew into his job. In the War of 1914–18, when the need for officers became urgent, there were plenty of men who could be sent for training as officers because they had actively proved themselves in actual battle. The British Army had not got adequate opportunity for this kind of experience in the early days of the War of 1939–45. In 1941 there was a high rejection rate from officer-cadet training units, and therefore a serious wastage in training time. Men, whose shortcomings in ability and personality might have been compatible with efficient service in the ranks, proved unable to carry the extra responsibility that came with an advance to commissioned rank. It was clear that the mental health of the potential officer should have as much attention given to it as his physical health, though this had never been attempted before. Experiments were carried out in which all candidates were examined in great detail by medical specialists to see if the standard physical examinations through which the men had passed before they were sent up as candidates were adequate. It seemed that they were, and that the main emphasis had, therefore, to be put on the psychiatric aspect of this problem. Various experiments were started to discover possible techniques for the rapid selection of large groups of candidates, and to study the value of a psychiatric interview as a method of assessing officer quality.

In 1942 the assessments made by psychiatrists were compared with those made by combatant officers on a sample of existing officers. One study of this problem was carried out at the Scottish Command Company Commander School, which provided advanced training for officers. A good deal was, however, known about their officer qualities before they joined the school, and during their course, which lasted four to five weeks, the commanding officer of the school and his instructors knew them very intimately. Between January and August, 1942, 222 officers were interviewed by psychiatrists at this school. On the basis of their interviews, which lasted from one-half to one hour, and the score in an intelligence test, the psychiatric assessments were found to agree, on an average, with the commanding officer's and instructors' opinions at the end of each course in 88·3 per cent. of cases; but whereas the psychiatric assessment was based on one interview with the officer lasting from one-half to one hour, the assessment of the commanding officer of the school and his instructors was based on knowledge of the officer built up over four to five weeks. The variation in the percentage of agreements among the different psychiatrists who did this work was consistent with each other and with themselves over a period. This experiment showed that, provided experience and training were adequate, the psychiatrist in one interview could achieve a high degree of reliability when estimating officer quality. Where there was divergence of opinion between the psychiatrists and the school authorities—i.e. in 11·7 per cent. of cases—about half of the divergent opinions were reconciled after discussion.

This and other experiments were so successful that it was decided to set up an experimental War Office Selection Board, and later to have boards through which all candidates passed. The staff of each board included one or two psychiatrists and a psychologist. The psychiatrist on the board had no direct responsibility for accepting or rejecting a candidate. This was the responsibility of a senior combatant officer who presided over each board and made the final decision of acceptance or rejection on the basis of the evidence presented to him. In order to supplement the psychiatric interview other forms of tests were used to reveal personality factors. Group Rorschach tests were used but had to be abandoned because of the time required. Finally three group projection tests were developed; an adaptation of Murray's Harvard thematic-apperception test, an adaptation of the word-association test, and a self-description test in which the candidate described himself in two or three minutes as his best friend and as his worst enemy would describe him. These proved so valuable that they were retained throughout, and, with questionnaires and intelligence tests, formed a battery through which every candidate passed. From this battery the psychologist and his assistants constructed 'personality pointers'. These picked out the men in whom there was some evidence of instability or peculiarity of personality, and who should therefore be interviewed by a psychiatrist.

The psychiatrist at first interviewed all candidates. Later, partly owing to shortage of psychiatrists, he saw only a proportion of the candidates, and this allocation of candidates for psychiatric interview resulted in some criticism of the psychiatric rôle. There was the implication that those selected to see the psychiatrist were a little peculiar, and therefore the psychiatric interview took on a more sinister rôle than it did at first when the psychiatrist interviewed all candidates. The introduction of this method of officer selection reduced the great wastage which had formerly been occurring in training units, and the gradings given to candidates at officer training units who had passed through the new selection procedure were on the average higher than those given to candidates who had not passed through this procedure. The proportion of candidates accepted under the new procedure was almost exactly the same as formerly obtained. Modifications of the Army technique were later used in the selection of officers for the civil defence organisation and, after the war, by Civil Service Selection Boards.

Selection of Army Parachutists

In 1943 an inquiry was carried out to ascertain whether it was possible to predict, by psychiatric selection, soldiers who were likely to fail during parachute training. At the time of this inquiry the failure rate during training was about 20 per cent. The psychiatrists who carried out the investigation were themselves trained and qualified as parachutists.

A screening procedure, similar to that used at War Office Selection Boards, was carried out by sergeant testers in order to select suitable cases for psychiatric interview. All candidates were provisionally placed in one of five grades predictive of training success, and psychiatrists then interviewed those in the lowest two grades, those difficult to grade and a sample of those in the highest grades. The psychiatrists then gave a final psychiatric predictive grade. The results showed that the final psychiatric grading gave effective prediction of training failure. Of those placed in Grade I only 3 per cent., and of those in Grade 2 only 7 per cent. failed during training, whereas in Grades 4 and 5 the corresponding rates were 23 per cent. and 46 per cent. respectively.

A second follow-up conducted about twelve months later, and when the men were in the final stage of collective training, showed somewhat similar results. The highest two grades showed a wastage of 15 per cent., and the lowest two grades a wastage of 25 per cent. Twice as many men in the highest grades were promoted to non-commissioned officer rank as were promoted from the lowest grades.

Psychiatric selection test results, therefore, had a significant relationship to success and failure, both during the individual and the collective training of parachutists.

TRAINING

Psychiatric advice was frequently sought on many training problems. A psychiatrist was attached to the G.H.Q. Battle School, and, in an advisory capacity, exerted considerable influence on the development of techniques towards 'battle inoculation'. Apart from conditioning students to the realism of war, the school intended to provide a training in 'hate', and all kinds of aggressive activities were organised during training with the idea of stirring up hatred for the enemy in the belief that it made better and keener soldiers. The psychiatrist was able to show that such methods, far from preventing breakdown, actually increased the incidence of breakdown in training. Some of the men who had been the best and keenest students going through these battle courses afterwards lost interest and became rather ineffective. They had gone into depression. This artificial stirring up of hate was not a good preparation for battle. A similar experiment was made in noise training at battle schools. By beginning slowly with battle-like experiences it was possible to help the soldier, and to reduce the over-estimation of the noise of war.

MORALE

Psychiatrists were concerned with morale in two ways. If the psychiatrist, in preventing breakdown, could promote good mental health, he had made a contribution to morale. Good morale lowers the incidence of psychiatric breakdown, and therefore psychiatrists were directly concerned with its promotion. Accordingly, psychiatrists made both indirect and direct contributions to morale. Two examples will suffice for the indirect contributions made.

Psychiatrists were aware in the very early days of the war that men who were misfits were more liable to neurotic breakdown, and accordingly they did everything in their power to introduce vocational selection into the Army. Their efforts were eventually successful in the summer of 1941. It was also recognised that the misfit tended to feel and become an 'outsider' in his unit, that his loyalty to his unit was always doubtful and that he was a cause of low morale.

The effect on the morale of dull and backward men transferred to unarmed companies of the Pioneer Corps was very striking. In their previous units, where they had been employed on duties beyond their capacities, they showed, apart from neurotic features, all the symptoms of low individual morale. They regarded themselves, quite correctly, as being of no use to the Army, absented themselves frequently and were guilty of many breaches of discipline. When grouped together in unarmed companies, a most dramatic change in their morale occurred. They became noted for their keenness, discipline, industry and cheerfulness, and vied with each other in setting up records for the amount of work performed.

Among direct contributions made to morale were lectures and discussions with regimental and staff officers on psychological principles, with an explanation of their application to the management of men, and advice on the help films could give to a recruit's emotional training in military values.

An investigation was carried out in 1941 to ascertain to what extent misfits and dullards were repeatedly absent without leave. Forty-three per cent. of absences were related to about 4 per cent. of the men, and men with intelligence below average were twice as frequent among recurrent absentees as might be expected on the basis of an average Army sample. Psychiatrists in the Army had a good deal to do with disciplinary cases, and useful work was done to bring the legal and medical points of view together. All men in detention barracks who appeared abnormal were seen by psychiatrists to advise on their posting or disposal at the end of sentence, and in certain places committees were set up for the review of sentences with a psychiatrist as a member of the committee. Before trial the psychiatrist was asked to see every man where the Commanding Officer or unit medical officer thought there was some reason to suspect that the man was not quite normal. The report of the psychiatrist was made out on a standard form of psychiatric report. This ensured that the psychiatrist gave clear and unequivocal answers to the four questions of the McNaughten ruling on the question of criminal responsibility, that any psychiatric factors present could be considered in mitigation in appropriate cases and that, after the disciplinary charges had been disposed of, any recommendation made by the psychiatrist in relation to the future employment of the soldier could be fully considered and acted upon where necessary. During the period October, 1943–October, 1945, 4,332 disciplinary cases were examined by Army psychiatrists. An analysis of 1,242 consecutive disciplinary cases referred to Army psychiatrists before trial is set out in tabulated form :—

TABLE I

		Per cent.
Fit for trial and fit to undergo punishment	1,079	86·88
For observation before trial—admitted to hospital	97	7·81
Unfit to plead and admitted to hospital	66	5·31
Total	1,242	100·00

TABLE II

Analysis of Diagnosis by Psychiatrists

		Per cent.
No psychiatric disability	253	20·37
Diagnosed as neurosis or psychopathic personality	616	49·59
Diagnosed as mentally defective	332	26·90
Diagnosed as psychoses	41	3·14
Total	1,242	100·00

PSYCHIATRIC CASUALTIES IN BATTLE

The proportion of psychiatric breakdowns to total battle casualties varied greatly, and depended partly on the kind of warfare. In the Western Desert during 1940 the absence of psychiatric casualties was striking, for some of these actions were quite severe. Fluid war in the desert, when we were winning, produced little neurotic breakdown. The nearer, however, the fighting approximated to the 1914–18 trench warfare the higher became the incidence. When men were continually exposed to methods of warfare they dreaded most, when they were separated from each other in fierce battle and were without sleep, the incidence rose to 10 per cent. or even 20 per cent. of the total casualties. The numerical incidence of psychiatric casualties in battle was therefore sufficiently high to present a considerable problem.

During the North-West European campaign the total number of psychiatric battle casualties was 13,255. Statistics and percentages by themselves give only a partial and inadequate picture of the situation as a whole, and the potentially 'infective' nature of psychiatric casualties was a factor of considerable importance.

However well a unit may have been screened by a psychiatrist to sift out personnel of 'poor moral fibre', it is inevitable in modern warfare that psychiatric casualties will occur. There was, however, a comparative absence of psychiatric casualties in units with a high standard of leadership, high ideals and traditions, and good morale. Men with a past history of psychotic or neurotic breakdown or with psychopathic traits clearly expressed in delinquency or crime, and men whose innate intelligence was limited, especially if accompanied by emotional instability, seldom made good soldiers. The breakdown was assisted by poor incentive, faulty training, lack of adaptation in the unit, poor leadership, domestic anxieties and prolonged exposure to battle stress.

The signs and symptoms of neurosis became increasingly common in men who had undergone long campaign periods. Psychiatric casualties in battle did not occur to any great extent in really well trained determined soldiers with zeal, dash and energy in battle. They occurred mainly among the slightly unwilling soldiers who required persuasion and encouragement to do their duty. The type that broke down very readily and became demoralising to others was essentially the poor, unselected recruit, often a reinforcement to a strange unit and often badly trained. Such a soldier, when he found himself in battle, was already half-way to a breakdown because he was unfitted to meet the physical and mental demands of battle. There can be no doubt that if adequate selection of personnel had been employed in the early part of the war before men had been despatched from the United Kingdom to the Middle East theatre, a very marked decrease in the incidence of neurotic breakdown would have occurred in that theatre.

Clinical types. The common clinical syndromes were:—

(i) Simple terror states.

(ii) Anxiety states:

(*a*) Mild, with symptoms of sweating, trembling, insomnia and battle dreams.

(b) Severe, with a pronounced and uncontrollable startle reaction, coarse tremors, and often terror-stricken and mute.

(iii) Stuporose states with a complete absence of anxiety.

(iv) Conversion hysteria.

(v) Depressive states.

(vi) Miscellaneous group, including men of poor moral fibre, malingerers and psychopathic types, etc.

There was a significant difference from the clinical syndromes met with in the War of 1914–18. Hysteria seldom took the form of these gross locomotion disturbances so common in the previous war, and the amnesias were less profound and much more amenable to resolution by simple techniques.

Treatment

Early treatment began with the unit medical officer. If he found evacuation was necessary, the soldier was sent down the line adequately sedated in order to prevent anxiety becoming conditioned. This simple measure improved the chance of treatment. The use of the term 'exhaustion' for all psychiatric casualties in the line proved successful on the whole. Though true exhaustion was seldom present, the label had a much less serious implication of illness than 'shell-shock' or even 'anxiety neurosis'. The main principle was early and prompt treatment. The earlier the treatment was begun, and the nearer to the scene of onset it took place, the better the prospect of a return to full combatant duty in the original unit. The value of having treatment centres in divisional areas was proved, and their introduction was a great step forward. The patients were still within the 'family', and intimate contact was possible between the centre and the divisional regimental medical officers. The principles of treatment at a divisional centre were:—

(a) Maintenance of a curative atmosphere.

(b) Fairly deep sedation for the first forty-eight hours, followed by a rapid appraisal and vigorous tackling of the remaining symptoms by the medical officer. Wide use was made of narcosynthesis.

(c) A rehabilitation period, during which there was a definite re-imposition of military discipline: a military, rather than a hospital, type of discipline was maintained.

Men considered unlikely to return to duty after a few days' treatment at a divisional centre were evacuated to a corps centre or, if necessary, to a Base Psychiatric Centre. In all centres the patient was made to feel that from the start he was caught up in a progressive programme whose final aim was to return him to duty. The aim was to reinfuse morale and to integrate each man once again into a group. The entire programme was directed to provide the factors which would produce good group morale in the centre, and the individual's re-absorption into the group was carefully supervised and seriously studied. The section of each centre concerned with actual physical treatment was relatively small—approximately one bed to five in the rehabilitation section of the centre.

Results

Approximately 65 per cent. of psychiatric casualties arising in a corps were returned to full combatant duty in their own units after an absence of less than a fortnight. Palmer reported from North Africa the return of 98 per cent. of unselected casualties back to full duty, of which between 50 and 60 per cent. were returned to full front-line duty.

Relapses

Though it has been impossible to form any accurate estimate of relapses, it is estimated that in the North-West European campaign over 80 per cent. of the men returned to full combatant duty remained with their units for at least six weeks. Davis, who was psychiatrist to 2nd British Division from November, 1943, to November, 1945, in India, Assam and Burma, has reported that the number of psychiatric casualties who again broke down during battle after return to duty was in the neighbourhood of 10 per cent., and that in almost every instance it was possible for the relapsed case later to perform duty within the Division in a rear area. After the campaign was over a follow-up by Davis in his Division showed that approximately 6 or 7 per cent. were unfit to face further battle stress.

TREATMENT AND DISPOSAL

Disposal of Out-patients

The recommendations made for the disposal of out-patients varied considerably as the psychiatric organisation of the Army developed. Army Council Instruction 84 of 1942 authorised psychiatrists to recommend suitable employment. Many men were returned to duty, and it was therefore necessary to assess not only whether the man was likely to improve or deteriorate as a result of living and working in a particular environment but also whether the man was in fact fit for the actual work he would be asked to do. The opening of Army Selection Centres later in the war was of considerable assistance to psychiatrists, who were now able to recommend that men should undergo selection procedure at these centres, whereas formerly they had to recommend alternative employments solely on the basis of their psychiatric interviews.

Details of recommendations made by Army psychiatrists for the disposal of out-patients at home during the period April, 1941, to October, 1943, were as follows:—

	Per cent.
Returned to unit. No further action	19·24
Returned to unit for observation or out-patient treatment	9·48
To E.M.S. Neurosis Centre	8·87
To Military Neurosis Centre	4·19
To Military Mental Hospital	4·15
To other hospitals	1·25
To duty and reduction in medical category	7·23
Transfer to Pioneer Corps	13·09
Other methods of disposal, i.e. change of employment, etc.	17·23
Discharge from the Service	15·27

The psychoses formed only a small fraction of the out-patients seen, i.e. 3·51 per cent., and their incidence was lower than was anticipated.

In-patient Treatment of Psychosis

The peace-time policy of immediately discharging to civil care all soldiers suffering from psychosis, when applied during the early part of the War of 1914–18, aroused considerable public protest. For this reason it was decided in 1940 to retain cases of psychosis in the Service for treatment, up to nine months if necessary. The peace-time accommodation for Army psychosis was, however, very inadequate, and accordingly accommodation in certain civil mental hospitals was taken over and designated as military hospitals, and a complete staff of R.A.M.C. and Q.A.I.M.N.S. posted to each hospital. The main advantage of this arrangement was that patients could be admitted to these military hospitals without any form of certification, and consequently with less chance of any stigma attaching to the patients. The term 'mental' was avoided as far as possible. Accommodation and treatment were also provided for R.A.F., Dominion and Allied psychotic cases and, later, for Italian and German prisoners-of-war. By 1944 a total of 1,550 beds for other ranks and 64 for officers had been provided.

The peace-time policy of discharging all recovered psychotics from the Army was modified by a War Office instruction to the effect that, where a psychosis of short duration occurred in an individual of good constitution with severe precipitating cause and with apparent good recovery, such a case could be recommended for retention in the Service. In fact, in areas like the Middle East, where the question of transport home was difficult, many recovered psychotics went back to duty and did well.

Treatment given included all forms of active therapy, continuous narcosis, insulin and malarial therapy, etc. On discharge from hospital most of the patients were fit to return to their homes; approximately 7·5 per cent. were transferred to civil mental hospitals. The low figure transferred to civil hospitals was an encouragement in stressing the wisdom of early treatment for the psychotic.

In-patient Treatment of Psychoneurosis

From the outbreak of war until April, 1942, the majority of Service personnel suffering from neurosis were treated in E.M.S. neurosis centres. In April, 1942, the Military Hospital, Northfield, was opened. It was formed by taking over the whole of the Hollymoor Mental Hospital, Birmingham, and was an entirely new type of unit, providing 200 beds in a hospital section and 600 beds in a training section. While in the hospital section patients received active treatment and wore hospital blue clothing; in the training section they wore khaki and were given a modified military training under combatant officers and N.C.O. instructors.

This approach in 1942 to the rehabilitation of military neurotics was merely carrying to its logical conclusion the conception of occupational therapy in the military sphere. All modern forms of psychotherapy short enough to be applicable to military cases were carried out, and certain experiments in group psychotherapy were undertaken.

Bion and Rickman in 1943 endeavoured to bring the atmosphere of the hospital into closer relationship with the functions it ought to fill, and regarded training in the management of inter-personal relationships as valuable as a therapeutic approach. They endeavoured to display neurosis as a problem of the group, and to show the group that it was their problem and one worthy of study. A purely individual approach did not cover the whole field, and a soldier's group activities and inter-personal relationships had also to be explored. In all, there was evidence that inter-personal relationships had been disturbed. They were failures in their own eyes and psychologically isolated from the group in which they lived, and the aim was to restore self-confidence and to re-integrate each man into a group, so that his adjustment towards others and to the Army could improve.

The method finally arrived at became known as the Northfield Experiment. This laid emphasis on the social aspects of treatment, and was an attempt to use a hospital as a community with full participation of all its members in its daily life, and with the aim of the resocialisation of the individual for military life. Patients ran their own ward and other activities. Each one accepted an activity, chosen by himself in conference with his psychiatrist, from a wide range of social fields created in the hospital. Special facilities were available outside the hospital for those who were interested in engineering, farming, etc.

Inside this framework meetings of groups of patients were held; generally seven to nine men composing a group. The group assembled in an informal way with the psychiatrist for one or two hours about two or three times a week. The psychiatrist's function at these group meetings was to encourage men to talk and help them to interpret their views. All temptation to assume an authoritative rôle had to be avoided. He acted mainly as an observer, not as a leader, and endeavoured to wean the group from its desire to be led. In this way it was encouraged to show an increasing capacity to tackle problems by its own efforts. Among other advantages this method of approach shortened the time required for therapy, and, though no precise statistics are available, it was generally considered that it was possible to return a greater number of fit men to duty than had been possible before. In any case the numerical incidence of neurosis was such that individual psychotherapy was not a practical proposition.

Rehabilitation and Civil Settlement of Repatriated Prisoners-of-War

From 1940 onwards, Army psychiatrists repeatedly drew attention to the difficult problems of repatriated prisoners-of-war. In 1942, an Army follow-up of a sample of repatriates confirmed the earlier impressions as to the reality and intensity of the difficulties experienced in rehabilitating and successfully employing these men, and it was seen that a comprehensive plan for dealing with future released prisoners was necessary. It was eventually decided that the Army, apart from providing special training to refit the repatriate for military duty, should also itself undertake the first steps towards re-equipping him for civil life. This led to the development of a constructive scheme along the lines advised by Army psychiatrists, who had made a special study of the problem.

In November, 1944, a small 'pilot' Civil Resettlement Unit (C.R.U.) was set up at Derby with accommodation for sixty cases. This pilot experiment justified the inauguration of a Civil Resettlement Planning Headquarters in April, 1945. By the end of May, 1945, the first C.R.U. was functioning, and by January, 1946, there were twenty regional C.R.Us., each capable of taking some 250 repatriates for a period varying from a few days to three months. The average length of stay was about five weeks.

Throughout, attendance at C.R.Us. was on a voluntary basis, in that men were entirely free to enter them or not and to leave at any time. All ex-prisoners-of-war were offered C.R.U. treatment. Some 63 per cent. of ex-prisoners from Europe entered C.R.Us., and approximately 45 per cent. from the Far East.

The purpose of the C.R.U. was to reintroduce the repatriate to civil life: to enable men not only to learn about post-war civil life and receive the benefit of the specialist advice they required, but to live as members of a free society while they were in the C.R.U., and to reintegrate themselves within the civilian community in general and within their home environment in particular.

Opportunities were provided in the workshops for men to rediscover or practise skills which they might have feared they had lost, or to acquire and discover new skills. 'Job rehearsals' were arranged at a local firm, and vocational guidance given with the aid of tests for aptitudes and abilities. A Ministry of Labour representative then gave assistance in placing the man in appropriate employment.

The most important aspect of all, however, was the re-socialisation of the individual, pre-eminently by group discussions, aided, where necessary, by specialist psychotherapy. Careful examination by the medical officer was required to exclude physical illness or to treat such illness as might be present: the majority of complaints were those symptomatic of psychological maladjustment, and these were dealt with mainly by the medical officer, either in group discussions or by reassurance of the individual.

Much valuable information was obtained on the reactions of groups, and on the usefulness of group discussions in aiding individuals to solve their problems of readjustment and of establishing inter-personal relationships. In all, a total of some 19,000 ex-European and 4,500 ex-Japanese prisoners-of-war had attended the C.R.Us. up to March 31, 1947. In order to gain more precise information as to the condition of ex-prisoners-of-war after their release from the Service, and to assess how far their condition had been modified by C.R.U. training, an intensive survey of released repatriates was undertaken by Curle. For the purpose of this investigation a man was referred to as unsettled when the over-all picture of his family, social and work relationships showed a withdrawal from healthy contact and co-operation. Assessment of unsettlement on this basis in C.R.U. and non-C.R.U. cases revealed the following results:—

	C.R.U. per cent.	Non-C.R.U. per cent.
Settled	74	36
Unsettled	26	64

The two groups—i.e. C.R.U. and non-C.R.U.—were analysed in relation to age, married state, length and place of captivity, disability, etc., and also psychologically to see whether special personality types were more prone to attend or stay away from C.R.Us. The two groups, however, showed a remarkable identity in all respects, and therefore comparison between the two groups was not invalidated.

The effect on the two groups of external stresses—i.e., disablement, financial ruin, etc.—were as follows:—

	No stress per cent.	Presence of stress per cent.
C.R.U.:		
Settled	42	32
Unsettled	8	18
Total	50	50
Non-C.R.U.:		
Settled	28	8
Unsettled	36	28
Total	64	36

Although after a period of time, which varied between about three and six months after repatriation, the more obvious symptoms of unsettlement frequently abated, more intensive investigation showed that true re-adaptation had not occurred, and that, in fact, unsettlement had often grown deeper roots. This increase in unsettlement with the passage of time did not, however, occur in men who had attended C.R.Us. It appeared that a man acquired at the C.R.U. a sort of developing stability which took some time to mature.

This resettlement, undertaken on a large scale by the Army, has seemed the best way to ensure that those qualities of the soldier which make for his success on the field may be turned to the best account in the civilian way of life which he had fought to preserve.

(b) Psychiatry in the Middle East Force 1940—1943

By G. W. B. JAMES
C.B.E., M.C., M.D.

A survey of the Middle East campaigns which ranged over a wide field covering thousands of miles showed that, on the whole, psychiatric casualties were relatively few.

Before the fighting in the Middle East began it had been estimated that about 5 per cent. of patients in the convoys arriving for treatment in the hospitals would prove to be cases of neurosis, though the figure might be exceeded or lessened according to the extent of the fighting. This estimate proved too optimistic. During the early campaigns convoys coming into the hospital centres in the delta showed that 10–20 per cent. of all sick were cases of neurosis or psychosis. This figure held up to 1942 when there was a steady fall, so that before, during and after the battle of Alamein the incidence of true psychiatric casualties in convoys fell to the low figure of 1–2 per cent. Table I shows the

TABLE I

Psychiatric Casualties Expressed as Incidence per 1,000 of the Middle East Force

Period	Psychiatric casualties	Battle casualties	For comparison	
			Malaria	Dysentery
1940 (based on 3 months)	8·5	—	—	—
1941 (all troops) . .	24·0	36·7	19·5	28·9
1942 (all troops) . .	21·2	31·1	29·1	33·3
1943 (based on 6 months, Jan. to June, all troops)	15·2	22·5	29·1	33·2

incidence of all psychiatric casualties for the period surveyed, here expressed as per 1,000 men yearly and compared with battle casualties, malaria, and dysentery.

In August, 1940, there was no psychiatric organisation and nowhere where the soldiers of the splendid Middle East Force could be treated on modern lines for psychiatric breakdown. There were, indeed, the very small observation wards in the military hospitals in or near the larger towns, but these were only sufficient for a garrison force. The provision of adequate psychiatric hospital accommodation seemed the first problem to be solved, and by March, 1943, there were over 2,000 psychiatric beds available from Tripoli in Northern Syria to Tripoli (West) in Tripolitania. At the rate of 2 hospital beds per 1,000 men this provided adequately for the highest level of troops (approximately 1,000,000 men) drawn from twenty-eight nationalities.

At an early date a firm evacuation base was formed in the Union of South Africa where at Pietermaritzberg there was an excellent wing of a military hospital for 250 long-term cases of neurosis and 60 beds for long-term psychotics. Arrangements were made at the civil mental hospital at Pietermaritzberg (Townhill hospital) for difficult and anti-social cases of psychosis to be maintained and cared for by the civilian mental hygiene service. The military hospital psychiatric wing was staffed by the South African Medical Corps and at one of the consultants' visits the nursing was being done by Canadian nursing sisters who had both general and psychiatric nursing qualifications.

By July, 1941, two centres, one in Palestine and one in the Canal Zone with 350 beds and some expert staff, were available to enable psychotic and neurotic soldiers to receive adequate specialised medical and nursing care. Narcosis-therapy, electroplexy, and occupational therapy had by then been established. It was considered unwise to establish insulin therapy, partly on account of lack of skilled staff and partly because patients in deep insulin coma seemed to lose control of temperature regulation and, perhaps owing to the hot climate, pyrexia seemed liable to rise to dangerous heights.

A hospital (No. 41 General) of 600 beds was opened at Kantara in March, 1942, in a 1,200-bedded hospital building evacuated by the Second Australian General Hospital which was moving East; No. 1 Centre in the Canal Zone was ultimately replaced by No. 78 General Hospital of 600 beds early in 1943. As need arose huts were built for special purposes or in isolated regions throughout the immense area of the Near East. With firm and established psychiatric hospital centres—all of which dealt with out-patients—some of the wider aspects of psychiatry were dealt with, such as the problems of delinquency, reviewing soldiers under sentence, the maintenance of morale, the survey of drafts from the psychiatric standpoint, the urgent and important welfare aspect of officers and men, leave arrangements, the question of the brothels, psychological aspects of warfare, the effect of enemy weapons and of our own weapons on the enemy, and the prevention of psychiatric breakdown. With this went work on personnel selection in the Middle East, the selection of airborne units and their training, the establishment of War Office selection boards, welfare arrangements for the Women's Services and the selection of local enlistments for service with the British forces (which proved a difficult matter partly on account of language differences). Then hospital and psychiatric care was provided for the Royal Navy and the R.A.F. personnel, and for numerous nationalities, including French, Americans, Poles, Czechs, Greeks, Cypriots, Armenians, Syrians, Arabians, Egyptian labourers and civilians, a few Turks, and even one or two Chinese. But the commitments were met, thanks to the unsparing efforts of the ever-growing psychiatric team. Later the areas of the Middle East were provided with area psychiatrists so that local specialist opinion was obtainable, while the Eighth Army possessed a specialist psychiatrist attached to a mobile hospital which travelled as fast as the Army and enabled specialist opinion and treatment to be given at a forward level.

The defence of Tobruk in 1941 enabled essays in forward treatment of battle breakdown to be made, in which officers of the Australian Medical Service were specially interested.

The incidence of psychiatric casualties fell relatively more heavily on the fighting men (see Table II).

TABLE II

Percentage Incidence by Units of a Sample of 3,724 Psychiatric Casualties among British Troops in the Middle East Force, 1942–3

Source	Casualties per cent.	Average strength by arms per cent.
Services, including R.A.S.C., R.A.M.C., R.E.M.E., R.A.P.C., R.A.O.C., A.D.C., C.M.P., R.A.Ch.D., Pioneers, A.C.C., etc.	32	37
Infantry	22	17
R.A. (including R.H.A. and A.A.)	20	22
R.A.C., R.T.R., and Recce Units	12	9
R.E.	9	9
R. Corps of Signals	5	6

All men serving in the desert suffered great physical and mental strain, often underwent loss of sleep and rest, and had to endure the glare of the sun, the flies and the sandy fogs churned up by the vehicles. The majority of casualties among forward troops were precipitated by physical factors, and among the lessons drawn it seemed that from time to time whole units required recuperative and training periods together. The more unpleasant the terrain in which the fighting occurred the more necessary such periods became. There was no place for the retarded and backward man among troops required to engage in active combat with the enemy. This point was clearly shown by the fact that in a group of 1,000 cases of psychiatric illness in the Middle East Force less than 40 per cent. were related in any way to war stress, while over 60 per cent. were cases of breakdown in men who had no experience of battle conditions. In one quarter of 1941 over 80 men were admitted to psychiatric centres or hospitals more or less direct from transports or within a week of arrival in the Middle East, while in another quarter 74 men were admitted direct from transports or broke down within four weeks of arrival in the Middle East.

Many acute cases recovered quickly when suitably treated, and in order to avoid the diagnosis of neurosis in such cases the consultant in psychiatry in 1942 suggested that whenever possible the diagnosis of 'physical exhaustion' should be permitted for a week or ten days and only changed when soldiers were obviously suffering from a psychiatric condition requiring more lengthy treatment. From July to November, 1942, all cases labelled 'physical exhaustion' were sent to the Army Rest Centre at Ikingi Mariut, where they were well fed, rested, bathed, and provided with clean garments; at this centre there was a large recreation hut and a comfortable canteen, while a hairdresser and chiropodist were available. No psychotherapeutic treatment was attempted beyond advice and encouragement from the medical officer. The average stay in the unit for pure exhaustion was five to ten days. All severe cases of psychosis or neurosis were speedily evacuated to a psychiatric centre, as were a portion of those 'exhaustion' cases that did not respond to rest and good feeding.

Psychotic cases constituted roughly 30 per cent. of all psychiatric casualties; of these, one-third were due to mental deficiency, one-third were cases of psychopathic personality, and one-third were true psychoses. The term schizophrenia was used as a diagnosis so frequently that it was clear it served as a convenient label for almost any mental illness occurring in young men. Of the psychotics evacuated to South Africa in an eighteen months' period in 1941–2, as many as 80 per cent. were labelled schizophrenia, whereas usually only 16 per cent. of admissions to civil mental hospitals are cases of schizophrenia. Probably the explanation was that the term was applied by the inexperienced to anxiety reactions or hysterical states sufficiently unusual or bizarre, possibly occurring as a result of battle conditions, and presenting psychotic features such as stupor, aggression, and violent conduct or paranoid features and regressive signs of various kinds. In any case schizophrenic reactions in soldiers are of less serious import than among a corresponding civilian group.

Manic depressive states formed 12–13 per cent. of the total psychoses. Maniacal states were unusual. As regards the decision to evacuate such cases, if it were found that there was a well-marked periodicity between the attacks with a lengthy period of normality, the patient was kept in the Command if recovery was reasonably quick (three to four months). When the cyclothymic events were accompanied by ideas of reference, by alcoholism, or by litigious habits of mind, evacuation was insisted upon.

Depression was more common than mania and was especially frequent among officers. Hysterical headache plus depression was widespread especially in the early years. Depression not amounting to a real disability was a general reaction to heat, to flies, to desert surroundings, and to the sense of frustration induced in many by fighting what looked to be a losing war.

Organic states, or 'toxic confusional' and 'exhaustion' reactions. The Middle East Force encountered certain infective and deficiency diseases which were often accompanied by mental symptoms. The chief of these were malaria, typhoid, bacillary dysentery, epidemic jaundice, heat stroke, sandfly fever, relapsing fever, amoebic dysentery with abscess of the liver, and some avitaminoses. It had constantly to be borne in mind that these conditions might begin as a mental rather than a physical illness. A memorandum (A.M.D. Bulletin, No. 24) was published on this subject in 1943 in which it was pointed out how serious an attack of excitement could be in a hot country and how urgent was the investigation of symptoms indicating an early confusion. These organic states accounted for about 8 per cent. of in-patient admissions to psychiatric hospitals or centres. Throughout the campaigns of the Middle East soldiers were from time to time admitted to psychiatric hospitals as cases of 'anxiety neurosis', who were in fact suffering from malaria. If they began during or soon after a battle the uncontrollable tremors of a malarial rigor were occasionally taken for evidence of an 'anxiety state'. When such patients arrived at a psychiatric centre apparently normal and with no fever it was not till the next rigor occurred that the correct diagnosis was made. Soldiers sometimes became mildly affected mentally or even quite grossly disordered during the prodromal period of malaria, and such patients were at times sent into hospital with psychiatric diagnoses which even included 'schizophrenia'; others were admitted as neuroses showing comparatively minor mental manifestations of a neurotic type such as irritability, lapses of memory and minor delinquency. Such symptoms occurring suddenly in otherwise good soldiers led to medical advice being sought and some were referred to the psychiatrist. As a rule the diagnosis was made promptly as a result of an examination of the blood.

Serious mental symptoms associated with fully developed malaria were not common but patients sometimes became disorientated in time and space, mistook the identities of those about them or even became delirious. There were no deaths from malaria in the psychiatric hospital centres. It was noted that a soldier who had shown mental symptoms during the prodromal period of malaria was likely to show the same changes in any relapse or reinfection which might occur. Mild depression was not uncommon as a sequel to malaria.

The practical conclusion was reached that, in malarious country, men admitted to psychiatric centres for any type of mental reaction should as a routine have their temperatures taken at least morning and evening for several days after admission. If small rises of temperature occur, and the patient be known to have come from a malarious district, it is worth while instituting a full course of anti-malarial treatment.

Dysentery. Apart from the delirium and coma seen in the acute phases (especially in Shiga infection) the mental symptoms of bacillary dysentery called for no special comment; sometimes, however, the dysenteric attack was followed by depression and hypochondriasis with marked fatiguability and interference with sleep.

Amoebic dysentery associated with liver abscess occasionally presented mental symptoms. On one occasion a patient was admitted to a psychiatric centre from a desert hospital for acute mental symptoms which took the form of a severe confusional state. At first he was thought to be suffering from a right-sided pneumonia but he collapsed and died three days after admission and the post-mortem revealed an unsuspected liver abscess.

Other conditions

Avitaminosis was occasionally accompanied by mental symptoms. If soldiers lived over a long period on bully beef, biscuits and tea, often with shortage of water, a B-complex deficiency occasionally resulted. For example, late in the summer of 1941 twenty-four men arrived at Alexandria from Tobfort showing a dry wrinkled skin, oedema of the legs and in some cases albuminuria; eight of these (two officers and six other ranks) were profoundly confused. They soon recovered under treatment by a good mixed diet with additional B-complex vitamins.

Occasionally mild mental symptoms such as headache, vertigo and depression, developed after heatstroke, and in one case an almost maniacal condition developed with heat hyperpyrexia.

Mental confusion and excitement were sometimes prodromal features of epidemic hepatitis and such cases were occasionally sent to a psychiatric hospital. One officer suffering from this disease was admitted to a centre with the diagnosis 'acute schizophrenia'. A number of cases occurred in which depression and lack of concentration followed an attack.

The number of patients who suffered from mental symptoms due to infective diseases may not have been large but they formed a very important and interesting section of the psychiatric work in the Middle East.

The Backward Individual

The number of dull and backward individuals was not large in any of the forces comprising the M.E.F. and they were easily picked out by their constantly reporting sick, by their unusually dirty appearance in desert conditions, and by their emotional instability and inability to look after themselves. The description of such a soldier made by an N.C.O. in presenting him for assessment could not be bettered—'There's not much wrong with him, but there's not much right with him either. He's always in trouble and he has nearly always got a desert sore. His clothes are a disgrace to the section and if I say anything to him he is insolent or bursts out crying. In action he puts the wind up us all with his carryings on. But he can eat and sleep with the best of us, though he can't carry his beer.'

Unstable defectives and those with strong delinquent or anti-social features were dealt with by the psychiatrist, but undoubtedly a few *stable* defectives managed to serve throughout the campaigns in the Middle East and gave satisfactory service provided they were led by officers who understood them. When such defectives served in a battalion of normal individuals, however, it was common for nervous symptoms or delinquent behaviour to develop.

Psychosis among Non-European Troops

These troops included the splendid fighting men of the Fourth and Fifth Indian Divisions and the Maoris; also a great variety of African troops. Their behaviour in mental disorder depended a great deal upon the cultural background and it was often difficult to determine the difference between severe psychosis and hysterical reactions among many of the native troops. For the most part the Indian fighting men were remarkably free from neuroses and psychoses, but the followers who lacked the pride of fighting troops were much more frequently affected. The Maoris were wonderful troops with no appreciable breakdown rate.

THE PSYCHO-NEUROTIC CASUALTIES

The neuroses of war are clinically much the same as the neuroses of peace but there are differences in aetiology and effects. The acute neuroses of war occur in a dramatic setting in the dust, noise and filth of battle, often in strange countries far from the soldier's home, perhaps in climatic extremes of heat or cold, in conditions of almost unbearable wetness or in dry searing sandy heat. In the Middle East campaigns neurotic breakdown was a dual matter of mind and body; more or less prolonged emotional struggles with fear and disgust, rage and resentment were added to severe physical stress including hunger and thirst, loss of sleep and fatigue to the point of exhaustion. It should be noted also that at the point of breakdown the soldier was often seen first by men who were themselves in a highly emotional state, which was reflected in the attitude to and treatment of the nervous and sometimes demoralised soldier.

Compared with the amount of breakdown in other campaigns against the Germans the incidence of battle breakdown in the total psychotic casualties of the Middle East Force was low at 35 to 37 per cent. of all psychiatric casualties. Apart from the high tradition and training of the troops an important factor in sustaining the men was the presence of the waterless desert, which some dreaded more than the human enemy. It was noteworthy that cases of psychiatric breakdown were rare in units with a high standard of leadership, high ideals and traditions, and good morale.

Of the symptoms shown by those whose state was precipitated by battle, anxiety and depression were the most common. Compared with the War of 1914–18 there were many fewer cases of tachycardia and dyspepsia. Some of the worst anxiety cases were seen among those men who cleared the mines at the Battle of Alamein; they were tremulous, dazed, tearful, showed the startle reflex, were restless, and had severe battle dreams. In ten days they were symptom-free and anxious to return to their units.

It deserves to be recorded that a great many officers and other ranks carried on very well in spite of symptoms which would have justified them in seeking treatment and which in men of poorer morale would have led to admission to hospital.

THE DIFFERENCE BETWEEN BATTLE NERVES AND NON-BATTLE NERVES

Chronic depression was more frequent in non-battle cases. Sleep was much more disturbed in the battle cases, either by insomnia or by vivid battle dreams. There was a much greater prominence of somatic features in non-battle cases and perhaps the most widely spread were the dyspepsias, suspected ulcers and the like. The 'effort syndrome' or anxiety expressed in cardiac terms was almost entirely confined to non-battle cases and was remarkably rare compared with the War of 1914–18. Morale was at a low level among non-battle cases of nervous breakdown and rehabilitation was difficult.

As in civil practice the classical syndrome known as neurasthenia was rare. Depression, vertical headache, fatiguability and insomnia formed a syndrome not infrequently seen after tropical illness, e.g. the sharp depression after sandfly fever, and also after lengthy service and much action. This type of neurasthenic reaction was met with among hard-worked officers and N.C.Os. on dull routine jobs.

The great majority of soldiers bore a heavy emotional burden of grief, shock and frustration without a depressive reaction.

Of special interest to the psychiatrist were those officers and men who complained of serious and crippling symptoms following head injury, often of quite a mild type. Concussion, however slight, frequently produced an array of symptoms which required skilful psychiatric handling, and among them the psychiatrist paid particular attention to changes in personality as shown by memory defects or by the appearance of asocial or anti-social behaviour.

The serious complaints of a mental kind which sometimes followed minor head injury were mainly hysterical in nature but there were cases of more severe injury, with laceration and contusion of the brain, in which there were found personality changes of organic origin. The more serious types of case became forgetful, emotionally labile, and intolerant to alcohol, while their inclination to be truculent to superiors might lead them into disciplinary trouble. Briefly, the psychiatric effects of head injuries seen in the Middle East Force were, first, the excitement and restless delirium commonly seen in the early days both of closed injuries and penetrating wounds of the brain, an excitement which was often well controlled by the intravenous paraldehyde drip method used by Majors Ascroft and Kremer at the Neuro-surgical unit attached to No. 15 General Hospital. Next, the difficult and rather obstinate post-concussional syndrome, which was mainly hysterical and often associated with neurotic personalities. Thirdly, the delayed post-traumatic deterioration, which was important on account of the fact that soldiers suffering from it were likely to get into disciplinary trouble.

Hospital Accommodation

Experience showed that the psychiatric hospital base for a large force should be planned at two beds per 1,000 of the force, and should be situated well away from the fighting but close to railways or ports well served by roads. The best results were obtained by minimising the patient's stay in hospital by very active treatment, and by transferring him to the military atmosphere of a rehabilitation centre or convalescent depot as soon as possible.

Rehabilitation

It was found better to have an entirely separate wing at a convalescent depot under psychiatric command rather than to mix medical and orthopaedic cases with psychiatric cases. Both physical and mental well-being needed to be cared for by providing games, occupational therapy, physical training, leave, studies and entertainment.

In 1942 at El Arish and in 1943 at Tripoli, psychiatric blocks were set up in convalescent depots. After three or four weeks' training with open-air games, bathing and swimming, lectures, entertainments and any necessary minor treatment, usually for the common complaint of sleep disturbed by battle dreams, soldiers became bronzed and fit, and actively cheerful, losing the look of dispirited apathy, indifference or depression with which many had been admitted, even after a period of hospital treatment.

Occupational therapy was frequently utilised, not only for its curative and remedial value but because it had a special place in a force separated so far from home and family, in giving soldiers a therapeutic distraction from constant thoughts about home during hospital periods. The psychiatric hospitals in the Middle East developed many more outlets of an occupational kind than the general hospitals. As instances of this, the concert parties provided much work and occupation at the psychiatric hospitals and centres; not only were band instruments purchased for patients, but all the clothing for costumes, carpentry for the stage, the electrical work and the painting of scenery was done by the patients during their residence in hospital. Shops were opened for the repair of hospital furniture, for repairs to clothing, for the cobbling of boots and shoes and for the manufacture of articles in wood or in tin, such as office furniture. In spite of the fact that many of the hospital wards were situated in desert sand, and water was scarce, there were instances in which remarkable flower and kitchen gardens were made to flourish.

Though there was a shortage of trained occupational therapists, many women resident in the Middle East rendered voluntary help, and valuable monetary and other aid was obtained from the British Red Cross Society and the Order of St. John of Jerusalem.

EVACUATION

From May 1, 1941, to October 1, 1942—a period of seventeen months—a total of 1,456 psychiatric cases were evacuated from the Middle East, of which 1,188 were drawn from the British Army, 121 from the Royal Navy and 152 from the R.A.F.

The evacuation of psychiatric casualties had to be done by sea-route, first from Suez to Durban and later from Durban to the U.K., and in performing this evacuation certain important points had to be attended to. In the first place there had to be enough hospital accommodation of a suitable kind at the ports of embarkation to allow for quite long periods of waiting. Then there was need for security precautions, adequate escorts and personnel on the hospital ships. The ship had to be inspected with a view to minor alterations which would enable psychiatric cases to travel in reasonable safety with a minimum of nursing staffs; only one exit from ward to the deck could be permitted and portholes (especially in lavatories and bathrooms) had to be protected. Moreover, the patients were provided with simple games or occupational work of a diversional nature. Also, a safe exercise space on deck had to be arranged.

TREATMENT

No fresh methods of treatment were devised or learned during the Middle East campaigns. The keynote of forward treatment of the neuroses was adequate sedation at an early stage. If a unit medical officer thought evacuation necessary, the evacuation needed to be as speedy as possible and it was recommended that the soldier-patient should be given sedative drugs so that he travelled in a drowsy or almost unconscious condition. For this to be achieved any suitable sedative was given in doses adequate for the purpose. The dosage required was much bigger than the dose first thought of by the average clinician. On waking from the narcotic period many of the symptoms had usually disappeared, but, before he was allowed to get up, the rest of the symptoms must have been removed. Sedatives were necessary to produce sleep for a few nights, or even longer if very disturbing battle dreams remained. The return of the soldier to his unit was expeditious and he was not allowed to remain indefinitely in reinforcement or transit camps.

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Neuro-Psychiatry in the Royal Air Force

Based on the work of

SIR CHARLES SYMONDS *and* DENIS WILLIAMS

K.B.E., C.B., M.D., F.R.C.P. — M.D., F.R.C.P.

The part played by the psychiatrist in the selection of personnel was perhaps not so great in the R.A.F. as in the other Services.

At the outset of the war the initial selection procedure depended upon an unstandardised interview. In 1940 a few psychometric tests were introduced to assist the Aviation Candidates Selection Boards. In 1941, Ground Trade Selection tests were added by the personnel adviser to the Central Trade Test Board. In 1943 the technical responsibility for all selection-test procedures became centralised at the Air Ministry. The tests were carried out by a specially trained personnel selection staff recruited chiefly from intelligent airwomen.

The importance of confidence and mental stability in members of the Royal Air Force led to many investigations into the causes of mental breakdown, the relative value of symptoms pointing to that breakdown, and the best methods of eliminating those whose temperament was unsuitable for flying, either with or without the extra risk of combat.

Air Vice-Marshal Sir Charles Symonds and Wing Commander Denis Williams published many reports bearing on these subjects, issued by the Air Ministry in Air Publication 3139 (*Psychological Disorders in Flying Personnel of the Royal Air Force investigated during the War*, 1939–45, H.M.S.O., London, 1947). Their conclusions are briefly summarised in the following pages.

FIRST INVESTIGATION

In 1942 an analysis was made of 1,197 cases from flying personnel who, during six consecutive months in that year had been referred to the neuro-psychiatrists. The research was undertaken in the belief that the symptom-pattern or reaction-type of a neurosis could not be related to a single cause but might have as its main cause either emotional conflict, infection or exhaustion, while much was thought to depend upon the individual constitution. It was found that neurosis in different tactical units varied directly with the amount of hazard encountered, as measured by the casualty rates. It was highest in night bombers, lowest in Flying Training Command. Emotional tension proved more important than physical fatigue. Exhaustion, air sickness, cold, injury, and the effects of altitude were subsidiary factors. Temperamental unfitness for the job was a most important causal factor. The effect of flying stress became more urgent according to the number of hours, particularly operational hours, flown.

FACTORS IN FLYING STRESS

The most important element in flying stress as a cause of neurosis was fear, or lack of confidence, within certain limits. Fear sometimes lost its inhibiting power when the mind was under the influence of a strong anger or loyalty; in such cases it might even act as a stimulus. When fear dominated the mind to the exclusion of other emotions it became harmful. Confidence was shown to be a positive quality of inestimable value to the airman; without it he could never achieve outstanding success, and the lack of it led to flying accidents, operational failures, and psychological breakdown.

There was a type of fearlessness associated with lack of intelligence or imagination which, though a source of strength in time of some dangers, carried with it the risk of sudden fear and panic in presence of a more obvious and obtrusive danger. In others the threshold of fear was unusually high; or the threshold of certain factors which inhibited fear might be low. In the normal man courage was required to overcome fear; after an emotional conflict this might lead to the best form of fearlessness—equanimity under stress.

Analysis showed that emotional tension resulting from the prolonged exercise of courage was the most important element of stress, but that did not exclude other factors such as skill-fatigue, fatigue of vision and hearing, the effects of acceleration and decompression and even anoxia.

Among the 1,197 men specially examined it was found that as many as 68 per cent. showed some predisposition to neurosis. To assess the true value of that estimation a control group of 100 men was examined by the same methods of clinical assessment. The control group of normals consisted of 100 flying personnel admitted consecutively to the Military (Head Injuries) Hospital, Oxford, with an acute head or spinal injury resulting from plane crash, car accident, or enemy action. The normal group showed only 15 out of the 100 with predisposition to neurosis.

Predisposition	100 normals	Percentage among 1,197 with psychological disorders
Nil	85	32
Mild	12	52
Severe	3	16
Total percentage predisposed	15	68

In the series of 1,197 cases there were 176 with no medical disability. Of those who were definitely affected two-thirds had been subjected to slight or no flying stress. Severe predisposition was especially high in those who had not flown. Clearly predisposition played an important part in conducing to neurosis.

The problem then arose whether it would be wise to reject any of those who might be found to have a predisposition to psychological disorder. After carefully weighing the evidence, Symonds and Williams came to the conclusion that the total contribution made to the operational effort by the mildly predisposed before they broke down amply repaid their acceptance, though it might have been profitable to reject those who were severely predisposed.

Although the exact incidence of psychological disorders in flying personnel could not be calculated, the available figures showed that the incidence was certainly less than 5 per cent. Since this is less than a third of the percentage of normals which had been found to be predisposed to neurosis, it followed that for each breakdown prevented by rejection two efficient men would also have been debarred from the Force.

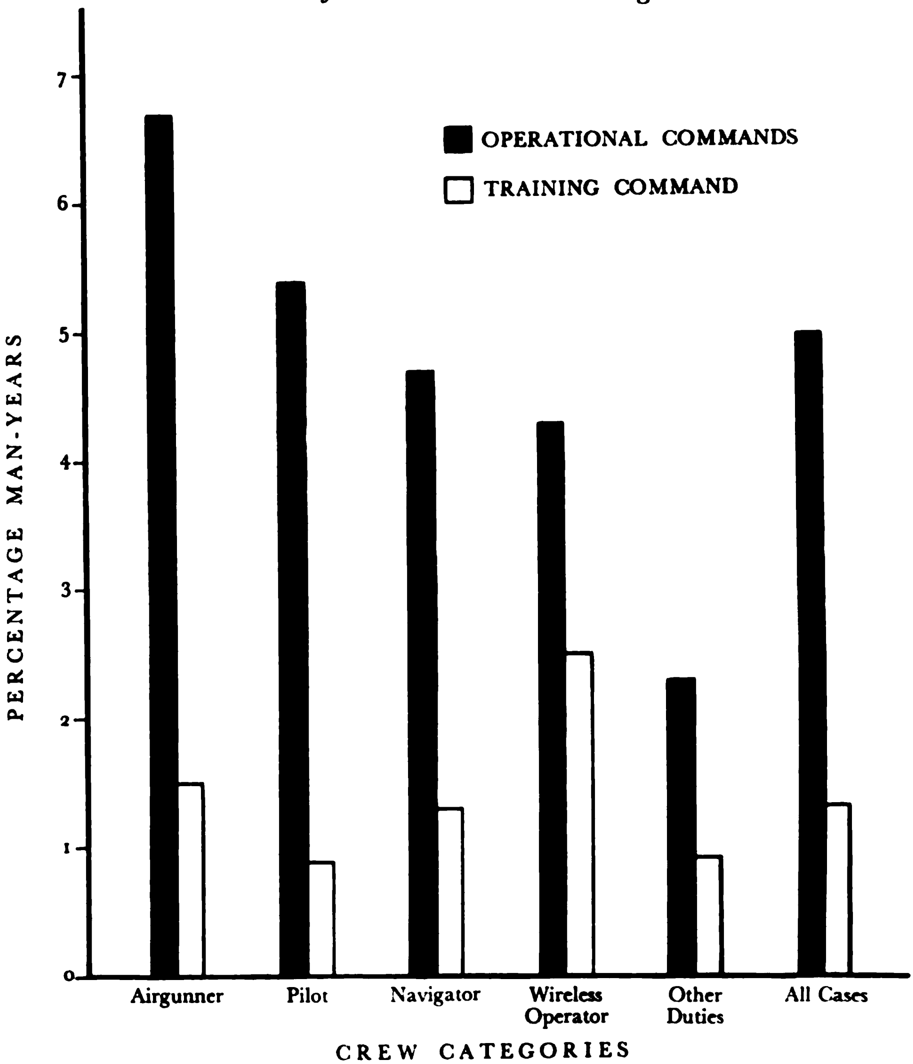
SECOND PSYCHIATRIC REPORT

In the succeeding year (1943) Symonds and Williams published the results of an investigation into 2,919 cases of psychological disorder occurring in flying personnel in the R.A.F. during the year ended February 9, 1943. The neuro-psychiatrists decided that 2,200 of these were cases of neurosis arising mainly from flying duties, 303 showed a neurosis not directly caused by flying duties, while in 416 cases there was no neurosis but simply lack of confidence.

It was found that 96 per cent. of cases occurred in pilots, wireless operators, air gunners and navigators, but the incidence in crew categories as a percentage of man-years was greatest in air gunners and wireless operators.

FIG. 1

Incidence of Neuroses in Crew Categories

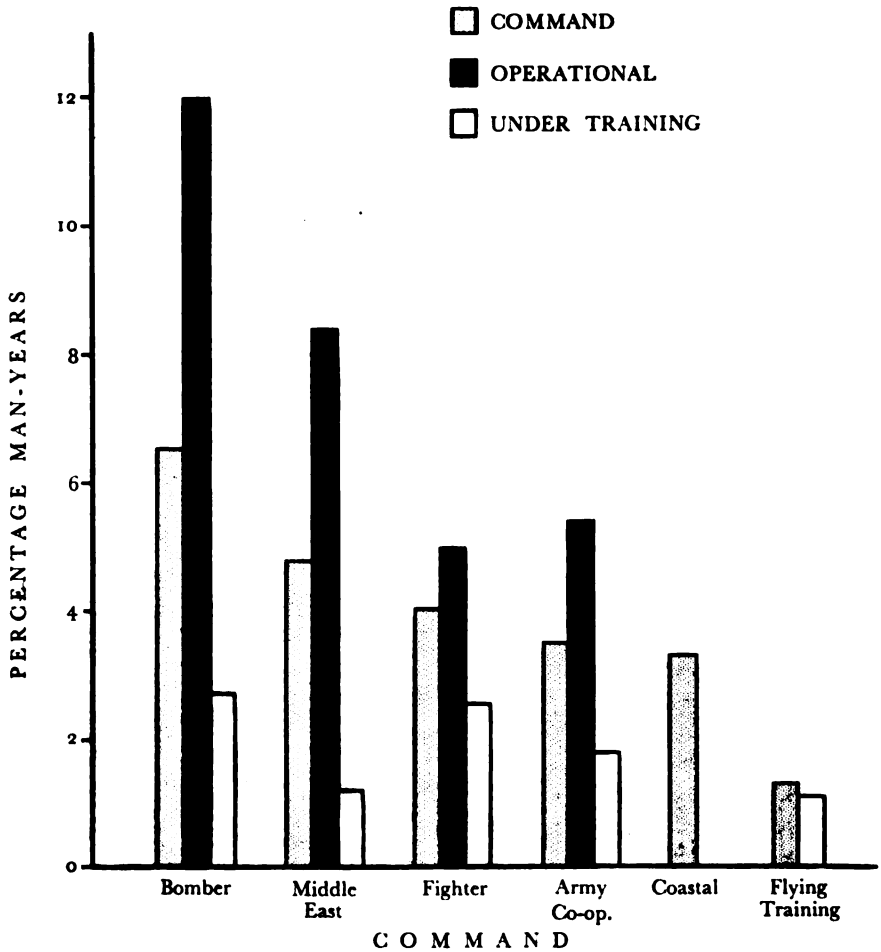


(From *Psychological Disorders in Flying Personnel of the Royal Air Force, investigated during the War*, 1939–45. Air Publication 3139 H.M.S.O. 1947)

In Flying Training Command there was a much lower incidence of neurosis resulting from flying than in the operational commands, but among those cases which occurred the incidence was higher in air gunners. In every operational command the breakdown rate was greatest in air gunners, next greatest among pilots, lower still for navigators and wireless operators. Considering the duties performed, it was found that among the operational units of Bomber Command the

FIG. 2

Incidence of Neuroses in Commands



(From *Psychological Disorders in Flying Personnel of the Royal Air Force, investigated during the War*, 1939–45. Air Publication 3139 H.M.S.O. 1947)

incidence was higher than that for any other operational duties; breakdown rate was low among the night fighters.

It was found that the incidence of neurosis unrelated to flying duties tended to diminish with increasing flying experience; this might lead one to conclude that the pre-occupation with the hazards of operational flying might in some way have protected the individual from the effect of worries unrelated to flying. Three-quarters of these cases occurred in men who were under training. Moreover, in operational Commands marriage played a more important part in the neurosis unrelated to flying duties, while the reverse obtained in Flying Training Command. The explanation of this might be that in the squadron the man was not only cut off from his family life, but was so imbued with the squadron and crew spirit that the anxieties of his private life were relatively unimportant.

The incidence of neurosis attributed to the duties of bombing was nearly four times that for the Air Force as a whole, twice that of day fighting and nearly four times that of night fighting.

Investigation showed that in nearly every case of neurosis arising from flying duties the main cause was psychological. In only 9 cases out of 2,200 was exhaustion, physical illness or injury the sole cause, though physical injury contributed in 18 per cent. and illness in 9 per cent. of cases. Neither cold nor altitude were recorded as causal factors; extreme cold appeared to have a numbing effect upon the emotions as upon the senses, and anxiety gave way to apathy and lessened mental strain.

In 4 out of 5 cases the clinical pattern of neurosis due to flying duties took the form of an anxiety state. Just under 10 per cent. suffered from depression, and hysteria accounted for over 12 per cent. Sometimes (11 per cent.) the forms were mixed.

The distinctive feature of the anxiety neurosis was a morbid state of fear which was more likely to be excited in the air and in the battle zone. It was often difficult to draw the line between morbid fear and natural fear, between anxiety neurosis and cowardice. Expediency counted for more than scientific judgment in the disposal of such cases.

Of those cases of flying personnel referred to the psychiatrist, 38 per cent. were returned to flying duties, but among those who were first given a spell of temporary ground duty or limited flying as many as 56 per cent. returned to flying duties. The chances of returning to flying duties were greatest in pilots, experienced aircrews, and those with little or no predisposition to neurosis.

THIRD PSYCHIATRIC REPORT

In 1943 and 1944 a further investigation by Symonds and Williams produced conclusions which supported those reached in previous years. There were 2,989 cases suffering from neurosis and 307 lacking in confidence. A third of those suffering from neurosis came from training units. As in previous years, pilots, wireless operators and air gunners had a high incidence of neurosis, but navigators now formed a higher proportion than any section except pilots.

From the fact that there was a fall of 10 per cent. in the incidence among those who had had considerable operational experience, it appeared likely that men suffering from a neurosis reached the specialist earlier in their flying career than they had done in previous years. This was probably the result of earlier recognition of temperamentally unsuitable air crew under training, and the more efficient prevention of neurosis in squadrons. This view was confirmed later by Williams, who showed that in 1943–4 there was a considerable increase in the number of cases of neurosis from Flying Training Command, while at the same time there was a considerable diminution in the number of similar cases from the night bomber squadrons.

The causes of neurosis in 1943–4 were similar to those in previous years. Of the 1,184 finally disposed by a medical board, 35 per cent. returned to full flying duties.

FOURTH PSYCHIATRIC REPORT

Similar confirmation of the accuracy of the earlier conclusions was afforded by the figures of cases of neurosis in Air Force crews in 1944–5. This can be seen at a glance in the following table:—

	Neurosis cases	Lacking in confidence
1942–3 . .	2,503	416
1943–4 . .	2,989	307
1944–5 . .	2,910	306

The contribution from each command and the proportion from each aircrew category remained about the same.

PSYCHIATRIC ASSESSMENT

For a man to be an efficient pilot or member of an air crew he had to have the right temperament. It was possible to assess temperament in one or both of two ways. The first was the method of appraisement by general observation. The instructor who was with the man in the air was in the best position to estimate this and was required to be methodical in his observations.

Signs of timidity or nervousness could be recognised either on the ground or in the air. If a man reported sick frequently, with insufficient or without any detectable cause for such a stoppage of his duties, or if he showed a general lack of keenness, timidity was suspected. If he went to the length of requesting to cease training the position was clear.

In the air the instructor could tell the man's reaction by noting his facial expression, his posture and movements, and his speech in relation to exercises or situations which contained real or imaginary danger. The way in which a pilot handled the controls gave valuable information, for a nervous man was inclined to be tense and to move the rudder bar jerkily and uncertainly. Still more could the instructor tell by the way in which a learner approached and dealt with the more difficult manoeuvres—going into a spin, stalling, steep turns and low flying—for as one instructor put it, 'One should be testing the man's ability to think methodically and clearly in situations containing an element of danger'. Finally, a general disinclination to continue the training, shown by flimsy excuses so as to avoid taking the air, was a valuable indication.

As a result of these investigations a memorandum was issued by the Director-General of Medical Services in June, 1943, which was circulated to all flying instructors, containing notes on the recognition of nervousness in pilots under training and emphasising the importance of eliminating those who were temperamentally unfit.

The other method, which attempted to be more scientific by giving the reasons for the opinion expressed, was the psychiatric method. In 1944 a special investigation into the reliability of this method was undertaken by Symonds and Williams. Two representative psychiatrists made a psychiatric examination of 1,009 pilots under training, and 335 pilots who had completed a night-bombing tour. The interview of each man lasted about three-quarters of an hour and took into consideration both predisposition and special traits which were put under ten headings: family history, previous nervous breakdown, morbid fear or anxiety, physiological instability, timidity, lack of aggressiveness, lack of persistence, affective lability, obsessional peculiarities and psychological immaturity. These ten traits were based upon an analysis by Gillespie (1941 and 1944) of features observed in flying personnel who had developed neurosis. These traits were taken into account by the psychiatrists but did not by any means form a mechanical method of estimating liability to neurosis. The assessment and the score of traits were to be made separately.

It was found that the percentage who were severely predisposed was two among those under training and 0·6 among the tour-expired pilots. As perhaps might have been expected, the traits which were seldom found among the tour-expired pilots were: lack of aggressiveness, timidity, psychological immaturity, and affective lability. On the other hand, four traits were heavily represented in both groups: physiological instability, anxiety and morbid fears, positive family history, and an obsessional predisposition.

These observations made it clear that many good pilots remain efficient in spite of some psychiatric weakness and it was important to determine which traits were of most importance. There was a general direct relationship between the score of traits and the psychiatric assessment, but it was quite clear that it was not enough mechanically to add up the number of traits to obtain the psychiatric assessment. It required other factors obtained at the interview but not able to be arithmetically expressed. Analysis of the cases examined showed that no single trait could be taken as ground for rejection. The traits which seemed to be most closely related to liability to a breakdown were: timidity, lack of aggression or of persistence, previous nervous breakdown, affective lability, and psychological immaturity. These were the traits as stated above which were seldom found in the experienced pilot and gave some guide to their relative importance.

A similar investigation, undertaken under the auspices of the Director of Medical Services of the Royal Canadian Air Force on 3,000 candidates for flying, showed a lack of close relationship between the psychiatric assessment and the trait score, and it was concluded that the point score of traits had no practical value alone, though they might be used in arriving at assessment. In the R.A.F. investigation there was a direct relationship between psychiatric assessment and trait score but it was not very close.

Any method which tended to fix the attention upon a limited number of traits detracted from that freedom of movement and range of attention which was so necessary. The aim, which was attained, was to discover a small number of highly significant combinations which would serve as a guide to the total clinical appraisal.

AIR-SICKNESS AND PSYCHOLOGICAL DISORDER

In 1944 a thorough investigation into the relationship between air-sickness and psychological disorder was undertaken by Symonds and Williams. The broad general conclusion was reached that when a man was suspended for air-sickness at any stage of training the cause was usually motion-sickness uncomplicated by psychological factors. It might be that such factors—either neurosis, neurotic predisposition or faulty morale—might contribute by lowering the physiological threshold for tolerance of motion, or by reducing the man's ability or willingness to endure symptoms; but psychological abnormality might co-exist with air-sickness without contributing to it. It was important to distinguish true air-sickness from visceral reactions to anxiety occurring in the air.

THE STRAIN OF FLYING

Summing up the results of a great number of investigations into the effects of the stress of flying upon personnel, Symonds (in 1943) made some very valuable and pertinent remarks.

Flying stress should not be used as a diagnostic heading but should be used to designate the special strains and stresses to which flying personnel are exposed. Flying stress is that which happens to the man, not that which happens in him; it is a set of causes, not a set of symptoms.

The stress of flying might lead to change in appearance, talk and behaviour, to loss of keenness for flying duties, to loss of efficiency, or to alcoholic excess. A quiet man might become garrulous or a normal man solitary or moody. Facial expression might alter and the man look pale and worried. Diminished enthusiasm might be apparent in the man's manner or conversation on briefing for a flight. Errors of judgment or even carelessness might be evident. Some men reported sick with some trivial complaint which had no physical basis but was due to their mental condition. Sleeplessness might be a prominent feature.

The avoidance of a breakdown depended upon several factors, the chief of which was a suitable temperament and the right offensive spirit in the man himself. But there were many extrinsic factors which affected a man's ability to carry the load of responsibility. These extrinsic factors were either directly or indirectly connected with flying and were capable of modification. Morale was better when there was a good leader and the crew had a good team spirit and were confident in one another. It was also of importance that special success should be given prompt and adequate recognition. Discipline imposed on the ground was reflected in efficiency in the air, and flying discipline was of the utmost importance. At the same time discipline had not to be too strict. Good living conditions, adequate recreational facilities, games, and suitable periods of leave were factors contributory to maintaining a good morale; domestic anxieties often contributed to a mental breakdown.

In those who had to fly much over the sea the length of trip was an important factor; the monotony and, when flying at low altitudes, the strain of flying, as the automatic pilot could not be used, added to the fatigue and anxiety.

Though there were many factors of stress which might affect an aircrew the most important element was the emotional tension resulting from the prolonged exercise of courage.

(iv)

Psychiatry in the Emergency Medical Service

By AUBREY LEWIS
M.D., F.R.C.P.
and ELIOT SLATER
M.D., F.R.C.P.

EXPECTATIONS

After the abortive settlement of Munich in 1938, competent observers thought it desirable to make provisional plans for the care of the civilian population should war occur. These plans reached fruition in the Emergency Medical Service, which was actually instituted before the declaration of war on September 3, 1939. The danger to the civilian population was expected to come in massed air raids by bombing planes on the great cities, especially London, within a day or two of the outbreak of the war; heavy casualties in killed and injured were anticipated, together with an outbreak of hysteria, anxiety neuroses and other acute neurotic reactions. Psychiatric experience in the Spanish Civil War had attracted considerable notice, and a lesson was mistakenly learnt from the Spanish finding that, under intensive raids from the air, there was as much disablement from neurotic breakdown as from physical injury. Hospitals were therefore mobilised on the periphery of the great cities to care for civilian casualties of both types, and staffed with psychiatrists as well as physicians and surgeons; and ambulance services were built up to feed these hospitals. Hospitals in London itself were emptied of a proportion of their patients. It must be emphasised that the E.M.S. dealt with psychoneuroses, not with psychoses.

THE PHONEY WAR

The expected air raids did not occur; and the hospitals intended for civilian casualties remained for a month or two almost empty of patients. It was decided that they should not be used for normal civilian purposes, but a small proportion of the beds was made available to Service personnel. As time passed this proportion was increased, until most of the E.M.S. hospitals came to be occupied almost up to their full capacity with soldiers and airmen, retaining only a few wards for civilians. In some places the hospital had medical and surgical as well as psychiatric wards; in others, as for instance at Mill Hill, the hospital became a purely psychiatric one.

Whereas the problems of neurosis among civilians never approached even remotely the proportion which had been originally expected, their extent in the combatant Forces soon became evident. With mass conscription, men were embodied, especially into the Army, who broke down with neurotic symptoms almost at once. Almost every unit found that some of the men to be trained were incapable of becoming useful soldiers, and the problem of their disposal soon became a serious one. An increasing flow of patients of this type began to pour into the beds of the E.M.S. hospitals, to be cared for by civilian psychiatrists and nurses.

Clinical Experience

To most psychiatrists who had had only a peace-time experience of clinical work in mental hospitals, these men represented new experience. Although they contained a proportion of patients suffering from organic diseases or cerebral trauma, schizophrenia, pronounced manic-depressive or involutional affective psychoses, the numbers of these, the established and well-understood psychotic syndromes, were an almost negligible proportion of the whole. Furthermore, the anxiety states, hysterias and other neurotic reactions did not conform in all respects to the familiar peace-time pattern. The proximate cause of breakdown was evident enough—the dislocation of normal life by the war and calling up into the Forces. The nature of the stress was the same from case to case; separation from wife and family, Army discipline, a life of strenuousness and hardship, and the learning of new and unaccustomed occupations. But these were clearly a small part only of the totality of causative factors, and the importance of constitutional elements had to be ranked high. Many of the men had long histories of mental instability, of recurrent unemployment, of previous nervous breakdown; their family history showed other relatives similarly affected and the early history contained reports of nervous symptoms in childhood. In a considerable proportion there was evidence of a dull or sub-average intelligence, and in a smaller one a record of minor criminality or anti-social traits.

The clinical pictures exhibited did not fit cleanly into the recognised neurotic syndrome, in which the symptoms are usually pronounced and of some duration before psychiatrists see them; in the same patient there would be evidence of hysteria, anxiety, depression, and of a paranoid and resentful attitude. A large number were found to suffer from symptoms which might have been attributed to physical disease but were really symptoms of mental ill-health; dyspepsia, and tachycardia and breathlessness on exertion were conspicuous examples of this. In the War of 1914–18, D.A.H. (disordered action of the heart) had been a common cause of invaliding from active service: Thomas Lewis had studied the condition and called it "effort syndrome". Early in 1940 it was decided to set up at Mill Hill Hospital a special unit for the study and treatment of effort 'syndrome'. In systematic psychological and physiological investigations it was demonstrated that the condition was a neurotic one and that the term 'effort syndrome' covered conditions better described by the usual psychiatric diagnoses. The mental state of many of the patients indicated an affective disorder in which anxiety and depression were responsible for conspicuous vegetative symptoms. The physiological response of those patients to effort was investigated; the oxygen uptake, lactate rise and pulse area after exercise on a bicycle ergometer, were measured and the response of the patients found to be less satisfactory than that of normal healthy persons of the same age. The oxygen-uptake figures indicate that poor exercise response is an attribute of neurotic patients in general.

The differences between patients with 'effort syndrome' and the normal controls were more evident when from among those with 'effort syndrome' there were isolated those who had a long history of poor exercise response, to which they had reacted by developing an invalid's outlook in the arrangement of their lives, so that they avoided heavy physical work, believing themselves to have some vague organic disability of the heart or lungs. These patients showed significantly higher pulse rise and decrement of lactate rise after standard work than the normal controls, and also differed in these respects from those patients with 'effort syndrome' who had shown no neurotic predisposition or avoidance of physical effort in earlier life, and whose symptoms had been brought on by understandable emotional difficulties during the war. Metabolic studies on these patients suggested that persons with 'effort syndrome' give up exhausting physical work before they have reached the physiological end-point which would be attained by normal persons in similar circumstances; they have what amounts to an 'effort-phobia'.

The treatment of the 'effort syndrome' patients on psychiatric lines in a special unit yielded fairly satisfactory results, similar to those obtained in other parts of the hospital dealing with neurotic soldiers.

Theoretical Interpretations

The clinical experience gained with these men brought about a change in the prevailing attitude towards neurotic reactions. Before the war, neurotic syndromes such as hysteria, anxiety neurosis and obsessional neurosis were sometimes regarded as fairly well defined types of illness, although it was recognised that on their periphery there were numerous illnesses which did not fit so well into a single pattern and showed a mixture of symptoms attributable to different forms of neurotic disorder. The specificity of the neurotic illnesses was often accepted as roughly equivalent to that of schizophrenia; for instance, investigations were even staged to discover the specific genes responsible for 'hysteria'. But in the war-time material it was found that there were many more mixed than 'pure' cases; signs of more than one mode of reaction might be found in nearly every individual patient. Nevertheless the evidence pointing to a constitutional diathesis still predisposed clinicians to think of a qualitative distinction between the normal members of the population and those who broke down under the stresses of war-time.

Practical Problems: Treatment

Treatment was obviously a matter of considerable difficulty. Individual psychotherapy on an adequate scale was out of the question when the number of patients was related to the number of available therapists. An effort was made to begin psychological treatment with groups of patients. In Wharncliffe Hospital, near Sheffield, Rickman organised a unit for the special training of neurotic soldiers along 'paramilitary' lines. Men of better calibre were given honorary non-commissioned rank within the hospital and entrusted with the organisation of groups for training in military strategy, grenade throwing, the use of terrain in mock battle, signalling, and so forth. The main purpose was to improve morale, to re-establish personal confidence in men who had proved failures under less individual and less psychiatrically controlled methods of training, and to return as large a proportion of patients as possible to active service.

A development of group therapy along rather different lines was begun at Mill Hill Hospital by Maxwell Jones, who combined group explanation and discussion with dramatic presentation of prevailing conflicts.

Disposal

However, despite all such efforts, a large proportion of the psychiatric patients who came into E.M.S. hospitals at this stage in the war because they were misfits in a military machine, had to be discharged from the Army on medical grounds. Medical Boards were established at the E.M.S. hospitals, with their own clerical staffs under a military registrar, who was given an establishment for maintaining the discipline of the military patients. The military staff, which could include an education officer, made it possible to organise entertainments, classes in adult education, working parties, and other features in the day-to-day life of these mostly able-bodied patients, which greatly helped in the development of a healthy atmosphere. This was a matter of great importance from the beginning, as the presence in a hospital of large numbers of patients believing that they might shortly be returning to civilian life tended to produce a general air of laxity or dissatisfaction, as well as resentment in some of the patients who knew they would have to resume their military service. In the course of the next year arrangements were made by which the proportion of men whom it was necessary to discharge was much reduced, though this proportion varied appreciably from hospital to hospital.

THE DUNKIRK EXPERIENCE

In the early summer of 1940, after the defeat of the Allied Armies in France and the evacuation of a large part of the British Army from Dunkirk, there was a rush of admissions to the E.M.S. hospitals of patients of a different type. Clinically they showed acute and severe neurotic states which had come on abruptly after intensive air bombardment, forced marches, hunger and deprivation of sleep. Physically they were reduced, with thin, fallen-in faces and sallow complexion; the expression was one of intense anxiety; functional tremors and even a mild parkinsonism were common. Loss of memory for the recent critical events was common, and some men had hysterical twilight states, convulsive attacks or other signs of dissociation. Nearly all were subject to disturbed sleep and nightmares.

Treatment was given along the lines suggested by Mira's work in the Spanish Civil War, i.e. it was directed towards providing rest, adequate sleep and physical restoration. Continuous sleep of up to twenty hours a day for a week to ten days was found invaluable in the graver cases, and the technique of giving sleep by barbiturate drugs was greatly improved. Thereafter treatment along individual and group psychotherapeutic lines was helpful.

Theoretical Interpretations

The effect of this experience on the clinician was salutary. Many of the men who thus broke down lacked the signs of constitutional instability which had been so prominent in the earlier patients. So far as could be seen they represented a sample of the average population. The stress factor was abundantly in evidence, and this stress was seen to have been as much physical as emotional. Old lessons, which had been partly forgotten, were learned and emphasised anew. It was evident that the *psyche* could not be separated from the *soma*, and that the events which affect an individual have their physiological and their mental aspects. Both deserved close study; neither could be ignored in treatment.

The significance of the constitution was seen in a different light, as an endowment that varied in subtle degrees from individual to individual and, in so far as it could be seen as a capacity for resistance to stress, it had to be considered in quantitative terms. Degree of stress, too, had to be considered quantitatively, and between stress and constitutional predisposition there was a reciprocal relationship: the greater the one, the less might be the other. The neurotic reaction was the product of the two, and its nature, i.e. the preponderant symptoms observed, was determined both by constitution and by stress. Persons of neurotic or 'psychopathic' disposition had to be seen as only a special selection of the average population; and the difference between individual and individual conformed to the usual laws governing human variability. The whole field of the neuroses and psychopathies could thus be viewed not so much as a problem of pathology but rather as part of normal physiology and psychology.

Progress towards treatment

In addition to the modification of views on aetiology, treatment was seen in a new light. The observation that physical exhaustion predisposed to neurotic breakdown, that men with neurotic illnesses showed also signs of physical impairment, and that improvement in one aspect was associated with improvement in the other, all suggested that patients might be helped by physical methods of treatment. In many of the men who broke down under enemy action there was considerable loss of weight; and if their physique could be re-established, it seemed that the improvement obtained by sleep treatment and by rest could be increased and further secured against the liability of relapse. A modification of the method of producing hypoglycaemia by the injection of insulin, which had already been used for some years in the treatment of schizophrenia, was found to be useful. This came to be known as 'modified insulin treatment', and consisted in giving only sufficient insulin to cause a soporose state (not coma as with schizophrenics), which was interrupted after two hours by a sweet drink and a large breakfast. A great increase in appetite and rapid gains of weight were obtained in this way, but also an improvement in residual anxiety symptoms and other mental signs of incomplete recovery. This, like other forms of active treatment, was helpful in maintaining ward morale.

FIVE YEARS OF WAR

In the succeeding years the pattern of work changed but little in the E.M.S. hospitals, though their staffs developed lines of special interest, e.g. in out-patient work with adults or children. Towards the end of 1940 and in 1941 London and other cities experienced a succession of heavy air raids. They came a year later than had originally been expected, but they never caused the epidemic neurosis in the civilian population which had been anticipated. In the hospitals themselves the reactions of neurotic patients, however, were sometimes extreme. Some of the men being treated for anxiety neuroses would leave the hospital, and camp out in shelters provided for the civilian population, or in open spaces. Hospital morale and hospital discipline were at first maintained only with difficulty.

During this time, as in any body of people subjected to severe stress, there were individual cases of breakdown in civilian security personnel, in the fire-fighting and ambulance services for instance, and among other people experiencing a narrow escape from injury by a bomb explosion. These patients were treated in the E.M.S. hospitals, but did not differ clinically or in their reaction to treatment from Service patients. But their number never became a serious problem and, all things considered, remained remarkably small.

The immunity of the civilian population at large was a subject for considerable surprise, and led to an inquiry into the general incidence of neurotic illness in the population before and during the war. It was found that severe neurosis hardly occurred as a war phenomenon, except in people who had been neurotic before the war; when neurosis developed or was aggravated during the war, war stress was responsible for this in one-quarter of the previously healthy, and in one-fifth of those with previous neurotic history; recovery or great improvement was the rule in those who had not already shown neurotic disorder before the war.

The incidence of neurotic illness was low in fire-fighters and other workers in civil defence. The number of persons admitted to mental hospitals did not increase, although more persons with senile deterioration were admitted to mental institutions than previously, because their relatives could no longer look after them, and because the air raids had disturbed their routine or their precarious adaptation. There was no increase in alcoholism, such as some had anticipated on the analogy of previous wars, but there was an alarming rise in juvenile delinquency, which could be attributed to the environmental changes, particularly in the immediate family and in parental control, which the war entailed. Studies in a London general practice and in a heavily bombed area amplified these findings.

The Placement of Personnel

Disposal problems came to occupy the first attention of clinicians as well as administrators. The position was a serious one. It was estimated that in the Army about 1 man in 65 could expect to be admitted to hospital for a neurotic illness during any one year, and of these the majority could expect to be invalided from the Service. On the one hand there was the need to keep in the Service every man who was capable of doing useful work, on the other hand, to cut out dead wood and to prevent the inefficient from impairing the efficiency of others. Clinicians were generally agreed that many of the men were capable of useful work, even when they were no longer capable of front-line duty; and to save wastage it became necessary to set up a scheme by which a man might be marked as fit, on psychiatric grounds, only for duties of a special or limited type. The need for this had become painfully apparent to psychiatrists in the E.M.S., and by February, 1941, it was possible to put an array of instances and some statistics before the Director of Organisation at the War Office, who then instituted a jointly agreed procedure for altering the military employment of suitable soldiers with neurotic illness. This procedure, often called the 'annexure system', remained a valuable means of utilising the judgment of the psychiatrist in placing soldiers who had broken down, so that after treatment their services might be used to military advantage.

In 1944 a review was made of 1,500 soldiers and 170 women of the A.T.S. who had been dealt with in this way at Mill Hill Hospital. It was found that the method had been employed actively; thus, of all patients admitted with 'effort syndrome' during 1942, 35 per cent. were returned to duty through this procedure, 24 per cent. returned to their former unit through the normal channels, and 41 per cent. were discharged from the Army. After the introduction of the scheme, a higher proportion of men was returned to military duty than during the six months before it had been introduced.

At this hospital a concomitant scheme for providing engineering and clerical courses at a technical college, for patients during the six weeks of their hospital stay, permitted a closer study of their occupational suitability and the likelihood of their being fit for further military duty. This occupational scheme reinforced the more clinical methods on which the psychiatrist had relied in making his recommendation for the soldier's disposal. A follow-up inquiry of a large sample of the patients thus dealt with showed that during the twelve months after they returned to military duty, more than half continued to carry out their military duties efficiently. This occupational arrangement had particular interest, since it played an important part in the treatment of the patients while in hospital, and in addition showed the value of psychological tests and of the opinion of skilled instructors in assessing occupational fitness.

The Morale of the Soldier

As in the War of 1914–18, it was found that morale was best near the front line, and the further back towards the Base one went, the worse it became. Between Dunkirk and the Battle of France of 1944, the E.M.S. hospitals were in the position of being Base hospitals, and morale was always a serious issue. On their side, the Army authorities made arrangements for the treatment of neurotic casualties as near the front line as possible, and established field rest-centres where a man might for instance receive even twenty-four hours' continuous sleep, and then return to battle. Behind the field centre there were other camps and hospitals, at each of which treatment might be given, and disposal made either forwards or backwards towards the Base. The further the patients got away from the front, the more likely it became that the man had eventually to be discharged still further back. The patients who eventually reached the E.M.S. hospitals in Britain were, under these conditions, not a selection likely to respond rapidly to remedial measures. In hospital they saw many of their comrades being invalided out of the Army for psychological symptoms, and knew that they could look forward to the same release if only they could be regarded as equally sick themselves. This tended to foster the exaggeration of complaints, and the development of a resentful attitude in those who felt themselves to be less favoured than others.

An experiment in combating the spread of this spirit was begun at Sutton Hospital. This hospital took over the control of a second 200-bedded hospital some two miles away in a rather isolated position in extensive grounds. All patients admitted to Sutton were sifted in the course of the first few days, and those with a good prognosis for further active service were transferred to the secondary hospital. Here every man knew that he was to return in due course to military duty, and the general acceptance of this promoted good morale. An active and co-operative spirit was further encouraged by an active daily routine, varied much to suit individual needs, together with a generous allowance of leisure and leave. Extensive use was made of the 'annexure scheme'. Few of the patients, however, were returned to service oversea or in theatres of war. In the few instances, where prolonged observation and treatment showed that invaliding would be necessary, the patients were not 'boarded' at the hospital itself, but returned to the parent hospital at Sutton for the purpose. Although there were many administrative difficulties, the scheme was a success on the whole. It would have been better if the sifting could have taken place at transit hospitals, and if certain Base hospitals had been set aside for patients likely to be invalided, while other hospitals were reserved for more hopeful cases.

Patients from Distant Theatres of War

The E.M.S. hospitals had to cope with considerable numbers of patients returned from North Africa and from India and Burma. The problems they offered were similar to those seen in the general run of patients. Nevertheless, two types of disorder were particularly numerous. The first of these was the combination of neurotic and physical disabilities; in patients from the Far East the late results of tropical illnesses, dietary deficiencies, and other organic factors played a considerable rôle. Some of the E.M.S. hospitals, such as that at Sutton, still had a general as well as a psychiatric side, with a staff of physicians and surgeons; this arrangement was found most helpful in dealing with problems of this combined type.

Here is perhaps an appropriate point at which to say something of a group of patients in whom organic and neurotic disabilities were often inextricably mixed—those with head injury. Head injuries were, of course, extremely common; but where there were signs of gross cerebral damage the condition was commonly dealt with in specially staffed hospitals. The patients seen in E.M.S. hospitals were largely those in whom there was no demonstrable lesion, but whose history included a fairly severe concussion or a mild cerebral contusion, and whose clinical findings were often, on a superficial view, neurotic—headaches, lassitude, anxiety, depression and hysterical manifestations. Examination of the illness as a whole might show that the head injury had brought about a change of personality, with perhaps slight traces of cognitive defects, but with an enhanced susceptibility to emotional reactions and neurotic symptoms as its main manifestation.

The second type of problem found with unusual frequency in the oversea patients was that of the man who had reason to believe his wife had been unfaithful during his absence. News of this sort, conveyed by the wife herself or by well-meaning relatives, often had a disastrous effect on the morale of the soldier oversea, and could be a direct cause of depression or other neurotic illness. It was a much commoner problem in Army than in R.A.F. personnel, owing to the longer tour oversea called for by the Army. Problems of this kind, as they arose in the Base hospital in Britain, needed the active co-operation of the psychiatric social worker, but even so they often proved incapable of any satisfactory solution.

Clinical Research

The experience of these four years provided an encouraging background for clinical research. Psychiatrists were stimulated by the problems posed by the mass psychological experiment of war. They were insistently confronted with the problem: What is the nature of the difference between one man and another which leads the one into a neurotic illness and, under identical strains, spares the other? Something has already been said on the revised theories of the nature of the constitutional make-up of the personality, and the significance of hereditary factors. Related to this, a considerable advance could also be made along psychological lines. Owing to its possession of an active psychological department, Mill Hill Hospital was able to carry out extensive work on the correlation of clinical findings and the results of more exact psychological tests. This work, as it progressed, threw light on many fundamental as well as technical problems in the objective evaluation of personality. The scientific advance represented by these studies could not have been made so rapidly, or on such a scale, if it had not been for the profuse clinical material which the war-time conditions afforded at this E.M.S. hospital.

An approach along different lines was made by the use of the electro-encephalograph. This machine at the beginning of the war was still in an experimental stage of technical development, and had been principally used for the examination of epileptics and of those with focal cerebral lesions, such as cerebral tumours. When neurotic patients were examined by this means, it was found that a rather higher proportion of them than of the average population showed abnormalities of a non-specific kind. However, men of a markedly psychopathic temperament, particularly those liable to aggressive outburst and mood changes in which aggression and irritability were prominent, showed a very high incidence of these non-specifically abnormal patterns. Research, stimulated in this way, developed in various directions; such as the relation of aggressive types of personality to the epileptic constitution, the concept of cerebral maturation, and the effects of physiological stress (such as variations in blood *p*H or glucose level) on the electrical responses of the brain.

THE BATTLE OF FRANCE

With the invasion of Normandy in 1944, E.M.S. hospitals in the neighbourhood of London were partially evacuated and their psychiatric staff distributed to other centres. The main part of some of these hospitals was handed over for the care of the wounded. Nevertheless, a skeleton staff remained to make in due course a useful contribution to the treatment of the psychiatric symptoms which may complicate bodily injuries. As was expected, acute neurotic syndromes appeared in considerable numbers of the men engaged in the very heavy fighting that followed. Accommodation for these men was provided in the first place at Southport, and later in a special unit at Chichester, to which the patients could be flown from France almost directly.

Constitutional factors again showed up; many men who broke down in the first week or two of hostilities were burdened with signs of a previously ill-adjusted personality, or had residual symptoms of earlier neurotic reactions to previous experience of warfare. As the weeks followed, constitutional factors receded into the background, and the men who came for treatment were predominantly those who had been subjected to unusually severe or prolonged stress.

Further Progress in Physical Treatment

At the Chichester centre interesting work on the treatment of these acute syndromes along abreactive lines was done. This work, which derives its original inspiration from the early experiments of Breuer and Freud, and the procedures employed by Bernard Hart and his associates during the War of 1914–18, is connected closely with the neurophysiological theories of Pavlov and his school. Earlier in the war it had been frequently observed that a marked improvement of symptoms occurred during the sedative treatment of patients with acute symptoms, or in hypnosis or the psychotherapeutic exploration of the past history (with or without the help of intravenous barbiturate) if, during the recounting of the traumatic experiences of the past, the patient became excited and an explosion of affect followed. Treatment had been directed in part towards encouraging the patient to regain his lost memories and, facing them in the secure atmosphere of the hospital, to make a more consciously controlled adaptation to them. The observation that the explosion of affect was itself beneficial suggested the trying out of measures to provoke it. Therefore, instead of using a sedative drug such as amytal or pentothal to dull the patient's consciousness, an exciting drug like ether or nitrous oxide, given by inhalation, was tried; Palmer had lately been using ether actively for the treatment of neurotic illnesses in the Army in North Africa. In these investigations the patient, called on by the doctor to recount his experiences, began to re-live them in a highly dramatic manner, imagined that he was at that moment surrounded by the enemy, climbing out of a burning tank, or in whatever other set of circumstances he might have gone through at the time of his breakdown, and passed thereon into a state of mounting excitement. This proceeded to a climax, abruptly terminated by a general inhibition, in which the patient was for a few seconds totally unresponsive, this state being itself succeeded by returning clarity of mind and sometimes the immediate subjective experience of freedom from symptoms. Hysterical symptoms, such as tremors, mutisms, amnesias, etc., sometimes responded to these methods when they had failed to react to simpler suggestive or other methods. For this Sargant put forward an interpretation along Pavlovian lines. The original stimulus which had occasioned breakdown was, he considered, a supramaximal one which had initiated mentally some dissociation of consciousness, and physiologically the isolation of some neuronic centres from the general pattern of brain activity. These centres either remained inhibited (if the phenomena were of a negative kind such as an amnesia or a mutism) or responded with a stereotyped activity of their own (as in a tremor). Only the submission of the patient to a second supramaximal stimulus, under controlled conditions, could break through the barrier and re-establish complete cerebral integration.

By the use of this and other methods—such as continuous narcosis for the acutely anxious, modified insulin treatment for the physically deteriorated, and for the convalescent psychotherapy by suggestion, explanation and reassurance, and occupational therapy in its widest sense—it may be said that the treatment of the acute neurotic casualty of war achieved much success.

Whereas after the Dunkirk experience, considerable numbers of patients continued to come into hospital for neurotic symptoms which had first appeared months or even years earlier, but had never been successfully treated, the number of residual cases of this type after the battles in France in 1944–5 was remarkably small. Credit for this must be given to the efficiency of psychiatric services in the field, and the rise in hopefulness and confidence prevalent at this stage of the war.

THE END OF THE WAR

Towards the end of the war a small but increasing number of patients was referred to E.M.S. neurosis hospitals by the Ministry of Pensions, because of neurotic symptoms which had persisted after invaliding from the Forces and caused some disability in civilian life. It had been decided early in the war that neurotic syndromes could not be regarded in general as attributable to war service when there was a history of antecedent symptoms and constitutional predisposition; this decision, which applied to a high proportion of neurotic casualties, reduced the tendency to chronicity which is likely to arise where compensation becomes a prominent issue. Public opinion, however, as expressed both in Press and Parliament, went against this decision, and it had to be reversed to a substantial extent. Nevertheless, the 'pension neurotic', as far as can be judged at present, will probably not be such a large-scale problem after the Second as after the First World War. Apart from the decision already mentioned, which was operative for several years, and apart from the beneficial effect of improved methods of treatment given when the neurotic reactions were still fresh, social factors, especially the general industrial situation, were also to be thanked. Full employment, even for those still subject to minor symptoms, provided the circumstances in which recovery was most likely to be early and complete. The measures instituted by the Government for the restoration of disabled persons to working capacity and health played a large part in this.

The Returned Prisoner-of-War

Another problem in chronicity was raised by prisoners-of-war who returned to this country after the collapse of Germany and the later surrender of Japan. The number of these who had developed symptoms during the long period of their imprisonment, as well as those who had never recovered from symptoms which first came on before they were made prisoner, was so considerable that special centres were set up for their treatment and rehabilitation. An active centre for this purpose, making use of group therapy and vocational guidance on a large scale, was set up at Dartford, as an offshoot of Mill Hill Hospital. It proved successful, and its experience and staff provided the basis on which, in due course, a similar centre was set up at Sutton Neurosis Hospital, under the auspices of the Ministry of Labour, for peace-time civilian purposes.

SURVEYS

In 1943 an initial study had shown that of 120 soldiers treated in a neurosis centre and subsequently discharged into civilian life, an alarming proportion had not recovered their health or become capable of doing useful work; some of them were also socially unsatisfactory; for example, they were delinquent or excessively quarrelsome and disturbing.

A systematic investigation was therefore instituted by the Ministry of Health and entrusted to Dr. Eric Guttmann. A sample of 382 such men discharged from the Army during the first three months of 1943 was taken, in such a way that the sample would reflect regional differences. It was found that these men had had considerable difficulty in readjusting themselves to civilian life, and that even fifteen months after they were discharged they still showed a high incidence of neurotic complaints and illness. They showed a high rate of absenteeism due to sickness after they had returned to work; they changed jobs frequently and they were not happy in their private lives. Three-quarters of the men had had marked neurotic traits before their enlistment and more than half had complained of physical ill-health before joining the Army; since leaving it, three-quarters of them required medical attention during the ensuing fifteen months, and many more wished to receive psychiatric care than had been able to get it.

Another important survey was carried out for the Ministry of Health by Dr. C. P. Blacker. The amount and adequacy of provision for the mental care of neurotic persons was ascertained in a thorough-going inquiry, which covered the whole country, and the desirable plan of a comprehensive mental health service was drawn up in the light of the analysed findings. The results of this survey have had far-reaching influence.

The extent of psychiatric disabilities in industry during the war was recognised to be a matter deserving exact study. Following on some small-scale inquiries, the Medical Research Council entrusted to Dr. Russell Fraser the conduct of a systematic investigation into this among men in light and medium engineering. His team of investigators produced a report which was the first reliable study of this sort based on adequate psychiatric and social investigation. It was found that in a sample of over 3,000 male and female workers, 10 per cent. suffered from definite and disabling neurotic illness and over 20 per cent. from minor forms of neurosis during the course of six months—the period chosen for study. Neurotic illness caused between a quarter and a third of all absences from work due to illness; it was responsible for the loss of 1·09 per cent. of the men's possible working days and 2·4 per cent. of the women's—a loss equivalent to an annual absence of three working days by every man studied and of six working days by every woman. These losses amounted to between a fifth and a quarter of all absences from work from whatever cause. The study contained a thorough analysis of many complex problems involved in any attempt to relate the findings to environmental, psychological and constitutional causes.

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CHAPTER XVI

DERMATOLOGICAL PRACTICE IN WAR-TIME

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THE most important feature of dermatological practice in war-time was the great increase in bed accommodation available for dermatological cases. Skin diseases stand high in the order of incidence of diseases in civilian and military spheres. In spite of this, allotment of hospital beds to dermatologists averaged 1–2 per cent., and with this negligible accommodation dermatologists in this country were at a disadvantage compared with their colleagues abroad who had ample facilities in hospitals of several hundred beds devoted entirely to skin and venereal diseases. So, for the first time in this country, dermatological units or centres were established in the Emergency Medical Service, and their value was abundantly demonstrated. It is beginning to be realised that the care of dermatological cases requires nurses and junior personnel with specialised knowledge. Unfortunately, the shortage of nurses in most hospitals has rarely made it possible to have more than one nurse, a Sister, specially detailed for the dermatological beds; the other nurses are usually changed rapidly before they have been adequately trained in the treatment and management of this type of case. More beds for these cases are needed, not only in order that full laboratory investigation may be carried out and that local and internal treatment may be given under supervision, but also because removal of the patient from the home environment and temporary freedom from anxiety may be of paramount importance.

Discussions are taking place about the institution of a special diploma in dermatology for intending specialists, and it is to be hoped that ancillary courses of training will be arranged for nurses and sisters, some of whom should be encouraged to devote themselves entirely to the nursing of patients with skin diseases.

SCABIES

Considerable advances in the treatment of this disease were made during the war, and were largely stimulated by the extra facilities available for in-patient treatment. The chief contributions came from the Services, where it was possible to treat large numbers of patients under close supervision with adequate controls. In the early days, when some dissatisfaction was expressed with the old routine treatment by sulphur ointment, extensive trials were made with derris preparations, 'rotenone', and certain organic sulphur preparations, but ultimately interest centred around benzyl benzoate. The original preparation of Kissmeyer—that is, equal parts of benzyl benzoate, soft soap and isopropyl alcohol—was found to be quick and satisfactory in its action (Lydon, 1941) but often irritating to delicate skins and badly tolerated by children. Emulsions of benzyl benzoate proved to be much less irritating, and ultimately the Ministry of Health recommended as a standard treatment the application of a 25 per cent. emulsion of benzyl benzoate with 2 per cent. lanette wax, and this was generally accepted as the most satisfactory method of treatment. Experimental work by Mellanby (1941, 1942) demonstrated that the risk of infection from clothing and bedding was slight, and in consequence the practice of disinfection was entirely abandoned by some authorities. Probably the pendulum swung too far, because, although the results from highly efficient centres of treatment were excellent, the incidence of scabies was not dramatically affected and many dermatologists held to their opinion that some attention to infected clothing was desirable.

Benzyl benzoate was adopted for routine use in the Army in 1942 for the following reasons: (1) it was efficient; (2) it enabled treatment to be carried out in units while the patient remained on duty; (3) its use obviated the enormous cost of providing special camp reception stations, with lavish hot-water supplies and beds where patients could be accommodated for a minimum period of three days (which was the period the old system using sulphur ointment required); (4) its use also obviated, in all but some 4 per cent. of cases, the provision of disinfesting apparatus, which was costly in material and damaging to blankets and clothing.

The Scabies Order, 1941, helped to deal with contacts in civilian life from whom the military often contracted the infestation.

The introduction of a soap containing 5–10 per cent. tetra-ethylthiuram monosulphide, largely as a result of the efforts of Professor R. M. Gordon, of Liverpool, promised to do much to prevent scabies, but his discovery coincided with the preparations for D-day (Normandy) and events moved too swiftly for the use of this prophylactic to be adopted.

Before the outbreak of the war, treatment of scabies by the method introduced by Kissmeyer (1937) was well established in the Royal Navy. The scabiecidal preparation used was a lotion consisting of equal parts benzyl benzoate, isopropyl alcohol and water. Later industrial spirit replaced the scarcer isopropyl alcohol, as suggested by King

(1940), and this lotion was eventually superseded by the National War Formulary emulsion of benzyl benzoate. The routine adopted was as follows: the patient was immersed in a bath of water at 100° F., anointed with soft soap and allowed to soak for ten minutes, the sites of the burrows being gently scrubbed with a soft nail brush. While still wet the parasiticide was painted on the whole body from the neck to the soles of the feet. This painting was continued for five minutes and the body was allowed to dry. The lotion was then again applied to the whole area and again allowed to dry on; clean clothing was then worn. Next day the patient had a hot bath, dried himself and dressed in his own clothes which, together with his blankets and hammock, had been disinfested while he had been undergoing treatment, and he then returned to duty.

The treatment of scabies by this method was easily carried out in large shore establishments and in big ships, but small establishments and ships had difficulty in dealing with the clothing, sterilisation of which was at that time thought to be essential in treatment, and cases occurring in ships and establishments without facilities for disinfestation of clothing were usually admitted into hospital. The cases of uncomplicated scabies remained in hospital for one day, being treated on admission and discharged the following day unless, in Royal Naval Hospital, Haslar, that day was a Sunday or the last day of the quarter, when no discharges took place, and the patient had then to remain in hospital an extra day.

From great experience with scabies during the war the following points, which were not fully appreciated previously, may be detailed: (*a*) blankets were not a common source of infection; (*b*) the sarcoptes was usually vulnerable and unless faced with a severe epidemic the disinfestation of bedding and clothing was not necessary; (*c*) 'silent carriers' were a definite problem; (*d*) in the Army the civilian population was the source of infection; (*e*) there was a seasonal incidence in scabies in the United Kingdom, the peak being in the first three months in the year, with an annual fall in the summer; (*f*) with proper treatment great rapidity in therapy could be achieved and men could be treated without having to go off duty; (*g*) accurate diagnosis was a matter of much greater difficulty than it would have been had junior medical men been more conversant with elementary dermatology—in the matter of differential diagnosis dermatitis herpetiformis was never considered by the average medical officer as an alternative to scabies, but the chief error lay in not distinguishing between eczematous eruptions, prurigo, pediculosis and scabies; (*h*) as in the War of 1914–18, ecthyma was a post-scabietic complication and often developed some days after the scabies was cured; (*i*) in the average case the patient was not teeming with parasites; (*j*) the incubation period might be as long as six or eight weeks.

PEDICULOSIS

At the beginning of 1940 the Ministry of Health issued a memorandum on the possibility that infestation with body lice might increase under war conditions. It was not then expected that public air-raid shelters would be used as dormitories, but when heavy raiding began many people made a practice of entering the shelters for sleep. Various measures were taken to minimise the risk of body lice spreading among the huge population of shelterers throughout the months of severe raids, but in the event there was never any serious increase of infestation. The subject was reviewed by P. G. Stock in a paper given before the International Conference of Physicians held in London in 1947. But while the position with regard to pediculosis corporis belied gloomy forecasts, head lice in town children presented a difficult problem from the time of mass-evacuation at the outbreak of war, and there was much inquiry and debate about the educative and administrative measures for controlling infestation in the reception areas.

Pediculosis capitis in entrants to the Women's Services caused much trouble. From certain industrial areas an average of some 65 per cent. of the girls were lousy. The introduction of lethane hair oil did much to solve this difficulty by giving those Army medical officers concerned a quick, reliable method of treatment, much superior to anything else then available.

Pediculosis corporis was, surprisingly, never much of a military problem, except among native civilian labour abroad and prisoners in concentration camps. In certain typhus centres (e.g. Naples), A.L.63 and D.D.T. were of great use in disinfesting the population without the necessity of undressing them.

Pediculosis pubis in men was only troublesome in a few military units. The A.T.S. appeared to be so free from this complaint, despite their incidence of head lice, that there was some debate whether women were relatively immune.

IMPETIGO AND THE PUS-COCCAL SKIN INFECTIONS

There was an increasing tendency to discard the ointment treatment of acute pus-coccal infections of the skin in favour of lotions, pastes or creams. The sulphonamides were used extensively, and the most effective preparation, up to the end of 1943, was sulphathiazole, 5 to 20 per cent. in a cream or paste (Peterkin and Jones; MacCormac, 1943). A suspension of 15 per cent. microcrystalline sulphathiazole was investigated because some reports claimed the cure of impetigo in one or two days with this preparation.

Further experience with the use of the various sulphonamide preparations as external applications in the treatment of impetigo and other pus-coccal skin infections showed that there was a very real risk in their use (Barber, 1944). Many reports, both from Allied military and civilian sources, showed clearly that unfavourable reactions might occur. These reactions varied from scarlatiniform, erythema multiform-like, urticarial, purpuric, varicelliform, vesicular, pustular, fixed bullous, exfoliative, and pemphigus foliaceous-like eruptions and might even resemble erythema nodosum or angioneurotic oedema. Probably the most serious risk, from the dermatological point of view, was the possibility of the skin being rendered 'light sensitive' by the external application of sulphonamide preparations, in the same way that it may be so affected by their internal administration. This condition is more likely to occur if the treatment is carried out in climates where there is much bright light or sunshine, and of course the risk will be greatly increased if the treatment is combined with the use of ultraviolet light. It is not certain, but it seems possible, that the use of X-rays may have the same unfortunate effect. This light sensitivity has a long-lasting effect; it may even be permanent, though cases have not yet been observed over a sufficiently long period to be certain of this. A case of fatal agranulocytosis was reported from Chicago following sulphathiazole therapy (*J. Pediat.*, April, 1943). It has also been shown by Park (1943) and others that unfavourable reactions to the external use of sulphonamides are likely to render the patient prone to similar reactions from internal use of the same drug in even minute doses. This may be a serious state of affairs if the patient subsequently develops a condition such as pneumonia or meningitis where the danger to life may only be controlled by giving a sulphonamide.

From this it would appear to follow that the sulphonamides should not be used in the routine treatment of such non-dangerous, self-limited and superficial infections as impetigo, folliculitis and other pus-coccal skin infections. There are other well-tried remedies for these conditions, though they may act rather more slowly.

In contrast to the skin complications which are so prone to develop after the sulphonamides it appeared at first that penicillin had no such disadvantages. While emphasising that the routine cases of impetigo and pus-coccal infection respond readily to simple and economical preparations, the occasional resistant case must be borne in mind. Excellent results have followed the application of penicillin cream containing 200 units per g. in an emulsifying base. Roxburgh (1944) used an ointment containing 400 units of calcium or sodium penicillin per g. of base, the latter being a mixture of equal parts of lanette wax S.X., petroleum jelly and water, and in a few cases a strength of 200 units per g., the base containing 50 per cent. of water and 25 per cent. each of the other ingredients. A cream containing 30 per cent. of lanette wax in water has also been used and it is considered likely that a cream will be found better than an ointment, for the reasons already stated. On the other hand, it is the experience of some dermatologists that local applications of penicillin cream are just as likely to provoke a contact dermatitis as are those of sulphonamide preparations; either penicillin itself or the base may be responsible. When pus-coccal lesions recur after cure, and especially if they are associated with deeper infections, such as boils, intramuscular transfusion of penicillin solution is found very effective. Supplies of penicillin only became available for experimental use in E.M.S. hospitals in the latter half of 1944, so that civilian experience with the drug was much more limited than that of the Services.

The aniline dyes were greatly used in pus-coccal infection, acriflavine, gentian violet and brilliant green being the most popular. But aniline dyes in the treatment of infections of the face were largely discarded when it was realised that the psychological effect on the patient was deplorable.

The careful observation of patients, and of the details of their treatment necessitated by experimental work with new drugs, may well account for no small part of the success obtained, and it is likely that many new applications may be discarded when they are used more casually in general practice.

In almost every theatre of war in hot countries, ecthymatous sores were a constant trouble and caused much discomfort, a serious loss of efficiency (especially among armoured-vehicle personnel), and some sick-wastage. These lesions were variously described under geographical names, which led to confusion in accurate diagnosis; thus the whole Desert Army knew of 'desert sores', and the men in Burma of 'jungle sores'. The aetiological factors appeared to be loss of resistance of skin devitalised by exposure to sun, wind and dust, so that at the site of minor injuries, painful ecthymatous sores developed. These sores usually developed on exposed parts. The introduction of sulphonamides, and later of penicillin, helped to obviate the enormous sick-wastage which had occurred in the War of 1914–18, though injudicious use of local sulphonamide treatment not infrequently led to sensitisation. On the advice of Lt. Col. B. C. Tate, attempts were made to issue a cold cream to the troops as a prophylactic agent, for he and the hygiene officers believed that if the undue dryness of the skin caused by sun, wind and dust were relieved, the incidence of desert sore would drop. But the battle of El Alamein led to such a fast advance that the cold cream never reached the units where it was most needed.

With reference to the use of micro-crystalline sulphathiazole, a clinical investigation with statistical control showed that in men it was the quickest method of treatment known—before penicillin was widely available—but carried a slightly higher hazard of dermatitis than the ordinary form of sulphathiazole.

Much research was done in the Army by Sheehan, Fergusson, Bigger, Hodgson, Stuart Harris, Kendal Dixon and Twiston Davies (see

Quart. J. Med., 1945, **56**, 183, and *Lancet*, 1943, **1**, 544 and 547) concerning the aetiology and treatment of impetigo. Considerable doubt arose as a result of these researches, taken in conjunction with earlier work, as to whether impetigo was in fact caused by streptococci or staphylococci. The last three writers emphasised the importance of the skin and nose as carriers of pathogenic organisms. It was found that there was much confusion in distinguishing between impetigo and seborrhoeic dermatitis, and therefore the introduction of penicillin—in the belief that it would stop the sick-wastage from so-called impetigo—was not so advantageous as was at first hoped.

RINGWORM INFECTIONS

A general increase in the incidence of ringworm infections, particularly of the scalp, was observed during the war. In some areas epidemics of infection occurred in certain schools, and, in one group of cases in the Birmingham area, difficulty was found in eradicating the infection, because some of the children were regarded as too young for X-ray treatment and were treated ineffectively with thallium acetate. Cochrane Shanks (1931) has shown that, with a restrictive appliance, no child is too young for X-ray epilation and this should be more widely known, because it is generally admitted in the British Isles that ringworm of the scalp is more readily cured after X-ray epilation than after epilation with thallium acetate, but insufficient attention has been paid to the treatment of the epilated scalp. Although the X-ray technique had been correctly applied, the result was marred by inadequate instruction to the parents, who should manually assist epilation when the hair begins to fall. The failure of well-directed local therapy also accounted for many relapses after treatment, and the tendency to depend too much upon X-ray epilation has had an unfortunate effect.

There was a considerable increase in scalp ringworm in London, probably due to the effect of evacuation and the return to the City, for it would appear that no determined attempts were made to eradicate tinea capitis among rural populations. Owing to shortage of school medical officers and to some disorganisation, the return of evacuees to London was followed by a marked rise in the incidence of scalp ringworm in the metropolitan area. Another point of interest, raised by a school medical officer, was the necessity for at least three negative examinations with Wood's light before accepting a cure in the case of ringworm of the scalp. Spores may persist in some of the follicles unless treatment to the bald scalp has been vigorous, and, as the hair reappears, re-infection may occur and become manifest after a negative examination with Wood's light. No notable advance was made in the local treatment.

Many more cases of ringworm due to infection from domestic and farm animals were seen, and this was not unexpected because, for the first time, large numbers of volunteers worked intermittently on the farms. Ringworm of the body did not show any appreciable rise in incidence among the civilian population. It was noted for the first time by military dermatologists that tinea cruris, common in men, was very rare indeed in women. Tinea cruris frequently caused incapacity from sepsis and maceration in unacclimatised troops in hot countries. Tinea tonsurans was a considerable problem in Gurkha troops, the fungus probably being an animal type of microsporon, for it was reported that many cases were cured by the use of Whitfield's ointment alone. Tinea circinata was a frequent and discomforting complication of prickly heat in S.E.A.C. and India, the lesions being particularly troublesome at the level of the waist. Tinea pedis was diagnosed with great frequency in the Army, despite the efforts of dermatologists to indicate that more eruptions between the toes are caused by maceration and low-grade infections of many varieties than by epidermophytosis. The work of Bentley Phillips and others indicated that, when used by an expert under controlled conditions, applications of camphor-phenol were a rapid and satisfactory method of treatment.

The diagnosis 'epidermophytosis' had a loose meaning in the Royal Navy, and included nearly all forms of excoriation, vesiculation and pustular eruptions found on the feet and hands. During the war the incidence of skin lesions of the feet among ratings serving in ships and ashore in tropical climates was at times almost 100 per cent., and in very few ships did the incidence remain below 50 per cent. Among the large body of men affected a considerable number became incapacitated to such an extent as to require hospital treatment and later invaliding to a temperate climate. A certain number of those invalided home were found unfit to continue service in the Navy, even in cool climates.

DERMATITIS VENENATA, INCLUDING DERMATITIS IN WAR INDUSTRIES

Although many of the industrial processes in war economy entailed contact with skin-irritants, the problem of occupational dermatitis was much less serious than had been anticipated. Much credit for this was due to the central administration of the Home Office and Ministry of Labour during the war; also to the many medical officers who, for the first time in history, were attached to the larger factories. Under their supervision, better facilities for cleanliness were installed, and a wide range of barrier creams were employed for the workers' protection. There is little doubt that these substances did much to prevent the incidence of occupational dermatitis. In addition, forced-draught extraction of fumes and dust, adequate ventilation and protective clothing did much to reduce the incidence of occupational dermatitis.

Trouble arose in a few instances in the Army from sensitisation to accelerators and anti-oxidants present in the rubber facepieces of respirators. This was overcome by issuing special rubber facepieces to those proved to be sensitive to the rubbers concerned. Sensitisation to battle-dress and woollen clothing caused some difficulty. Usually this sensitisation was not due to chrome dyes. The full aetiology of this matter was investigated by several experts, but the problem was not solved by the end of the war. (See *Brit. J. Derm.*, 1944, **56**, 33.)

F. F. Hellier, Adviser in Dermatology to B.L.A., noted, shortly after D-day (Normandy), a number of cases of dermatitis having a very definite distribution, which appeared to be due to some allergen in the men's shirts. This matter was investigated at Porton, but the results were not conclusive. Possible interaction between some soap or detergent used in the field laundries and D.D.T., with which the garments were impregnated, may have been a cause of the eruption. Dermatitis venenata occurred in personnel engaged in spraying with D.D.T. The majority of these cases were due rather to the kerosene solvent than to the D.D.T. (The mixture used was D.D.T. 25 per cent. in kerosene.)

It was found for military record purposes that 'Dermatitis-Contact (X)' was the most convenient form of appellation for dermatitis venenata, for this indicated at once the disease and the suspected nature of the allergen. (Included in parenthesis, and indicated above as X, was the name of the irritant.)

A certain number of diesel-oil dermatoses occurred in petrol companies and armoured and other vehicle units.

ECZEMA AND DERMATITIS

Some of the most obstinate cases belong to this group, and they undoubtedly make undue demands upon hospital beds. The probable reason is that most of these cases are true eczema, which is essentially the reaction of a hypersensitive skin. Since hypersensitivity of the skin can be induced by continued exposure to the lesser irritants, many cases arise from contact with Service clothing, and although the patients may recover fairly quickly in the first attack, recurrent attacks on wearing uniform are apt to be more chronic and may eventually prevent the individual from continuing in that particular duty. When the eruption was provoked by some external agent it became the established custom to call the reaction 'dermatitis', and this perpetuates the confusion which exists in dermatology between dermatitis and eczema. Consequently the term 'eczematous dermatitis' is often employed to bridge the gap, but for practical purposes sensitisation dermatitis is synonymous with eczema. The difficulties of treating the latter when well established, and its marked predisposition to relapse, accounts for the prolonged stay in hospital required, and it is thought that special rehabilitation centres would provide the best solution to this problem. Certainly it is unsatisfactory for patients in this group to spend months and months in hospital where they see many acute cases come and go and are left despondent by their slow progress. Facilities for rehabilitation were obtained at some of the larger base hospitals, but the restriction of beds in the older peace-time hospitals prevented its development.

SEBORRHOEIC DERMATITIS

Seborrhoeic dermatitis remained a problem in dermatology, and the incidence probably increased, though no figures are available to support this statement. The clinical condition is ill-defined and appears to depend upon a constitutional background which predisposes the individual to infection with the *pityrosporon ovale* or the mild pathogenic organisms that are common on the skin. The thesis of Dowling and MacLeod which contended that seborrhoeic lesions were specific to the *pityrosporon* has not been confirmed, nor is it generally accepted.

The psychological aspects of seborrhoeic dermatitis have been discussed by Wittkower (1947). With regard to nutrition, it is thought that the civilian diet is rather overbalanced with carbohydrate, and this calls for an increase in the vitamin B complex which is not entirely compensated by the national bread. Although many dermatologists prescribed vitamin B complex or aneurin in seborrhoeic conditions, the clinical evidence of its therapeutic value is disappointing. However, it is undoubtedly an advance to concentrate more upon the metabolic background of the seborrhoeic state, since local treatment which was often effective on the skin lesion, did not prevent relapses. Scott (1944) expressed his opinion that the seborrhoeic state resulted primarily from an excessive consumption of carbohydrates and fats, and an excessive intake of fluids. Contributory factors were a hormone inbalance especially marked at puberty and the menopause, and a deficiency of vitamin C. At one time the demand for ascorbic acid greatly exceeded the supply, but it was not found that the necessary restrictions had an appreciable influence upon the therapeutic results.

OTHER SKIN AFFECTIONS

Tropical Lichenoid Dermatitis

This was very important and caused much trouble and anxiety both to malariologists and dermatologists. R. M. B. MacKenna dealt with this fully in the *Medical Annual*, 1947, p. 168.

Trombicula Autumnalis

It was found by the troops, but not known before the great attack, that men lying in certain fields in Normandy and Brittany at that time of year were very severely bitten by harvest bugs. Certain fields were much more heavily infested than others; the peasants always knew which. (If this is encountered again, it should be remembered that benzyl benzoate, and perhaps also di-methyl-phthalate are satisfactory repellents.)

Prickly Heat, Sunburn, Thermogenic Anhydrosis

Officers in medical charge of troops were encouraged on troopships to make the men sun-conscious and to organise sun-bathing parades, whereby sun-tan was acquired slowly. This saved much wastage from sunburn, but severe sunburn was a cause of sick-wastage in the North African campaign. Adequate sun-tanning was the best prophylactic against prickly heat in all hot countries. But men in machine shops near Madras suffered severely from prickly heat in the monsoon of 1945, largely because of poor acclimatisation, and the conditions of work. Cases of thermogenic anhydrosis occurred. The mechanism of this was investigated, and the histopathology of prickly heat has been published in detail (as a result of war work in the Australian Army by J. P. O'Brien (1947)).

Cutaneous Diphtheria

Sporadic cases occurred in Netley, Colchester, and Harrow Road hospitals. In all these hospitals the buildings were old. At Colchester virulent diphtheria bacilli were found in the dust on roof beams. Secondary contamination of skin lesions with diphtheria bacilli is a particular hazard in skin wards, and for this reason it was held that skin cases should not be nursed in wards having more than twenty-five beds. Cutaneous diphtheria was a hazard of importance in P.A.I. Force as it was also in M.E.F.

REHABILITATION

This was possibly the most important advance in any dermatological service in the war. An auxiliary hospital (British Red Cross Society and Order of St. John) at Ragley Hall, Warwickshire, was used for some three years for the physical and psychological rehabilitation of military skin cases. Some 800 men passed through in the first two years. The average length of stay was eight and a half weeks; of these patients, 584 returned to duty and 216 were discharged from the Service. A follow-up of the former showed that some months later 75 per cent. were on full duty and 17 per cent. on light duty. These results were encouraging when it is realised that these men had spent on an average two-thirds of their total Army service passing from hospital to hospital before they were admitted to Ragley Hall. For details, see R. M. Bolam, *Brit. med. J.*, 1945, **2**, 539, and F. F. Hellier, *Modern Trends in Dermatology*, chapter 17, both of whom did much to make this experiment a success.

Special attention was paid to two matters in the arrangements for Ragley Hall: (*a*) the question of the patient's occupation; (*b*) the question of his rehabilitation. To get the men fit, increasing amounts of physical training were ordered; also, the men had to do five hours' work regularly each day, under reasonable discipline. Piece-work of a mechanical kind and the usual diversional therapy were available; and organised games were arranged. The schedule was planned so that the bias was on strenuous activity. The need for psychological as well as physical rehabilitation was always remembered.

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CHAPTER XVII
RESEARCH IN MEDICAL ENTOMOLOGY AND INSECTICIDES

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C.M.G., F.R.S.

PRELIMINARIES

THE period before 1938 saw great changes in entomology. There were important developments in insect physiology which culminated in the publication of Wigglesworth's *Principles of Insect Physiology* in 1939. The physiology of insects is a branch of pure science, but it became closely linked with the development of insecticides: for example, if one wishes to increase the efficacy of a contact insecticide (one which enters the insect through the cuticle) it is clear that much may be learned from physiological and biochemical studies of the cuticle itself. Other important developments came from the ecologists, who studied the living insect in its natural environment and became more and more quantitative in their methods and results. Studies which were made on the populations of insects were valuable because they helped to assess the size of a practical problem, or to measure one's success in dealing with an insect pest. Examples in medical entomology are the work on the bed bug, *Cimex lectularius* (Johnson, 1942, and earlier papers): on body and head lice (references given by Buxton, 1947): and on *Sarcoptes*, the parasite which causes scabies (Mellanby, 1944).

In the decade before the war certain entomologists, of whom Professor J. W. Munro was prominent in Great Britain, had made a scientific approach to the study of insecticides. They had worked out methods of chemical and biological assessment and had studied different methods of formulating and applying materials on a large scale: toxicity to man and vertebrates had not been forgotten. It had become recognised that the production of a lasting film of insecticide which would continue active for a number of days was possible at least indoors: it would be of great value in the control of pests, for instance in warehouses and dwellings. The insecticides used were preparations containing extract of pyrethrum and certain thiocyanates of fatty acids. Good results were obtained in the control of moths, which are pests of stored products (Potter, 1938), and of bed bugs (Musgrave, 1940).

It will be seen that in several directions entomologists had established a good scientific knowledge: it was not a very difficult matter for those who had worked in this way to turn to fresh, urgent and practical problems.

LOUSE PROBLEMS

On the outbreak of war there were reasons for fearing outbreaks of the louse, either among civilians or troops. The author prepared a monograph on the insect, and then, rather belatedly, gave attention to the possibility of controlling the louse by stable, lasting insecticides. Working with Busvine, he showed that certain thiocyanates, particularly the proprietary 'lethane' series, were valuable; they might have an effective life of at least a week on the head or the garments, which gave the infested man valuable protection. Lethane rapidly came into general use for the control of the head louse (Busvine and Buxton, 1942): it was less easy to use it against the body louse because the insecticide is removed from garments when they are washed. The difficulty was circumvented by the use of what became known as the 'sherlice' or lethane belt, which was woven with innumerable folds attractive to lice, and impregnated with the insecticide (Busvine, 1945). After some weeks of use the belt could be washed and re-impregnated. The belt was irritating to the skins of many Europeans, but was used on a large scale among oriental labour corps and found acceptable and efficient in holding down the louse, if not in exterminating it.

A valuable step towards control of the louse was the powder AL63, containing naphthalene and derris and introduced by Messrs. Cooper McDougal. Though this did not give lasting protection, it was a great advance in efficiency on the insecticides available at the time of the War of 1914–18.

During the greater part of the War of 1939–45, and especially during the months of heavy air raids, a very large number of people slept in communal air-raid shelters. Conditions were such that widespread outbreaks of insect vermin were probable; indeed, bed bugs were very widely introduced into the shelters. But these pests were controlled, and the more dangerous body lice virtually suppressed, by the vigilance of sanitary personnel, by hygiene propaganda (e.g. lectures on pests to shelter wardens) and by regular disinfestation of shelterers' bedding. In regard to the last measure, considerable progress was made in the technique of large-scale hot-air disinfestation. The possibility of using modern fumigants for disinfestation was very carefully investigated; but the advent of D.D.T. rendered such methods unnecessary.

The control of the louse was completely transformed when dichlordiphenyltrichlorethane, generally known as D.D.T., became available. The insecticidal properties of this substance had been discovered by workers for the firm of Geigy in Switzerland, who published some early work in relation to insects on plants in 1939. It is hardly to the credit of British entomology that the importance of this discovery passed unnoticed until small samples of the material were brought to the notice of ourselves and American entomologists about February, 1943. The Ministry of Production set up an Insecticide Development

Panel under the Chairmanship of Sir I. M. Heilbron, after which development was rapid and very successful, with good collaboration across the Atlantic.

D.D.T. possesses a combination of most valuable characters. It is lethal to insects of many sorts: a dry film remains insecticidal for periods of weeks or months: under normal circumstances it is not dangerous to man or domestic animals: it is capable of being made up in many ways for particular purposes. It is certainly not ideal, for its action is generally slow and it has no immediate 'knockdown', in which it contrasts with pyrethrum extracts: moreover, it does not kill eggs of insects as the thiocyanates do. It resembles other specific substances in that the lethal dose for one sort of insect may be many times that which is necessary to kill another. On balance one concludes that for most purposes D.D.T. is far more effective than any other known insecticide. A general review of its medical applications has been published (Buxton, 1945).

Against the louse D.D.T. has been used as a powder and as an impregnator for garments. The powder of 5 to 10 per cent. strength may be blown beneath the garments of a fully dressed man or woman. The material is therefore extremely easy to apply, even in the open street, and administrative problems are simple. This method was tested on a large scale in prisons in North Africa and then on a civilian population, which was mainly Arab, and which would not tolerate preventive treatment which would involve medical examination of the women: the method was acceptable, and individuals of both sexes came forward for treatment (Soper and colleagues, 1943). The use of D.D.T. dust blown under the clothes proved of great value in checking an epidemic of typhus in Naples and has received much publicity: it is understood that the early stages of control were carried out with an American powder known as MYL, which contained pyrethrum and which was also applied by blowing. Since that date D.D.T. powder has been used to check lousiness and outbreaks of typhus in several parts of Europe. We regard it as the method of choice where one has to deal with the body louse among civilians. The dust can also be used effectively against the head louse.

The second method of using D.D.T. against the body louse is by impregnating undergarments. Impregnation can be carried out in a dry-cleaning plant, the purpose being to leave 1 per cent. by weight in the garment. It is remarkable that such garments remain insecticidal for many weeks in spite of dirt, sweat and washing with hot soap and water, though the insecticidal effect becomes less quick and less complete after a time (Musgrave, 1946). Shirts treated in this way were used in the British Army in Europe on a very large scale. The method is probably not readily adapted to a diversity of mixed civilian garments made of different materials, because they would tend to take up the D.D.T. to different degrees. Attempts have been made, without success, to apply D.D.T. to the head in such a way that some of it would remain on the hair after washing.

ADULT MOSQUITOES

Until D.D.T. was available, adult mosquitoes were generally controlled by sprays containing pyrethrum, the intention being to hit the mosquito itself. Similar sprays containing D.D.T., with or without a proportion of pyrethrum were valuable. This method is passing out of general use, and is being replaced by films of D.D.T. which are sprayed on walls and such surfaces. A film of this type will remain effective for a period of months. The dose that is requisite varies much according to the type of surface. On some materials, such as mud walls, a proportion of the solution soaks into the porous material, so that much of the insecticide is not available on the surface. Loss of this type is probably much less with emulsions and wettable powders, which are now available.

During the war period, the application of paraffin spray containing D.D.T. to walls was in use on all malarious fronts, and was almost certainly responsible for an immense reduction in domestic mosquitoes and in malaria, though it was generally impossible to distinguish results thus obtained from those which accrued from other measures. From a very large number of papers which have been published one might select the work of Symes and Haddaway (1947) against *Anopheles darlingi*, the vector of malaria in British Guiana. These workers carried out one of the first sets of thorough tests, and studied a number of methods of application.

Among other ways of applying D.D.T. to the inside of houses some attention has been given to insecticidal smokes and paints. The smoke consists of solid particles of D.D.T. which has been sublimated by heat: as the particles tend to fall, they settle on the upper side of horizontal surfaces and very little remains on an upright wall. This is clearly a disadvantage when in use against insects such as flies, mosquitoes and bed bugs, which commonly rest on vertical surfaces. Paints and distempers are certainly convenient to apply and D.D.T. may be incorporated in them; but as a large proportion of the insecticide is left in the layer of paint and not on the surface, the results are sometimes disappointing.

Treatment of a building with D.D.T. against mosquitoes and other insects is evidently a measure of great value: we have recently begun to discover, however, that it is not invariably successful. It has been shown in West Africa that if a house is sprayed internally with D.D.T. in kerosene, very few *Anopheles gambiae* are subsequently caught settled on the walls. This, however, is due, at least in part, to the fact that the D.D.T. irritates the mosquitoes and acts as a repellent, so that after biting they tend to leave the house, not having received a lethal dose. Here the absence of resting mosquitoes from the house is deceptive (Muirhead Thomson, 1947). The explanation of this is not yet known. It may be that owing to absorption of the solution of D.D.T. into mud walls, a very small dose was left on the surface. If that is so, the difficulty could probably be overcome by using an emulsion which would tend to deposit the insecticide actually on the surface.

DOMESTIC INSECTS

The use of D.D.T. as a lasting film inside houses is of immense service in reducing domestic insects of many kinds. It proved to be a great boon in the war period when used against bugs in troopships and barracks, and is now used in urban areas on a large scale in many parts of the world. Applied in a similar way, or as a dust, D.D.T. kills many other insects, for instance fleas (it has been used to reduce a population of fleas during an outbreak of plague), and house-flies, which, however, rapidly produce a race which is highly resistant to D.D.T. The substance is also used in the control of numerous insect pests of cattle and horses and of warehouses in which dried food products are stored. It gives disappointing results against certain species of cockroach and of ant.

MOSQUITO LARVAE

One of the standard methods of destroying mosquito larvae is to spread a film of mineral oil over the surface of the water in which they breed. The oil enters the breathing tubes; all ordinary mineral oils contain substances which are toxic to larvae when applied in this way. If D.D.T. is dissolved in the oil one sometimes obtains an effect which continues after the oil itself cannot be detected. But on certain types of natural water, the insecticidal effect of the D.D.T. is not lasting, perhaps because the material has been absorbed in mud. The use of these oil films has become more effective owing to scientific study of the spreading pressures of various oils (Murray, 1939; Adam, 1945). Spreading pressure is the factor which tends to disperse the oil among stems of aquatic plants: oil with a high spreading pressure will cover stagnant water, even though it carries a thin film of bacteria, etc., which is resistant to the spread of certain types of oil.

During the war period it was discovered in the laboratories of Imperial Chemical Industries that the gamma isomer of benzene hexachloride is extremely insecticidal. Commercial preparations are marketed as Gammexane and are valuable as general insecticides, particularly because the material is effective against certain insects which are rather resistant to D.D.T.: among these one might mention ticks and certain mites, also some species of cockroach. The material may also prove to be of great value as an alternative insecticide for use against house-flies or other insects which have developed a resistance to D.D.T.

Gammexane has also been shown to be of great value in destroying the larvae of midges (*Culicoides*) in damp soil (Hill and Roberts, 1947). Under most circumstances Gammexane is not so persistent as D.D.T. Another point against the material is that most commercial preparations have a lasting and unpleasant odour. Some success has been achieved in removing the odour, which is due to an impurity, and certain 'odourless' preparations have been applied to the head in doses sufficient to kill lice. The only general account of the properties of Gammexane is that published by Slade (1945).

SARCOPTES

Scabies, due to infection by *Sarcoptes*, should perhaps be considered by itself. Under the unusual conditions which prevailed in the war, K. Mellanby was able to make use of a team of civilian volunteers and with their collaboration made important advances in our understanding of *Sarcoptes* and scabies (Mellanby, 1934). He studied the number of adult *Sarcoptes* on patients of various types, and demonstrated that transmission is almost entirely due to close bodily contact: as the result of this work many public health authorities have ceased to disinfest blankets and now concentrate their attention on the patient and the members of his family. Mellanby also showed that the symptoms of scabies are due to sensitisation: they may be absent early in the infection, though the patient is at that time capable of passing the *Sarcoptes* to others, and they may persist after all the *Sarcoptes* have been killed. Mellanby developed the method of searching for *Sarcoptes* and used the discovery of them, alive or dead, as an objective measure of the value of certain remedies.

The standard treatment of the patient and contacts is by painting all over with an emulsion of benzyl benzoate. An interesting alternative method is the use of a soap containing tetra ethyl thiram monosulphide or 'Tetmosol'. The method is suitable for an institution in which one can be certain that this soap and no other is used: this results in the gradual disappearance of scabies (Mellanby, 1945; Bartley, Unsworth and Gordon, 1945).

OTHER ACARINA

Scrub typhus was a serious military problem in South-East Asia, the infection being transmitted by the larva of a mite (*Trombicula*). These larvae were rapidly killed if they crawled on a garment or on human skin which had been brushed over with certain esters, such as benzyl benzoate, methyl phthalate or butyl phthalate. Such a garment retains enough of the substance, even after washing, to give protection against this mite, or against other larvae of *Trombicula* known as harvest mites or chiggers and which are very troublesome in England and the U.S.A.

Yet another acarine, *Ornithodorus moubata*, was of great importance because it is the vector of relapsing fever in East and Central Africa. The disease is serious to military and civilians alike. This tick is resistant to most insecticides but is readily destroyed by Gammexane applied as a dust (Jepson, 1947).

FOREIGN INSECTICIDES

The work done in Germany, during the war, on pests of medical importance has been revealed by the Allied Intelligence Teams (Smadel and Curtis, 1945; Schrader; Hall, 1945). It appears that the Germans soon became aware of the value of D.D.T.: they also found another compound (chlorphenyl chlormethyl sulphone 'Lauseto neu') at least equal in value against lice. They had developed methods of impregnation of clothing which did not require use of mineral oils, of which they were desperately short. Nevertheless, it is interesting to find that the German Army made comparatively little use of these discoveries and that many of their troops were lousy when captured.

So far as is known, Russian development of insecticides was not highly efficient. Against the body louse they used a diphenylamine dust, and a chlorinated turpentine oil, and diethyl xanthogen (which we had rejected at an early stage because of its unpleasant smell and irritating properties). Russian work on the louse is dealt with by Buxton (1947).

REPELLENTS

Before the war a standard repellent for personal protection against mosquitoes and other biting insects was a mixture of citronella oil, or other essential oil, and vaseline. This ointment is only moderately efficient and it is highly unpleasant to use in the damp tropics because it prevents evaporation of perspiration. An improved repellent for the Services was made up during the war in a 'vanishing cream' base with pyrethrum as its active constituent. This was acceptable to most people but caused dermatitis to a small minority. Later some new synthetic compounds, whose value was discovered in America (dimethyl phthalate; indalone, etc.), were introduced and found to be efficient in nearly all respects. The relative values of different types of preparation are well indicated in a study by Christophers (1947).

Many other subjects of great interest and importance have been omitted for lack of space. For instance, the protection of foodstuffs from destruction by insects; precise methods of assessing insecticides in laboratory work; mechanisms for dispersal of insects in houses and in the open air (which includes such things as the ingenious American bomb, which used 'freon', to propel a finely dispersed cloud of insecticide; and the use of air spraying and other methods which were developed in connexion with chemical warfare); studies on the toxicology of the newer insecticides and of dermatitis caused by pyrethrum.

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CHAPTER XVIII

PAEDIATRICS DURING THE WAR

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During the war the children of the United Kingdom were subjected to a series of experiments in social paediatrics on a colossal scale. Although some of the recent advances in child medicine might have occurred anyway, their tempo was probably quickened by the circumstance of war. The large-scale evacuation of children from cities that were likely to become, or had become, targets for air attack produced or brought to light many psycho-neuroses, maladjustments and behaviour changes, and revealed the surprising frequency of bed-wetting, lice infestation, scabies and impetigo. Many of the children were unsuitable for ordinary billeting, and hostels had to be provided for them. In some instances these troubles resulted from lack of a decent home-life in pre-war years, in others they were due to the separation of the child from its parents, and in others to life in unaccustomed surroundings, even when the mother was evacuated with her child.

Sometimes the possibility of evacuation led to a closing up of the family circle since 'not even the fear of death in a singularly terrifying form could make separation of families by evacuation tolerable; there was ever the pull to unite and face it together'. Incidentally, the return home of the evacuees after three, four, five or perhaps six years' absence created not dissimilar problems to those of evacuation, especially when the home had been damaged or destroyed by enemy action and a new home, often grossly overcrowded, had to be provided. Those children who remained in bombed towns also presented problems; shelter life meant loss of sleep, and an increase in uncleanly habits, in scabies and in lice infestation. Other results of the war and the bombing attacks on Great Britain and Northern Ireland were diminished parental control, an increase in juvenile delinquency, and a lowering of moral standards on the part of parents, leading to ruined homes, an increase in divorce and a great increase in the number of illegitimate children born not only to unmarried but also to married women. The illegitimacy rate in England and Wales in 1939 was 42 per 1,000 live births and began to rise in 1941 (54), reaching 72 per 1,000 in 1944. In Birmingham the rate rose from 36·1 in 1939 to 92·0 in 1945, and whereas in 1941, 11 per cent. of illegitimate children were born to married women, in

1945 the percentage was trebled. (Cassie, 1944.) The experience of the war also bore out the known fact of the higher infant mortality-rate in illegitimate than in legitimate infants. The obvious lowering of moral standards and the increased incidence of venereal disease among adults were more than offset by the admirable public health control and treatment of these adults, so that congenital syphilis and ophthalmia neonatorum occurred rarely.

BY-PRODUCTS OF WAR CONDITIONS

Although the foregoing state of affairs appears to have been more marked in this than in previous wars, it is probably an invariable concomitant of war and was familiar to Shakespeare, who wrote of France after Agincourt:

> " . . . . . . our houses and ourselves and children
> Have lost or do not learn for want of time
> The sciences that should become our country
> But grow like savages . . . . . . "

Another adverse factor in 1940 was the unprecedented call for women to go into industry. To ensure an adequate response day-nurseries were established for children between the ages of 6 months and 5 years in those areas in which women were required for work of national importance, and the number of nursery classes for children over 2 years was increased and their hours extended. At the end of 1944 there were 1,449 whole-time nurseries with 68,574 places, and although undoubtedly fulfilling a war-time need they were necessarily rather prodigal in 'man-power'; there was also the greater risk of infection, especially in babies; but it must be admitted that, owing to the excellent work of the staffs, the incidence of infection was not so great as many expected. In Birmingham in 1941 and 1942 an investigation on 4,365 babies in some of these nurseries showed a slight improvement in the frequency of breast-feeding rather than a decline, by comparison with results in 1937, when of 4,378 babies, 87 per cent. were wholly or partially breast-fed for three months and 51 per cent. for three to six months. In September, 1939, residential nurseries were opened in reception areas to accommodate children under 5 from evacuation areas, and by the end of December, 1942, there were 415 of these nurseries with accommodation for 13,007 children. These also proved their value, though the incidence of infection was greater than in the day nurseries. The success of these war-time nurseries led some people to advocate their retention in time of peace but it is the considered opinion of the Ministry of Health and of all paediatricians that, although the nursery school is a valuable instrument in the care of children from 2 to 5 years, infants under 2 years should remain at home to be looked after by their mothers.

The dispersion of families from their own homes and from large centres of population carried with it the dissemination of medical and of specialist services and of hospitals with the highest nursing standards. As new relationships developed between evacuated and local medical men the conception of regional paediatrics took clearer shape. The benefits of linkage between the various paediatric services, preventive, supervisory, consultant and hospital, have left their mark on paediatric planning for the future.

Another result of the difficult war-time domestic conditions was an increased need for institutional midwifery. Whereas before the war the local authorities accepted responsibility for mothers from unsuitable homes as well as those requiring hospital treatment, war conditions greatly increased the number of unsuitable homes. For example, in Hertfordshire in 1938 there were 6,582 births, of which 2,478 were in institutions and 4,104 domiciliary, while in 1944 there were 14,542 births, 4,324 under the emergency evacuation scheme, leaving 10,208 of which 6,982 were institutional and 3,226 domiciliary, the proportion having risen from 37·6 per cent. to 68·4 per cent. This change has called for an altered outlook in planning the maternity services for institutional midwifery for normal mothers, and has incidentally added greatly to the risks of neonatal infection.

Pregnancy among unmarried Service girls was regarded as in a sense a war-time casualty and such cases were treated in ante- and post-natal hostels (transit camps). In one such hostel, of 475 live births the neonatal death-rate was 23 per 1,000 live births, a much lower rate than might be expected for this class, as mentioned above. This sort of experience led some local authorities to establish permanent ante- and post-natal hostels.

STILLBIRTHS AND NEONATAL DEATHS

The war-time rationing of food was a controlled experiment which produced interesting and informative results. It was probably one of the most important factors in the striking reduction during the war years of the neonatal death-rate and the number of stillbirths, this latter having been acclaimed as one of the great victories of the war. The number of stillbirths in England and Wales is not known before 1928, when there were 40 per 1,000 total births. The rate remained about the same until 1939 when it was 38, but from 1941 onwards there was a rapid drop to 28 in 1944 and 1945. Stillbirths in Scotland have only been recorded from 1939, when they numbered 42 per 1,000 total births, and although consistently higher than in England and Wales, the Scottish rate too has noticeably improved, falling to 32 in 1944. It is significant that unlike the neonatal or infant death-rates the stillbirth-rate for Great Britain never increased at any time during the war.

The occurrence of stillbirths and the incidence of prematurity, whether the premature birth be a live or a still one, are greatly influenced by geographical and social factors. The lowest stillbirth rates in both 1939 and 1944 occurred in London (31 and 24) and speaking generally the rate rose the more northerly the region, with the striking exception that the highest rates and, incidentally, also the greatest reduction in rate occurred in Wales (49 in 1939 and 34 in 1944). The effect of social and economic factors is shown by the fact that in 1939 the rate for England and Wales in Class I of the Registrar-General's five social classes was much less than in the other four groups, the difference between Class I and Class II being 9 per 1,000 total births and between Class I and Class V, 15·7 per 1,000. Investigations in Aberdeen (Baird, 1942) showed that the greatest reduction in stillbirths during the war occurred in the lowest social classes and in those stillbirths resulting from 'unknown causes', 'trauma' and 'toxaemia' but not in those due to foetal deformity; in Birmingham there was a reduction not only in these three groups but also in stillbirths showing foetal deformities.

Unlike the stillbirth rate the neonatal death-rate in Great Britain rose in the earlier years of the war (1940 and 1941) but later fell to a lower level than in 1939. The fall from 28 per 1,000 live births in 1939 to 24 in 1944 is not so spectacular as the improvement in the stillbirth rate during the same period, but is equivalent to that which occurred over a much longer period before 1939, namely, from the quinquennium 1926–30 to 1939. The increase in neonatal deaths in 1940 and 1941 was due to deaths from direct enemy action and also from 'infections' consequent upon evacuation, bombing, shelter life, etc., being particularly obvious in large cities like Glasgow and Birmingham. In the latter it continued until 1942.

INFLUENCE OF DIET ON MOTHER AND OFFSPRING

That the neonatal mortality-rate fell in spite of the increase in deaths from infection compared with pre-war years, was due to fewer deaths from prematurity, asphyxia, trauma and congenital debility. This can hardly have resulted from better nursing or doctoring, since both nurses and doctors were consistently overworked, and the only important therapeutic advances, the introduction of the new sulphonamide drugs and, towards the end of the war, of penicillin in hospital practice, did not reduce the number of neonatal deaths from infection, which in fact increased. Neonatal deaths from prematurity and congenital debility, like stillbirths, occur most frequently in the lowest social classes, the result either of an inherited inferiority in reproductive capacity—a theory for which there is no evidence—or of the poor general health and nutrition of expectant mothers in this grade of society and the unfavourable environment in which they live; yet it was just in these classes that the fall in stillbirths and neonatal deaths was most obvious. This improvement may reasonably be credited to better environmental conditions and a better nutritional state of the mother following the abolition of unemployment, higher wages, greater antenatal care and better food. The lot of the expectant mother was usually hard; to the difficulties of blackout, overcrowding and queues was sometimes added actual bombing; frequently she was engaged in industry and in many instances was separated from her husband and her family for long periods. On the other hand, the rationing and the better distribution of food seem to have produced an improvement in the diets and health of a large part of the population, particularly in the lower social grades. In 1940 and 1941 there was a sharp fall in food supplies, notably meats, fats, sugar and fruit, but from 1942 until the end of Lend Lease, and chiefly as a result of it and of supplies from the Dominions, the diet in Great Britain was balanced and adequate, though monotonous and at times unattractive. The factors responsible for the improvement were probably: (*a*) the national loaf, which from April, 1942, to January, 1945, was made with 85 per cent. extraction flour; (*b*) the reduction of sugar in the diet, lowering the vitamin B required for its oxidation; (*c*) the increased consumption of milk; (*d*) the provision of school meals; (*e*) the additional rations of milk and vitamins for expectant mothers and children. Before the war many mothers lacked these supplements owing to poverty or to ignorance of their value, and even during the war and despite propaganda less than 50 per cent. of women attending antenatal centres took away their vitamins. Before the war everyone, including the poor, had a wide choice of foods, but exercised it unwisely; during the war the choice was limited but confined to good food of which hunger compelled the eating.

Researches carried out in recent years on sheep at the Agricultural Unit at Cambridge may be relevant. Wallace (1944, 1946) has shown that the weight of the foetus at birth and the lactating capacity of the mother depend entirely on the diet during the last third of pregnancy; severe restrictions in the first two-thirds of pregnancy had little effect on the weight of the newborn and on lactation if the ewes were given a generous diet in the last third of pregnancy. Severe restrictions of diet throughout pregnancy produced small lambs whose physiological development was also retarded. Restriction of certain articles of diet in the early stages of pregnancy will in some animals produce deformities similar to those arising from genetic causes, even if the diet is adequate in the later part of pregnancy (Warkany, 1944). The only changes in the number of deaths from deformities in newborn babies since 1936 have been a significant rise in those from spina bifida and meningocele in 1942, following a moderate drop between the years 1938 and 1941, and also an increase in hydrocephalus in male infants in 1940 and 1941.

CAUSES OF DEATH IN CHILDREN

The curve of the general infant mortality-rate during the war followed that of neonatal mortality. Omitting neonatal deaths there were 22 deaths per 1,000 children between the ages of 1 and 12 months in the year 1939 in England and Wales. This rose sharply to 27 in 1940 and to 31 in 1941, dropping thereafter to 23 in 1942, 24 in 1943, and 21 in 1944. The increase in 1940 and 1941 was due, as with neonatal deaths, to the direct and indirect effects of enemy action, important among the latter being deaths from infection.

The death-rate in children between the ages of 1 and 5 years showed exactly the same trend as that between the ages of 1 and 12 months, namely, a sharp rise in the years 1940 and 1941—in 1941 a 50 per cent. increase over 1939—and after that a progressive drop so that the figures for 1944 were strikingly lower than those for 1939. In the quinquennium 1921–5 the principal killing disease at school age in England and Wales was diphtheria, but following the intensive drive for immunisation during the quinquennium 1940–4, diphtheria lost that 'bad eminence' and in children aged 5 to 10 years took second place to deaths from violence (excluding enemy action), and in those from 10 to 15 years fourth place following violence, tuberculosis and heart disease, in that order. Yet far more children under 15 years were killed by diphtheria than by enemy action.

The mortality from tuberculosis, though much less in this than in the War of 1914–18, increased significantly in 1940, and even more in 1941, as compared with 1938. In children the increase was in tuberculous meningitis and probably resulted from the closure of the beds for tuberculosis in unsafe areas and the use of others for the Emergency Medical Service, so that the number available at the end of 1939 was reduced by 4,000 to 86 per cent. of the 1938 figure.

The probability of a live birth resulting from a pregnancy, and of the baby's not only surviving the most dangerous part of its life but of reaching adolescence, was considerably better during the war years, and the evidence suggests as causes improved antenatal care, a well-balanced and adequate diet, and the provision of increased rations for expectant mothers and children.

CLINICAL AND DIETARY SURVEYS

The effect of the circumstance of war on morbidity and non-fatal congenital deformities is, except in certain diseases, not so obvious. Clinical and dietary surveys of children carried out by or on behalf of the Ministry of Health showed that, although there was an undue amount of preventable anaemia among infants and young children, there was no greater degree of anaemia than in the limited number of children examined before the war, and in certain groups probably less. From 1940 onwards the heights and weights of some 1,200 children a year, living at home or evacuated to camp schools, were recorded, and although the growth rates of the latter group never quite equalled those of the former and there was in both a slight retardation between 1940 and 1942, yet this was generally made good by 1943, and in 1944 the rates corresponded with those before the war. The conclusions drawn by the Chief Medical Officer of the Ministry as the result of these surveys were that the nutritional state of children at the end of the war was somewhat better than at the beginning and that, though there is still much to be done before the elementary school child attains the full physical development of which he is capable, at the end of the war children were bigger, more resistant to disease and better nourished than their predecessors of the War of 1914–18.

DEFICIENCY DISEASES

There was no obvious increase in the incidence of deficiency diseases, as shown by a search for rickets carried out by the British Paediatric Association at the invitation of and with the support of the Ministry of Health. From the middle of January to the end of February, 1943, a random sample of children in twenty-three chiefly urban areas of Great Britain and Ireland was examined for clinical and radiological evidence of rickets. The number of children examined was 5,283 and except that 11 were under 3 months and 198 between 18 months and 3½ years, their ages varied between 3 and 18 months, and only 106 of them (2 per cent.) showed radiological evidence of rickets. In so far as any pre-war investigations are comparable with this inquiry, there is no evidence of any rise in the incidence of rickets during the war. In another small inquiry, the ribs of all children between the ages of 3 months and 13 years, on whom necropsies were performed at the Children's Hospital, Birmingham, in the year 1944 and part of 1946 were examined histologically. Comparison with the results of a similar investigation on the ribs of white children in Baltimore before and after 1939 suggests that there was somewhat less rickets in Birmingham than in Baltimore, despite the absence of war-time dietary restrictions and the presence of more sunshine in Baltimore.

There were no records during the war of vitamin-A deficiency—night blindness and xerophthalmia—such as led to the epidemic of blindness among Danish children in the War of 1914–18. The newborn full-time baby starts life with a supply of vitamin A and some other vitamins, hormones, metals, antibodies, etc., sufficient to last it until it can manufacture them itself or obtain them from food. In some animals, such as cattle or sheep, the thickness of the placenta prevents transmission, and vitamin A and antibodies are supplied in the colostrum. The human baby receives its vitamin A by both these channels and at birth the amount of vitamin A in its chief storehouse, the liver, is small; the more premature the baby the less the store. Human colostrum and breast milk are rich in vitamin A and the baby's stores increase rapidly as soon as feeding is established. An estimation of the vitamin A content of the livers from two series of necropsies on children of all ages, including premature babies, was carried out, the one (131 cases) before the outbreak of war and the other (144 cases) during the war years. The results in the two series were essentially similar, showing no evidence of vitamin-A deficiency in the war-time series at any age, including the foetus, although the numbers investigated were small.

OTHER MORBID CONDITIONS IN WAR-TIME

Certain morbid conditions increased during the war, such as staphylococcal infections in the newborn—e.g. sticky eyes, sticky navels—but not severe forms of pemphigus. Soiled blankets, scabies or lice-infested mothers, scanty and infected soap may have played some part, but possibly the most important factor was a change from the streptococcus to the staphylococcus in the nasal flora of the attendants on the baby. In one hospital epidemic in 1943 the nasal carrier-rate for staphylococci among the nursing and medical staffs reached 85 per cent., a change attributed to the blackout and the increase of dust.

Both steatorrhoea and epidemics of diarrhoea were more frequent during the war. No reason is known for the increased incidence of the coeliac syndrome, but the greater consumption of margarine has been blamed for the increase of steatorrhoea in adults. Although this theory might account for the increase in children already on a mixed diet at the time of onset, more stress has recently been laid on the association of infection with the onset of coeliac disease. The clearer separation of cystic fibrosis of the pancreas from the group of steatorrhoeas and its increasing recognition in this country owes much to the invasion by paediatricians of the U.S.A.M.C. (May, 1943), and it is not supposed that the disease has increased as the result of war conditions. Considerable claims were made by certain Canadian and American paediatricians for the successful treatment of coeliac disease by injection of crude liver preparations and the vitamin-B complex, but the results were not confirmed in this country and have not been so certain more recently in Canada and the United States. Epidemics of diarrhoea were frequent both in newborn babies, mainly in those artificially fed, and also in older children, but neither morbidity nor mortality reached the dimensions of the epidemics of summer diarrhoea which were so frequent in the early years of the century. At times gastro-enteritis of newborn babies followed on the same disease in the mothers, and was more likely to be fatal in the newborn than in older children, in whom it was usually of short duration. In some instances the infecting organism was the Sonne bacillus, but in the majority of cases, as in infantile gastro-enteritis, no incriminating organism was found in the stools and the suggestion was made that the infective agent might be a virus, or a pathological variant of coliform bacilli (Cruickshank, 1946). In some epidemics the association with overcrowding, understaffing and respiratory infections, supports the idea of parenteral infection as a cause. Great Britain remained free from such severe and fatal epidemics associated with Salmonella infections as occurred in British Columbia.

Epidemics of diarrhoea among older children in residential nurseries stressed again the dangers of grouping infants and young children together. In many, although possible pathogenic non-lactose fermenting bacilli were isolated at first, the epidemics were associated with a high incidence of giardial infestation in the stools. As treatment with mepacrine of the whole child population in the home was followed by cessation of the outbreaks of the diarrhoea, observers became convinced that *giardia intestinalis* was at least pathogenic to children in residential nurseries, even if its rôle in other human beings remains in doubt.

Acute rheumatism as seen in hospital practice was less frequent and less severe than in the pre-war years except for a short period in 1943. This may be the result of a decline in the incidence of streptococcal sore throats and of the virulence of scarlet fever which has occurred in the last two decades. On the other hand it may be due to the improved nutrition of the poorer classes, though against that view is the fact that the mild manifestations antedated the war and any obvious improvement in nutrition.

The specific infectious diseases showed some interesting phenomena. In the early part of the war there was an increase in primary tuberculosis and in tuberculous meningitis, as previously discussed. Meningococcal meningitis occurred in epidemic form in January, 1940, and continued throughout 1941 and 1942, and although the disease was severe, the number of recoveries following the use of the sulphonamides far surpassed those in any previous epidemic of this disease. Towards the end of the war the use of penicillin gave the patient an even greater chance of recovery. After the diphtheria-immunisation campaign began in 1941 not only did the mortality decline, as already noted, but the incidence of the disease progressively diminished.

Mention must be made of German measles, not because of its severity, but because if an expectant mother contracts rubella in the early months of pregnancy, her foetus may develop deformities. Intensive investigation in Australia has brought to light examples of this association, to which attention was first drawn by a mild epidemic of a form of congenital cataract in the year 1941 (Gregg, 1941). This followed a severe and widespread epidemic of rubella in 1940, for which observers blamed the war and the consequent movement of the young adult population. One investigator asserted that if a mother developed rubella in the first two months of pregnancy there was a 100 per cent. chance that her child would show some defect, and that if she developed it in the third month there was a 50 per cent. chance. The types of defect found were cataract, microphthalmos, congenital heart disease, deaf mutism, dental and mental defects; and many of the children were small, ill-nourished and difficult to rear. In 1940 there was in the United Kingdom a considerable epidemic of rubella in the Services and among civilians and there is a little evidence that this was associated with congenital defects in the newborn. The most suggestive evidence obtained in this country so far was in response to a questionnaire addressed to the mothers of 102 deaf children seen at a London hospital and who were born in 1940 and 1941 (Martin, 1946). In 15 instances the deafness was hereditary and in 8 it followed meningitis; of the remaining 79 mothers, 36 contracted rubella in the first four months of pregnancy and 6 others may have suffered from the disease. Further instances of the same association have since been reported (Clayton-Jones, 1947).

Since many congenital deformities are compatible with prolonged life and since neither deformities nor rubella (except in Manchester) are notifiable, it is difficult to be sure of the association. Further, retrospective inquiries are less satisfactory than follow-up observations on the effect on the offspring of rubella in early pregnancy. Because deformities are only notified when they cause death, it is impossible to say whether there were more or less of them during the war years.

HAEMOLYTIC DISEASE OF THE NEWBORN

Any survey, however cursory, of paediatrics during the war must include a reference to the immense amount of work on haemolytic disease of the newborn and to the facilities for its treatment provided by the war-time Emergency Blood Transfusion Service; furthermore the conception and the proof that this disease was haemolytic in nature were the work of British paediatricians. The identification in 1941 of the actual haemolytic agent—the Rh antibodies—was the result of a brilliant series of investigations in America (Landsteiner and Wiener, 1940), while the development and application of this discovery was the work of both British and American serologists. The disease is frequently called erythroblastosis, because of the presence of erythroblastosis in the foetus or young baby who suffers from this disease, but this erythroblastosis is purely a compensatory mechanism designed to increase the production of red blood-cells to replace those destroyed by the Rh antibody, and may occur in other conditions; the title, haemolytic disease of the newborn, is therefore a better and more accurate description of the disease. The subdivisions of haemolytic disease—hydrops foetalis, icterus gravis, haemolytic anaemia of the newborn—are so called because of the predominant symptoms—oedema, jaundice and anaemia—respectively presented by these three different varieties. The serological aspect of this subject is extremely and increasingly complicated, but reduced to its simplest form it may be said that the red cells of 85 per cent. of white people carry the Rh antigen (Rh-positive) and that if this antigen gains access to the blood-stream of one of the remaining 15 per cent. (Rh-negative) either by blood transfusion, or in the case of a pregnant woman by the passage of Rh antigen from her foetus, this Rh-negative woman develops an Rh antibody which haemolyses the Rh-positive cells of the transfused blood or of the blood of her foetus. This reaction may lead to a blood-transfusion accident and sometimes to the death of the recipient, and, in the case of a pregnant woman, the Rh antibody which she returns to the foetal circulation, not only produces haemolysis but also sometimes damages liver and other cells, and may lead to the death of the foetus or a miscarriage. The effect of the antigen is a cumulative one and more than one transfusion or pregnancy may be necessary to produce sufficient antibody to bring about these effects. When these facts became known arrangements were made for testing pregnant women for the Rh factor and its subgroups at the depots of the Emergency Blood Transfusion Service, and for the supply from these depots of Rh-negative blood for the treatment of babies suffering from haemolytic disease of the newborn, or for the transfusion of Rh-negative mothers when such transfusion was necessary. These facilities reduced the death-rate in haemolytic disease of the newborn and also prevented the occurrence of transfusion accidents in lying-in women.

PREMATURITY AND FOETAL DEVELOPMENT

One of the most striking trends in paediatrics during the war was the increasing attention paid to newborn and premature infants, and even to foetal development and the possibilities and importance of what has been described as antenatal paediatrics. The Ministry of Health in 1944 asked Welfare Authorities to provide notification-of-birth cards designed to show when the birth weight was 5½ lb. or less—the criterion of prematurity—and asked that maternity hospitals should provide accommodation for premature infants and facilities for the consulting services of a paediatrician. Research work, largely carried out in the war, has shown that while an organ grows in form during foetal life, early infancy and childhood, it also grows and changes in function. There seems to be a special physiology of infancy, most marked in prematurity. To take the example of renal function; mineral clearances are low in infants and particularly so in premature infants; hence one of the chief reasons they are so liable to oedema and why premature babies should never be given normal saline intravenously to relieve dehydration, but rather 4 per cent. glucose in 0·2 per cent. saline.

In the last three months of intra-uterine life the human foetus deposits 3·57 g. of protein, and during the last month, 6·4 g. per day (Huggett, 1946). During the war attempts were made to devise methods of high protein-feeding either by giving predigested protein in the food or intravenously, whereby the daily increase in weight of the premature infant might approximate to that of the foetus *in utero*. The protein hydrolysates used at first were not pyrogen-free and contained too much salt, but towards the end of the war satisfactory preparations became available. It is now possible by using these to give sufficient calories and sufficient protein, by mouth or intravenously, to ensure a gain of weight that approximates to the normal child *in utero*, or to obtain weight increases in wasted babies, and at the same time keep the serum protein and haemoglobin within normal limits. This method of treatment offers great possibilities for future therapy, although the results in adults' war-concentration camps were not so spectacular as those in infants; moreover, adults found the preparations nauseating.

The advances in therapeutics during the war which have been most important from the point of view of child health are essentially the same as in adults, and include the discovery of the newer sulphonamides, penicillin, insecticides, etc. By these methods the outlook in many infections, particularly meningococcal and other coccal infections, urinary and intestinal infections, and even neonatal sepsis, has been revolutionised. There are, however, two important therapeutic advances which are almost confined to childhood, namely, the use of rhesus-negative blood in haemolytic disease of the newborn and the surgery of congenital heart disease. The first of these has already been sufficiently dealt with and the surgery of congenital heart disease was chiefly limited during the war to ligation of the patent ductus arteriosus. Operations to relieve the cyanosis of children suffering from Fallot's tetralogy by anastomosing the innominate or subclavian arteries with the right or left pulmonary arteries were performed in isolated cases in this country; the operation has, however, been performed more frequently in America and Canada (Blalock, 1946). In Sweden coarctation of the aorta has been successfully relieved (Crafoord and Nylin, 1945) and there is no doubt that there is an increasing, if limited, field for these operations in children.

Although much still remains to be done to raise the standard of child health in this country and to prevent and treat disease in childhood, the advances made in the war period were most encouraging. During that time the nation became more conscious of the great importance of a high standard of physical, mental and spiritual health among its children and many people now feel that this ideal can only be achieved by ensuring all the advantages of a happy family life.

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CHAPTER XIX

TETANUS IN THE WAR

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THE war provided an opportunity for testing the efficiency of active immunisation against tetanus for the first time, and the result of this gigantic experiment is the main interest of the subject. To appreciate the position in 1939 it is necessary to recapitulate briefly the events which led up to it.

At the beginning of the War of 1914–18, tetanus was a deadly danger to the wounded in France and Flanders. When passive immunisation was introduced, the incidence fell from 9 per 1,000 in September, 1914, to 1·4 per 1,000 in November (Bruce, 1915–20). It remained about this level, falling again in 1917, partly because the importance of giving repeated injections of prophylactic antitoxin was realised, and partly from improvement in surgical technique. Prophylactic antitoxin for all wounded not only reduced the incidence of tetanus to less than 0·1 per cent. but it also modified the disease and reduced the mortality in those cases which did occur. At the end of the war in spite of this great improvement it still remained an appreciable risk.

No further advance in prevention was made until 1927, when Ramon and Zoeller (1927) advocated the use of tetanus toxoid for active immunisation, and since then their method has been modified and developed. As a result of promising animal experiments it was at first used to protect Army horses and then for the active immunisation of soldiers.

PROBLEMS OF ACTIVE IMMUNISATION

In developing this method many problems of technique arose and some of these had not been finally settled by 1939. The particular practical points at issue were:

(1) The choice of antigen—whether to use plain or alum-precipitated toxoid.

(2) The amount, number and spacing of doses both for initial immunisation and for permanent protection.

(3) Whether to rely entirely on active immunisation or to combine this with antitoxin at the time of injury.

These questions were not easy to answer, partly because there is no simpler method of testing the degree of immunity against tetanus in man than the laborious bio-assay. The titre necessary for protection was not known with certainty and various authorities gave figures between 0·001 and 0·2 international units per c.cm. (Ramon, 1936a;

Sneath *et al.*, 1937; Cowles, 1937; Gold, 1939). It was not known how long protection would last without repeated injections of toxoid, although appreciable amounts of antitoxin had been shown to be present months or years after active immunisation. There remained also the question as to how far the antitoxin titre *per se* was a true index of the degree of immunity, or whether the sensitisation effect alone would give a prompt enough response for protection against a natural infection (Schumaker and Lamont, 1942).

On the Continent it was usual to give three doses of toxoid at relatively short intervals, but in 1938 Boyd showed that equally good results could be obtained by giving two injections at a longer interval. Taking 0·01 unit of antitoxin per c.cm. as the effective lower limit of protection, he showed that this level could be obtained by giving two injections of toxoid, each of 1 c.cm., at an interval of not less than six weeks. Reactions to these injections were rare and, when they occurred, usually slight. Occasional mild anaphylactic reactions occurred, sometimes after the first dose (Cunningham, 1940), more commonly after the second (Whittingham, 1940), and rarely after the third (Donaldson, 1942). These were shown later to be due to the Witte or Berna peptone present in the culture media (Shumacker and Lamont, 1942), and ceased when a different brand of peptone was used. They were easily controlled by injections of adrenaline and no fatal reactions have been recorded.

It was also shown that by combining tetanus toxoid with diphtheria toxoid or T.A.B., its antigenic effect was increased, an observation of practical importance when large numbers of men had to be immunised against both tetanus and typhoid (Jones and Moss, 1939; Maclean and Holt, 1940; Ramon, 1936b).

During the early years of the war various workers confirmed the value of a third dose of toxoid a year after initial immunisation, which caused a large and rapid increase in the antitoxin content of the serum. This effect was particularly marked in those cases where the titre remained below the average or had tended to drop after a few months (Marvell and Parrish, 1940; Evans, 1941).

ACTIVE AND PASSIVE METHODS COMPARED

It was clear that if active immunisation could be relied on, it promised many advantages over the passive method, particularly for the soldier in war. The disadvantages of the latter are that antitoxin should be given soon after a man is wounded, which is not always possible in modern war; that occasionally severe reactions follow, or sensitivity to subsequent doses of antitoxin is produced, and that antitoxin, even when repeated, does not always afford complete protection. Active immunisation on the other hand only rarely produces slight reactions, has the great advantage that it can be completed before the soldier goes on active service and does not need to be repeated for a year or more. The outstanding disadvantage of the active method in 1939 was that its efficacy had not been tested on a mass scale over a long period, although experimental evidence and limited experiences suggested that it would be reliable.

METHODS OF ACTIVE IMMUNISATION

The diversity of opinion as to the best method of producing active immunisation, and lack of confidence in the efficacy of a hitherto untried measure of protection, were reflected by differences in practice in the allied armies. In the British Army, active immunisation by the two-dose method, each of 1 c.cm. of plain toxoid, was introduced as a routine in 1939 (Perry, 1941), and a high proportion, about 90 per cent. of those going on active service in 1939 were so immunised (Bensted, 1941). If, however, a soldier were wounded, he was given a single dose of prophylactic antitoxin. Then, if his records showed that he had received active immunisation, nothing further was done except in special cases. If he had not been actively immunised, he was given two further doses of antitoxin at weekly intervals, as was the practice in the latter years of the War of 1914–18. At a later date the practice of giving a further dose of 1 c.cm. of toxoid at the end of a year was introduced. This was not made a standard procedure until January, 1941. In the Middle East this order took long to implement, but in November, 1942, instructions were issued for an annual dose of 1 c.cm. of toxoid to be given to all Service personnel. Before the invasion of Europe the troops in 21 Army Group were practically all inoculated, and a special order was issued that every man who had received only the initial two doses should be given a third dose before going oversea. Very few evaded this order.

In addition any wounded man who was not actively immunised was given three doses of 3,000 international units of antitoxin at weekly intervals. Actively immunised men were given a single dose of 3,000 units as soon as possible after wounding. This procedure of continued active and passive protection was adopted in the United Kingdom, Australian, New Zealand and Indian Armies. In South African troops passive immunisation alone was used until 1942.

In the United States Army the practice was different. An initial immunisation of three doses of toxoid at intervals of three weeks was given as a routine, followed by a stimulating dose at the end of the first year, or prior to departure to a theatre of war if this occurred within six months of the first yearly dose (War Office, 1942). For battle wounds or secondary operations, a further dose of toxoid was given and antitoxin was reserved for clinical tetanus. If, exceptionally, a person who had not been actively immunised was wounded, he was given a single dose of antitoxin and a dose of toxoid followed by two further doses of toxoid as an initial immunisation. While the United States Army used plain toxoid, the Navy and Marines used insoluble alum precipitated toxoid.

Table I gives an analysis of the incidence of tetanus in battle casualties in the different theatres of war and in the different forces. The total number of cases is 35, and the average per 1,000 wounded (this figure includes 'died of wounds') is 0·12. But it is to be noted that of the 35 cases no fewer than 16 were in men who had not been actively immunised.

The average per 1,000 wounded (0·12) compares remarkably well with the corresponding figure for the Western Front in 1914–18, which was 1·47. There were several factors responsible for the decreased incidence. The terrain was different, for most of the fighting took place over pastoral or desert rather than agricultural land. It is doubtful if the administration of the sulphonamide drugs played any part in reducing the incidence, and treatment with penicillin at the most had a limited effect.

There is one other factor which may have contributed to the reduction of tetanus in this war, and that is improvement in the treatment of wounds. It is well known that the presence in wounds of necrotic tissue, blood clot, foreign bodies, and of other infections, whether pyogenic or anaerobic, all make it easier for *Cl. tetani* to flourish.

The evidence went to show that the active immunisation was the principal cause of the remarkably low incidence. This evidence may be briefly summarised:—

(1) In B.E.F. 1939–40 (with little sulphonamides and no penicillin) there were 7 cases among the non-immunised 10 per cent. and no cases in the immunised 90 per cent.

(2) In M.E.F. (where sulphonamides were used but no penicillin) there were 5 cases among 3,867 South African wounded, none of whom were at that time immunised. Throughout the whole campaign there was only 1 case (immunisation doubtful) in U.K. wounded (27,390), none in Australian wounded (8,270), and only 2 cases (both Maoris) in 7,238 New Zealand wounded, and 3 cases (1 not immunised, 1 doubtful) in 3,330 Indian wounded. The latter categories (exclusive of a small percentage) were all actively immunised.

(3) In B.L.A. there were 6 cases (3 immunised, 2 doubtful) among 103,343 wounded. The German Army was not actively immunised, and among the relatively small number of wounded who were captured (the exact total of wounded prisoners is not available) there were 25 recorded cases and 3 or 4 others of whom there are no records. Compared with the western front in 1914–18, the incidence was reduced from 1·47 per 1,000 to 0·06, or, to put this another way, tetanus was 24·5 times commoner in 1914–18 than in 1944–5.

RESULTS

Table I

(*Boyd*, 1946)

Incidence of Tetanus in Battle Casualties in European and African Theatres of War

Theatre	U.K. troops				Indian				U.D.F.				N.Z.				Australian wounded	Colonial wounded
	Wounded	Cases of tetanus		Rates °/oo	Wounded	Cases of tetanus		Rates °/oo	Wounded	Cases of tetanus		Rates °/oo	Wounded	Cases of tetanus		Rates °/oo		
		+	−			+	−			+	−			+	−			
B.E.F.	16,193	0	7	0·43	0	..	..	..	0	..	..	..	0	..	..	..	0	193*
Norway	404	0	0	0	0	..	..	..	0	..	..	..	0	..	..	..	0	0
M.E.F.	27,390	0	1	0·04	3,330	1	2	0·90	3,867	0	5	1·29	7,238	2	0	0·28	8,270*	0
Malta	565	1	0	1·77	0	..	..	..	0	..	..	..	0	..	..	..	0	145*
B.N.A.F.	20,838	0	1	0·05	787	0	0	0	29	0	0	0	1,396	0	0	0	0	0
C.M.F.	70,319	7	0	0·1	15,019	1	0	0·07	3,299	0	0	0	6,649	1	0	0·15	0	375*
B.L.A.	103,343	3	3	0·06	0	..	..	..	0	..	..	..	0	..	..	..	0	0

\+ = Immunised with 2 or more doses of tetanus toxoid.

− = Not immunised with 2 or more doses of tetanus toxoid; 3 doubtful cases are included in this category.

* No cases of tetanus.

These facts seem sufficiently conclusive. In an analysis of the records of 103 cases of tetanus collected from military and E.M.S. hospitals, Boyd (*Lancet*, 1946) was able to draw some interesting conclusions. The crude case mortality-rate was 46·16 per cent.—little better than in the War of 1914–18. Among battle casualties, however, the recovery-rate was slightly higher among those protected by two or more doses of tetanus toxoid. The giving of prophylactic antitoxin appreciably lowered the case-mortality in those who had been actively immunised, but had little or no effect on those who had not been actively immunised. In men who had been actively immunised the incubation period rarely exceeded ten days and, in those who survived, the duration of symptoms was significantly shorter than in the non-immunised. These facts find a ready explanation when we consider the time needed for the maximum formation of antitoxin in response to infection. The administration of 3,000 units of antitoxin to all wounded men not only lowered mortality but most probably prevented the development of symptoms in border-line cases.

Until some method is available which ensures that active immunisation will be invariably successful it will be necessary to supplement active by passive immunisation.

TETANUS AND THE TREATMENT OF WOUNDS

In connexion with the use of sulphonamides in the treatment of wounds, a case of fatal tetanus* was recorded after an operation for a pyosalpinx in which the infection was traced to a cardboard carton which contained unsterilised sulphapyridine powder poured into the peritoneal cavity.

Spore infection by infected sulphonamide powder applied locally had already been considered as a theoretical possibility before this case was published, and measures had been considered for obviating this danger. The method advocated by Hynson, Westcott and Dunning (Long, 1942) and practised on a large scale in America, depended on the fact that the most resistant spores can be killed at a temperature far below the melting point of sulphonamide if the time of exposure is sufficiently long. By their method, packages were exposed in an oven to a temperature of 145° C. for four hours. At a conference held in November, 1941, between representatives of the Medical Research Council and the Association of British Chemical Manufacturers, this procedure was also agreed on, and because it was not possible to apply it to existing stocks in hospitals and first-aid posts, methods of sterilising powder on a small scale were also considered and recommended. These were:— dry heat maintained at 150° C. for an hour in a paraffin bath (Berry, 1942) or an electric oven; or autoclaving in a dressings' steriliser (Buckland, 1942).

* *Pharmaceutical Journal*, 1942, **94**, 192.

The occurrence of tetanus in association with frostbite has frequently been stressed in German and Russian literature, but, so far as is known, no British troops were thus affected.

AIR-RAID CASUALTIES

The problem of preventing tetanus in air-raid casualties among the civilian population was a different one. Active immunisation of the whole civilian population, or even of the population in areas likely to be raided, was not a practical proposition at the outbreak of war even if it had been considered desirable. The Ministry of Health was therefore forced to rely on the stringent application of passive immunisation as it was used in the Army during the last two years of the War of 1914–18. With the routine use of prophylactic antitoxin after all severe wounds, both in war and in civilian practice, it has been more universally realised that tetanus often follows comparatively slight wounds (Cole and Spooner, 1935; Osborne, 1943). Failure to give antitoxin for these, because they are considered too trivial to merit it, is one of the commonest causes of tetanus. The other important cause is omission of the second and third doses of antitoxin at weekly intervals after wounding and failure to increase the dose in proportion to the severity and type of wound. These injections are important because the protective effect of a single prophylactic dose of antitoxin passes off in from one to three weeks, so that if the wound remains infected clinical tetanus may develop. When a wound is very heavily infected the usual prophylactic dose of 3,000 units is not enough.

To this end the Ministry of Health urged on all doctors working in first-aid posts and in charge of hospitals the importance of the following points (Ministry of Health, 1942a):—

1. A routine prophylactic dose of 3 c.cm. antitoxin equivalent to not less than 3,000 international units, to be given by intramuscular or deep subcutaneous injection to every wounded person however trivial the wound may appear.
2. This dose to be given irrespective of the fact that the patient may have been immunised with tetanus toxoid, and no reduction to be made for children.
3. Two further doses of 3 c.cm. to be given at weekly intervals to all patients not previously immunised with tetanus toxoid, and in the case of severe infection this dose to be increased to two- or three-fold. Notification of all cases of tetanus was also instituted.

RESULTS

No rise in the number of deaths from tetanus occurred in this country during the war period; rather was there a slight decrease in mortality from the disease.

Full reports of the total incidence of tetanus among air-raid casualties are not available, but a review of those which occurred in Sector 9 during the first two years of war shows that in 4,562 civilian air-raid casualties there were only 6 cases of tetanus (Smith, 1942). None of these had received active immunisation but a single prophylactic dose of antitoxin (2,000–3,000 units) had been given. In none had the dose been repeated although in 3 the wounds were severe. Two patients died but the severity of their wounds probably contributed as much as tetanus to a fatal issue.

As a result of the occurrence of such cases, the Ministry of Health again (1942b) emphasised those points about the proper use of prophylactic antitoxin which it had previously stressed.

TREATMENT

During the war there was little opportunity to treat clinical tetanus because there were few cases. Methods had not changed fundamentally since 1918. In the instructions on treatment issued to medical officers the Ministry of Health (1942c) emphasised the importance of a large initial dose of antitoxin (200,000 i.u.) given intravenously as early as possible, followed after an interval of not less than one hour by thorough surgical treatment of the wound. A further injection of antitoxin was only recommended after seven days if the wound was severe. If for any reason the intravenous route could not be used, the intramuscular was the suggested alternative and intrathecal antitoxin was not advised. Nevertheless, so few and so scattered were the cases that with rare exceptions each case was treated by a different doctor, and there was considerable variation in the amount of antitoxin given in different cases. A study of the treatment given to the more severe cases showed that the only factor with any apparent relationship to the recovery-rate was the early administration of large doses of antitoxin by the intravenous route.

TABLE II

Case-Mortality Rate in Relation to Antitoxin Treatment

	Cases	Deaths	Case-mortality per cent.
Total in series	38	21	55
Treated within 36 hours of onset with 100,000 units or more	18	7	39
Not so treated	20	14	70

Many of the cases which ended fatally showed for the first twenty-four hours or longer only mild local symptoms or trismus, and, presumably because of the mildness, heroic treatment was not immediately instituted. It appears advisable to give massive doses intravenously to all cases as soon as symptoms are observed, irrespective of their severity. Sedatives were used in most cases to control reflex spasm. Paraldehyde per rectum was most commonly used, but bromethol, avertin and pentothal were occasionally used. There is no evidence that these drugs had any life-saving properties, though they were undoubtedly of value in relieving symptoms. In some cases spasm, and even trismus, was abolished by their use, but in spite of this the patient's condition continued to deteriorate, and death ensued. Other sedatives, such as chloral hydrate, bromide, morphine and barbiturates, were freely used, but were clearly palliatives and had no influence on the progress of the disease. Neither was there any evidence that penicillin was of any benefit except as an adjuvant to the surgical treatment of the infected wound.

Emphasis was also put on sufficient nourishment in fluid form, if necessary by stomach tube, and good nursing with avoidance of unnecessary manipulations.

Sulphonamides did not affect the action of tetanus toxin in the body. Pneumonia was, however, one of the dangerous complications of tetanus, and sulphathiazole or sulphadiazine in full doses proved of undoubted value in preventing this, if given directly any sign of deterioration in the lung condition appeared (Cole, 1942; 1945).

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CHAPTER XX

(i)

Study of Diphtheria

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THE war period in this country was one of peculiar interest and of special activity in the study of diphtheria.

The special feature of the situation was a remarkable contrast between the Western hemisphere, where diphtheria has been on the decline for many years and has reached unprecedented low levels, and Europe, where diphtheria had remained overall a formidable problem up to the outbreak of war in 1939 and, during the war, assumed epidemic proportions, so that in many countries incidence reached levels never before recorded.

Thus in New York City, diphtheria had fallen from an average of 10,000 cases each year in the period 1920–9, to 400 in 1940, and in Toronto no case was recorded in that year. By contrast, the recent yearly average for London County was stated to be 8,000 in a population considerably lower than that of New York City (Hansard, referred to in *Brit. med. J.*, 1942), whereas Farrago (1940) quotes annual incidences varying from 68·9 to 371·9 per 100,000 of population for five European States in the period 1931–8.

In the U.S.A. and Canada, the great diminution of diphtheria had coincided with a campaign of prophylactic immunisation which in its scope and thoroughness had exceeded anything done on a large scale in Europe before 1939, although a considerable immunisation of the child population had been carried out in this country with various prophylactics; in France, Belgium and Holland, mostly with Ramon's toxoid; and in Hungary there had even been compulsory immunisation with A.P.T. European diphtheria, however, passed from a high level to epidemic proportions during the war and reached a peak in 1943, with rates of incidence per 100,000 of population of 110 in France, 315 in Greater Germany, 655 in Holland and 760 in Norway (the last represents a 420-fold increase in diphtheria since 1939) (Stuart, 1945).

It is noteworthy in this connexion that there had been no prophylactic inoculation in Norway and that Sigurjonsson (1939) in a carefully executed comparison in an isolated community (Iceland), in which the incidence of diphtheria was low, demonstrated a marked inferiority of Ramon's toxoid to A.P.T.

In this country, however, under the stimulus of a marked rise in diphtheria morbidity, an intensive campaign of immunisation was launched in 1940, which culminated in the immunisation of between 50 and 60 per cent. of the children of 0–15 years in the years 1943–5 (Brincker, 1946). This campaign was accompanied by experimental work with laboratory animals and field experiments, in which Schick conversion rates and levels of circulating antitoxin were determined in individuals immunised in various ways (Lewis, 1939, 1940; Saunders, 1940; Swan, 1940; Nicholson and Baker, 1940; Duke, 1940; Warin, 1940; Downie *et al.*, 1941, Fulton *et al.*, 1941, 1942; Leete, 1942; Freeman, 1942; Bousfield, 1942, 1943, 1944; Duke and Stott, 1943).

The main result of these investigations has been to emphasise the value of A.P.T. as the best prophylactic and especially to bring into relief the advantage of an interval of at least three weeks and preferably four weeks or longer between the first and second doses. There is apparently a very marked and sharp rise of immune-body formation in an organism which is exposed to a second injection of antigen when it has become fully sensitised by the earlier one; but an individual already sensitised by previous infection may react very vigorously to a single dose (Downie *et al.*, 1941).

It is clear that some prophylactics of insufficient antigenic potency have been put into circulation from time to time and the generally adopted recommendation as the result of all this work is two doses of 0·3 c.cm. of A.P.T., of a preparation with a minimum potency of 50 Lf per c.cm.

NATURAL SCHICK REACTIONS, CONVERSION RATES UNDER IMMUNISATION, CORRESPONDING LEVELS OF SERUM ANTITOXIN AND PERSISTENCE OF IMMUNITY

In rural and small urban districts the percentage of positive Schick reactions among normal young children has varied from 85 per cent. to 100 per cent., falling to 50 per cent. or even 35 per cent. among older children; whereas children from industrial cities have shown considerably lower rates (Duke, 1940; Freeman, 1942; Fulton *et al.*, 1942; Duke and Stott, 1943). A Schick plus reaction, as in earlier work, was not observed in individuals with 1/50 or more units or circulating antitoxin (Downie *et al.*, 1941).

Conversion rates from 97·6 per cent. to 100 per cent. are recorded by Fulton *et al.*, (1942) in a very large series of cases, but Bousfield (1942) from a very wide experience, is convinced that 1 per cent. or 2 per cent. of children refractory to immunisation are likely to be met in every series.

Fulton *et al.*, (1942) observed that Schick negatives in their group of immunised had fallen to 91·3 per cent. after twelve to fourteen months, whereas Duke and Stott (1943) in a group of 3,000 children Schick negative after immunisation, still found 96 per cent. negative after two years and 82 per cent. after six years. Lewis (1940), following up 49 immunised children, sixteen months after immunisation, with two doses of A.P.T., at fortnightly intervals, found that all had still titrable amounts of antitoxin in their sera, but that 22 were below the level constantly associated with the Schick negative state, i.e. 0·02 units.

Warin (1940) made the interesting observation that the percentage of Schick positives was considerably higher amongst those artificially immunised than amongst those who had had attacks of diphtheria. Sigurjonsson (1939) has emphasised the probable importance of distinguishing between persistence of immunity after prophylaxis in communities in which diphtheria infection contact is frequent, and those in which it is rare.

COURSE OF DIPHTHERIA SUBSEQUENT TO EXTENSIVE IMMUNISATION

The returns of diphtheria morbidity and deaths in England and Wales for 1942, 1943 and 1944 make it quite clear that the diphtheria epidemic which ravaged Europe did develop in this country. Nevertheless, the returns for 1944 show the lowest figures ever recorded in England and Wales.

	Year	Total cases	Total deaths
England and Wales .	. 1942	28,766 (3,689)	1,532 (41)
Children of 0–15 years	. 1943	22,289 (5,043)	1,079 (42)
	1944	17,088 (4,633)	735 (35)

Figures in brackets indicate cases or deaths in the immunised (Brincker, 1946).

This in itself is a sufficiently gratifying result; but if it has been obtained in circumstances which, without immunisation, would have led to an epidemic of unusual severity, it is an example of a great triumph in preventive medicine. The work of the last fifteen years on the typing of the diphtheria bacillus, however, has emphasised the great complexity of the subject of epidemiology in this disease and therefore of the need of caution in the assessment of results both of treatment and of prophylaxis.

NEW BACTERIOLOGICAL METHODS IN DIPHTHERIA

The practice of supplementing cultures on Loeffler slopes by blood-agar media containing potassium tellurite, first extensively used by Clauberg in Germany (1929 and 1931), had gradually been established in this country in the ten years before the war and had, together with the type-differentiation methods worked out by Anderson *et al.*, (1931 and 1933), Christison (1933), Robinson and Marshall (1934), Robinson (1934), Murray (1934a and 1934b), Mair (1936), Clauberg *et al.*, (1936), Cooper *et al.*, (1936), introduced a much higher degree of accuracy into diagnostic and epidemiological work. These methods have been widely although not universally adopted, and have been used to good effect, especially in the Emergency Public Health Laboratory Service, established at the beginning of the war, and for the development of which the late Professor W. W. Topley and subsequently Professor G. S. Wilson have much credit.

This service has carried out much combined laboratory and field work, especially in areas where previously bacteriological services had been neglected or defective, on account of the need to transmit swabs considerable distances by post. Many of these investigations have been recorded in the Monthly Bulletin of the Ministry of Health and Emergency Public Health Laboratory Service. By the elimination of carriers and the combination of passive and active immunisation of the population of many closed communities (Fulton, *et al.*, 1941), they have contributed in a valuable way to the total diminution of diphtheria referred to above.

K.L.B. TYPE INCIDENCE IN THE COUNTRY AS A WHOLE

No figures are available for type distribution in the country as a whole, but analysis of 31 outbreaks in closed institutions, schools, nurseries, etc., up and down the country, recorded by the Emergency Public Health Laboratory Service, probably gives a general indication of distribution. Of 31 such outbreaks recorded in the Monthly Bulletin of the Ministry of Health and Emergency Public Health Laboratory Service, 13 were due to *C. diphtheriae gravis*, 9 to *C. diphtheriae mitis*, 8 to *C. diphtheriae intermedius*, and 1 yielded both *gravis* and *mitis* cases. In 23 of these the total population at risk is recorded and for these the following results were obtained:—

Bacterial type	Population at risk	Cases	Carriers	Cases in immunised as percentage of total cases
Gravis . .	1,241	40	119	54
Mitis . .	1,286	33	91	13
Intermedius .	595	29	56	9

In four of the *gravis* and in one each of the *mitis* and *intermedius* outbreaks, infection (cases and carriers) reached 30 per cent. or more of the community concerned, which may be considered an epidemic incidence.

In addition, all the data with regard to type-incidence available in 1942 from the Emergency Public Health Laboratory Service and associated laboratories were published in the Monthly Bulletin of the Ministry of Health and Emergency Public Health Laboratory Service, 'Epidemiological Notes' (1943) and have also been carefully analysed by Russell (1943). These figures show *gravis* as the most frequent type in this country, especially in the north.

DIPHTHERIA IN THE NEW-BORN

As the result of the work done on this subject by the bacteriologists in the Emergency Public Health Laboratory Service some interesting new light has been shed on the general problem of diphtheria immunity.

Fatal cases of diphtheria in infants were recorded from Cambridge (Downie, 1941), *mitis* infection; Cardiff (Wilson and Allison, 1943), *intermedius* infection; and Poole (Chesney, 1945), *mitis* infection. In view of the general impression that young infants acquire sufficient immunity from their mothers, Chesney's careful observations on the antitoxin content of mother's blood and failure of transmission through the milk or placenta are valuable, and Payling Wright's and Charles's (1944) observations on Schick levels in recently confined women and their children emphasise further the diphtheria-risk for infants. About 50 per cent. of parturient women even from cities were found Schick plus, and these included some who had had diphtheria. It would appear, therefore, that many mothers themselves protected by latent immunity bear infants who are open to attack by diphtheria, although this may be less so in communities highly infected with diphtheria in which the mother's latent immunity is frequently reinforced by abortive infection.

DIPHTHERIA IN THE IMMUNISED

The statistics of the Ministry of Health show that approximately 30 per cent. of the children of England and Wales had been inoculated against diphtheria at the end of 1941 and that by June, 1945, the numbers of immunised had risen to about 60 per cent. (quite exact figures are not available, as some of those immunised earlier have passed out of the 0–15 years' group). In the years 1942, 1943 and 1944, therefore, when roughly half the child population was immunised and half un-immunised, the figures for incidence of diphtheria were 55,000 in the non-immunised and 13,000 in the immunised, i.e. nearly five cases in the first group for every one in the latter. The value of immunisation is much more emphasised, however, by the contrasts in fatal cases—these were 3,228 in the non-immunised and 118 in the immunised, i.e. 27 in the first group to 1 in the latter. More detailed information relating the disease in the inoculated to the type of infection is available in some areas, apart from the observations by the Emergency Public Health Laboratory Service already referred to.

Thus in Leeds, which passed through a severe *gravis* epidemic some years ago, and had a child population about 80 per cent. inoculated, and where *gravis* was still the predominating bacteriological type, it was found that the ratio of cases in the immunised to those in the non-immunised was slightly below one in five, much as in the country as a whole. Cases in the immunised occurred with all three types, but those with *gravis* were, relatively to the general incidence of the types in all cases, the most numerous.

Very similar results had been recorded for Liverpool by Glover and Wright (1942) in the period 1937–9, in which diphtheria was relatively severe and the highest case death-rates were associated with *intermedius* infections.

Figures for Type Incidence

	(*a*) Among whole population per cent.	(*b*) Among inoculated per cent.
Gravis	45·0	57·7
Intermedius	20·8	29·2
Mitis	34·2	13·1

From Gateshead (Grant, 1945), we have observations on the efficacy of immunisation in a community during a manifestation of severe epidemic diphtheria. This community was very poorly immunised at the start of the epidemic but by the end of 1942, approximately half the child population had been 'fully immunised'. The epidemic was due to *C. diphtheriae gravis* of the immunological type (i) of Robinson and Peeney (1936). In this population the figures for diphtheria in the 'fully immunised' for the years 1943 and 1944 were 205, and in the non-immunised 438; a ratio approximating to 1 to 2 and very different from that for the country as a whole (Grant, 1945). The great value of prophylaxis is brought out the more strongly, however, since there were no deaths in the first group and 29 in the second. There were several deaths in the partly immunised in this period and one in the 'fully immunised' in 1941.

Very similar findings with regard to diphtheria in the immunised are reported by Robertson for Dundee (1943) and by Gaffney for Dublin (1943), in the course of epidemic diphtheria due to the *gravis* type of bacterium. The contrast between these figures and those obtained, e.g. in Northants (*Lancet*, 1943):—

36,250 children immunised—1 case.
19,400 children non-immunised—101 cases.

which correspond to the North American figures, is sufficiently striking and strongly suggests that other factors besides slight differences in the percentage of children inoculated or the brand of prophylactic used are in play.

AGE INCIDENCE

A greater relative incidence of diphtheria in the higher age groups has been a subject of remark in some parts of Europe for the last two decades (Bamberger and Lachtrop, 1936; Spörl, 1936; Zischinsky, 1934; Rostoski, 1938); but has not been observed in the U.S.A. (Russell, 1943). This has been variously attributed to immunisation and to changes in social conditions (Cheeseman *et al.*, 1939; Russell, 1943). It is noteworthy that laryngeal diphtheria had much diminished in Europe at the same time and, since extended series of typed diphtheria cases show a much higher incidence of laryngeal involvement in *mitis* infections (McLeod, 1943), it seems possible that the changed age-incidence may be related to change in type of diphtheria. This possibility has been overlooked, or at all events left out of account, by many of those who have discussed the subject, as Seckel (1939).

Whatever the ultimate explanation may be, it is a trend which continued in this country during the war period (Wright, 1941; Russell, 1943).

CLINICAL FEATURES OF DIPHTHERIA DURING THE WAR PERIOD

In respect of the clinical features of the disease, nothing entirely new has arisen, but certain points have received fresh emphasis. Notable among these were the importance of the nasal carrier and hence the need to examine nose—as well as throat—swabs, in looking for carriers; the importance of alertness in recognising the hypertoxic case, in which swelling and reddening of the tonsils with oedema of neck and swelling of lymph glands may precede any very frank membrane formation (Grant, 1944); and finally the fact that in the early stages the differentiation of diphtheria from follicular tonsillitis may be difficult, especially in the diphtheria of the immunised (Neubauer, 1943).

OBSERVATIONS ON TOXIN AND ANTITOXIN

O'Meara (1939 and 1940) in Dublin drew attention to the possibility of a second toxic factor important in severe diphtheria infections, and to possible defects in the specially refined antitoxin at present in vogue. McLean (1941) was not, however, able to obtain a diffusing factor similar to that obtained from streptococcus and *Cl. welchii* from K.L.B. strains examined; but examination of antitoxin by electrophoretic methods has demonstrated that the more avid portions of anti-serum are lost in the processes of refinement commonly adopted (Kekwick *et al.*, 1941). Another interesting suggestion on toxin production is Mueller's (1941), that it may be controlled *in vivo* by the iron content of the tissues. This has been supported by the work of Zinnemann (1943) in this country, the point made being that *gravis* strains produce toxin better than others in media rich in iron.

OBSERVATIONS ON CROSS-INFECTION IN HOSPITALS DUE TO FLOOR DUST

One other new and valuable observation has been the demonstration of the surprising persistence of K.L.B. in large numbers in ward floor dust (Crosbie and Wright, 1941). This finding readily explains the cross-infection of types repeatedly demonstrated in hospital wards by the methods of type differentiation.

The possibility of markedly abating this danger by treating floors with spindle oil has been demonstrated by Van den Ende *et al.*, (1940).

SUMMARY

The severe type of diphtheria associated with the starch-fermenting variants of the *C. diphtheriae*, which was noted in Yorkshire and in the North Midlands in the eight years preceding the war, spread to the West and North during the war and might have been responsible for an outbreak similar to those which occurred in many countries in Europe, but was apparently largely controlled by a vigorous inoculation campaign instituted in 1941. The results, however, were much below those obtained in North America. There is considerable evidence to suggest that this is due to the increased prevalence of *C. diphtheriae gravis*, and it has yet to be determined whether the strain associated with the peculiarly severe epidemics in many parts of Europe was an immunological variant of this type, which is even more difficult to control by immunisation, or whether a combination of many factors, dietetic and other, contributed to raise the virulence of a number of distinct strains of the K.L.B. in these areas.

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(ii)

Diphtheria in the B.L.A.

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Diphtheria became a serious problem during the campaign in N.W. Europe; although the total number of cases was low compared with such diseases as scabies and urethritis, the wastage of man-hours was considerable in view of the long period spent in hospital. In the early stages of the campaign, when the fighting was confined to a narrow strip of Normandy and contact with civilians was rare, cases were infrequent, but after the rapid advance through France and into Belgium, Holland, and later Germany, there was a marked increase in the incidence of the disease. The cases were, however, mainly sporadic, and at no time reached epidemic proportions. Some indication of the extent of the disease is given in Table I; the figures are those of bacteriologically confirmed cases in 21 Army Group during the latter part of 1944 and the beginning of 1945. They consequently represent the minimum incidence of diphtheria in that theatre of war during that period, as it is certain that all definite cases were not confirmed by bacteriological examination.

TABLE I

Cases of Diphtheria (Bacteriologically Confirmed) in 21 *Army Group*

1944		1945	
		January	504
		February	380
November	138	March	272
December	252	April	153

Semi-official returns for this period gave the following figures:—incidence of diphtheria in 21 Army Group per 1,000 strength—June, 1944, to March, 1945 = 0·235; January, 1945 to March, 1945 = 0·454.

A. EPIDEMIOLOGY

The main factors concerned in the spread of diphtheria are the virulence and distribution of the infecting organism and the resistance of the community.

1. *Virulence and Distribution of* C. diphtheriae *in N.W. Europe*

There had been a considerable increase in the incidence of diphtheria among many European countries since the outbreak of the war. (Table II.)

TABLE II

Diphtheria Incidence (Rates per 100,000 *Population)*

	1939	1943
Germany	180·9	287·2
Belgium	28·8	191·6
France	35·9	118·7
Netherlands	14·6	638·9
Great Britain	114·0	84·0

The rise had been particularly marked in the Netherlands, where the incidence of the disease had increased some fifty times from 1939 to 1943. Probable factors responsible for this alarming increase were: (*a*) overcrowding due to war-time conditions, in particular the bombing of all important industrial centres and consequent crowding in air-raid shelters, (*b*) the breakdown of pre-war immunisation programmes, (*c*) the lowered resistance of the individual due to underfeeding, and (*d*) inadequate control and treatment of cases due to lack of medical officers and reduced hospital facilities—one small outbreak among British troops in June, 1945, in a small German town was traced to a German civilian who had been discharged, while still harbouring many

C. diphtheriae gravis in the throat, after only a week in hospital. Conditions thus favoured the spread of infection as the sudden entry into the liberated countries of large numbers of troops during the winter months, which proved to be very cold, led to further overcrowding as well as the introduction of many susceptible individuals.

2. *Resistance of the Community*

Schick testing is not a practical proposition during periods of active operations and therefore a general indication of the resistance or susceptibility of the troops of 21 Army Group was not obtained. Schick testing was, however, carried out in such closed communities as general hospitals, and the results showed that some 30–60 per cent. of the personnel were Schick positive, i.e. susceptible. These results agreed with observations made elsewhere on similar adult British communities and could be reasonably taken as an index of the resistance of the personnel of 21 Army Group as a whole. As the prevailing conditions favoured the spread of infection, the incidence of diphtheria among Service personnel was surprisingly low. Probable reasons for this are the energetic precautionary measures adopted and the limited mixing with civilians by forward troops.

B. PREVENTIVE MEASURES

Immunisation of the whole force was impracticable owing to operational activities, but all British medical units, e.g. General Hospital, C.C.S., etc., and associated units, e.g. dental, coming into close contact with patients, were Schick tested and all susceptibles were immunised by a course of T.A.F. It is important to note that, contrary to general statements on the subject, some adults react vigorously to T.A.F. and may develop temperatures up to 103° F.

In view of the impracticability of immunisation and the wide distribution of diphtheria in the theatre of war, an extensive propaganda campaign against diphtheria was instituted and instructions were issued to medical officers that in view of the prevalence of the disease, (i) all suspicious cases were to be isolated immediately and treated as diphtheria until proved otherwise, (ii) all close contacts and any person suffering from a sore throat were to be examined without delay and, if necessary, kept isolated and under close observation, (iii) all persons developing sore throats or running noses within the next ten days must report sick immediately.

These measures proved effective but clearly indicated that the majority of medical officers had had little previous experience of diphtheria; some 70 per cent. of the early cases diagnosed provisionally as diphtheria were proved to be conditions such as Vincent's angina, acute streptococcal tonsillitis and infectious mononucleosis. For this reason it was considered that figures for diphtheria obtained from

Army Form A.35 were wholly misleading and instructions were issued that Army Form A.35 should be completed by the medical officer making the final, and not the tentative, diagnosis. Preliminary notification of suspected cases was made by telephone or teleprint to all interested parties.

The routine swabbing of close contacts in such an open community was impossible in view of the frequent and rapid movement of troops, the number usually involved, and the difficulty in tracing all persons concerned. Mobile bacteriological laboratories were placed in strategic positions to cope with any demand for bacteriological investigations. In a closed community, such as a hospital ward where the number of contacts was limited and could be easily controlled, swabbing and segregation were carried out and, whenever possible, the ward was closed until ten days after the isolation of the last case.

C. CLINICAL

The clinical manifestations varied considerably from the severe fulminating haemorrhagic or 'bull-neck' types to the mild atypical forms, the diagnosis of which was difficult because membrane formation might not occur. Treatment consisted essentially of isolation and early adequate dosage with antitoxin, plus complete rest in bed; a minimum dose of 16,000 units intramuscularly was given for a mild or suspected case, and this dose was increased according to the severity of the case.

D. BACTERIOLOGY

In every case bacteriological confirmation of the clinical diagnosis was attempted. Swabs were plated on blood-agar plates, tellurite plates and Loeffler serum slopes. The tellurite medium was prepared by adding 0·035 per cent. sodium or potassium tellurite, with 5 per cent. sterile fresh horse blood, to melted agar at 50° C. Whenever possible two swabs were collected; one was used for the preparation of films to exclude Vincent's angina and the other for the cultures. The tellurite media proved particularly valuable for the clearance tests; Loeffler slopes alone were unsatisfactory for this purpose as they were not infrequently negative when the tellurite plates gave positive results. Typing of the strains was carried out whenever possible; the results from 840 strains are given in Table III.

TABLE III

Strain Incidence of C. Diphtheriae (840 *Strains*)

Mitis	312 (37 per cent.)
Intermedius . . .	318 (38 " ")
Gravis	210 (25 " ")

There was no striking predominance of any particular type: this is not surprising as most of the cases were sporadic. *Intermedius* strains, however, tended to be common among prisoners-of-war. On recovery, clearance tests consisted at first of three consecutive negative throat and nose swabs. It was later found that these tests did not provide a satisfactory criterion of clearance from infection and more vigorous tests were recommended; these required three consecutive negative nose and throat swabs taken at intervals of forty-eight hours, followed one week later by a fourth negative nose and throat swab. When recovered patients had been in hospital for five weeks and were still bacteriologically positive, they were considered to be carriers and were transferred to a special centre (110 Br. Gen. Hosp.) for further treatment.

E. TREATMENT OF CARRIERS

The treatment of carriers in the field is a most important, though difficult, problem. As indicated in Section D, all recovered individuals still harbouring *C. diphtheriae* after five weeks were considered as carriers and were segregated in a special centre. Here it was necessary not only to clear the infection but also to rehabilitate the men by exercise and graded P.T. Attempts to clear the infection were made by various methods, in particular by the local application of penicillin in the form of either lozenges or sprays. The results were disappointing, particularly as *C. diphtheriae* is relatively sensitive to this antibiotic. It was, however, found that the organisms tended to persist deep in the crypts of the tonsils and so did not always come into contact with the penicillin: in such cases the most satisfactory form of therapy was tonsillectomy. Virulence tests were not usually carried out in persistent infections with *gravis* and *intermedius* strains in view of the shortage of guinea-pigs. It is, however, interesting to note that two strains, isolated from persistent carriers, gave the typical cultural and biochemical reactions of the *gravis* type and yet proved to be avirulent. *Mitis* strains were checked for virulence and some were avirulent. Cases harbouring such avirulent strains were transferred to a convalescent depot.

SUMMARY

Diphtheria proved a serious source of man wastage in B.L.A. but never reached epidemic proportions.

The general application of Schick testing and specific immunisation proved impracticable.

Intensive propaganda and early segregation of suspected cases proved effective.

The use of local application of penicillin proved disappointing as a means of clearing carriers.

CHAPTER XXI

FOOD POISONING

By V. D. ALLISON
M.D.

UNTIL September, 1939, outbreaks and suspected outbreaks of food poisoning which came to the notice of the Ministry of Health were investigated in whole or in part in the Ministry's Pathological Laboratory at Dudley House, London. On the outbreak of war the Emergency Public Health Laboratory Service came into operation with a network of laboratories covering England and Wales, and was administered from Oxford by the Medical Research Council on behalf of the Ministry of Health. The Service issued a 'Summary of Weekly Returns' reporting the incidence of notifiable infectious diseases, including food poisoning, covering Southern England and Wales until May 11, 1940, but from May 18, 1940 onwards the returns covered the whole of England and Wales. The returns included notes on outbreaks of food poisoning, numbers of specimens examined and the results of bacteriological examination. Many existing public health laboratories under the control of local authorities, and hospital laboratories carrying out public health laboratory work for local authorities, co-operated with the Emergency Public Health Laboratory Service, so that information of epidemiological value was regularly sent to headquarters at Oxford. Such laboratories became known as Associated Laboratories. Arrangements were made for the laboratory diagnosis of rare or unusual infections, requiring special techniques, to be carried out in specialist laboratories; the services of these laboratories were available for the examination of specimens from all parts of the country. Monthly progress reviews of the work of the Service and associated laboratories were circulated from April, 1940, until November, 1941, when they were replaced by the Monthly Bulletin of the Ministry of Health and Emergency Public Health Laboratory Service, which is now a regular publication. These reviews and reports included many articles on, and short accounts of, outbreaks of food poisoning investigated locally by pathologists in the Service and associated laboratories, in co-operation with the sanitary authorities concerned. The present review has been compiled from information in the weekly reports, monthly reviews, monthly bulletins and the files of the Ministry of Health. The data on salmonella outbreaks given in the Ministry of Health Report (1946) have been revised and the present report includes additional information derived from other sources, in particular, the various reports of the Emergency Public Health Laboratory Service. The figures for salmonella outbreaks quoted below will therefore be found to be considerably higher than those in the Ministry's Report for 1946.

VARIETIES OF FOOD POISONING

Most outbreaks of food poisoning are bacterial in origin and may be conveniently grouped into (*a*) outbreaks due to infection with salmonella, (*b*) those in which a toxic product of bacterial growth in food is the cause, either presumed on clinical and epidemiological grounds or confirmed by additional laboratory evidence. There is another small group in which chemical poisoning conveyed in food or drink may be the cause of outbreaks; and finally, there is a residue of outbreaks caused by infection of food with organisms causing bacillary dysentery of either Sonne or Flexner type.

Among reported outbreaks there was a considerable group in which the illness was confined to a single family or to a single person, and no cause of the illness was ascertained. In some instances this was due to the impossibility of obtaining suitable specimens for laboratory investigation, and in many it may be presumed that the illness was due to the consumption of food improperly cooked, or otherwise unsuited to the digestion of the individual. This group showed a considerable increase in 1942 (Table I), but an apparent decrease in 1943 and 1944 was due to the elimination of single cases in which no useful investigation was possible, and dietetic indiscretions or allergic reactions appeared to afford a rational explanation.

The numbers of outbreaks of food poisoning which came under official notice during the six years 1939–44 are shown year by year in Table I. The total outbreaks in each year have been classified in relation to the cause as far as this was ascertainable. The table shows a steady increase in the number of outbreaks reported year by year, in spite of the elimination in 1943 and 1944 of reports of single cases considered to be due to causes other than food poisoning. The great increase in the number of outbreaks in 1944 (496) over 1943 (314) is noteworthy and is reflected in the increase in the number of infections due to salmonella organisms; this will be referred to again later in this review. The gradually increasing numbers of outbreaks reported from 1941 onwards was undoubtedly due in part to the increased facilities for laboratory investigation afforded by the Emergency Public Health Laboratory Service and its associated laboratories. An additional factor was the increased awareness of medical officers of health and general practitioners of the help which the improved techniques of laboratory investigation could give in isolating and identifying the bacteria causing outbreaks of food poisoning, and tracing the infecting agent from the victims, via the vehicle, to its source. With such facilities for both laboratory and field investigation available at hand, many more outbreaks, especially those mild in nature and involving few persons, were brought to the notice of the laboratory and fully investigated. In July, 1943, a memorandum was published in the Monthly Bulletin of the Ministry of Health and Emergency Public Health Laboratory

Service on the laboratory diagnosis of enteric fever, dysentery and bacterial food poisoning. This explained how the laboratory could help in establishing or confirming the diagnosis in suspected outbreaks of food poisoning. The memorandum was later circulated to medical officers of health and numerous practitioners in all parts of England and Wales.

OUTBREAKS DUE TO TOXIC PRODUCTS OF BACTERIAL GROWTH

A considerable number of outbreaks were attributed to the ingestion in food of toxic products of bacterial growth. The diagnosis was based on (1) the character of the illness—acute onset with vomiting and abdominal pain, frequently accompanied by diarrhoea, within 2–6 hours (average 3 hours) of eating the suspected food, varying degrees of prostration and dehydration, followed by rapid recovery in 2–3 days from the onset; (2) the recovery from the suspected food, and sometimes from the vomit or excreta of patients, of specific bacteria, known or suspected to be capable of producing an enterotoxin. In many outbreaks (Liverpool, 1941; Watford, 1942; Leicester, 1942; Abingdon, 1943; Barnstaple, 1943; Dorchester, 1943; Winchester, 1944; Cardiff, 1944; Norwich, 1944) from which material was obtained for laboratory examination, the predominant organisms found in the incriminated foodstuffs were coagulase-positive staphylococci, and these were found in such large numbers (10 million to upwards of 3,000 million per g.) as to justify, when combined with the clinical and epidemiological evidence, the conclusion that preformed staphylococcal enterotoxin was responsible for the symptoms. In other outbreaks, although the clinical histories provided convincing evidence that the illnesses were due to toxin, coagulase-positive staphylococci were either not found in the suspected foods or were present in such small numbers as were considered insufficient to warrant a diagnosis of food poisoning due to staphylococcal enterotoxin. From a number of specimens of incriminated foods, organisms other than staphylococci were cultured in large numbers; these included *Proteus vulgaris* (Oxford, 1941; Cooper, Davies and Wiseman, 1941), *Str. viridans*, *Str. faecalis* (Topley, 1945), aerobic sporing bacilli (Winchester, 1944; Oxford, 1941), lactose fermenting and non-lactose fermenting coliform bacteria. Many of the outbreaks associated with the presence of these organisms in the suspected food had an incubation period of 12–15 hours, and, while the attacks were often less acute than those caused by staphylococcal enterotoxin, they lasted longer and convalescence was slower.

The ability of certain strains of staphylococci growing under suitable conditions to produce a toxin which, when swallowed by man causes vomiting and diarrhoea, is now well recognised as a result of the observations of Jordan and Burrows (1934) and other workers. Their work has shown that while man and monkeys are both susceptible to staphylococcal filtrates taken by mouth, the susceptibility of the monkey is much less than that of man. Whereas as little as 2 ml. of a potent staphylococcal filtrate may produce a violent reaction in human volunteers, as much as 25 ml. to 50 ml. may be necessary to produce a similar reaction in the monkey. The introduction by Dolman, Wilson and Cockcroft (1936) of the kitten test for staphylococcal enterotoxin, whereby vomiting occurs following intraperitoneal injection of staphylococcal filtrate, was promising, but further investigations carried out by Fulton (Oxford, unpublished) during the war years seemed to cast some doubt on the specificity of the test, and it is now little used in this country. Fulton examined at Oxford the bacterial flora of suspected foods from 35 outbreaks of food-poisoning during the war years. In one outbreak the food contained large numbers of coagulase-positive staphylococci, in 5 outbreaks *Proteus vulgaris* was present, and in 3 the two organisms were associated. In the remaining 26 outbreaks the suspected food contained a mixed flora of apparently banal organisms, although the counts were very often high. Forty-six foods from outbreaks were injected intraperitoneally into kittens, and twelve caused vomiting. Unheated extracts of 78 strains of bacteria were tested similarly for kitten toxicity in 4 ml. amounts and 45 (58 per cent.) caused vomiting with or without diarrhoea. The types of bacteria which proved toxic in kittens were: lactose fermenting and non-lactose fermenting coliform bacilli, *Proteus vulgaris*, *Staphylococcus aureus*, *Staphylococcus albus*, and aerobic sporing bacilli. Several strains of micrococci and *Str. faecalis* proved non-toxic. No definite conclusions could be drawn from the observations, owing to doubt of the validity of the kitten test, and to the need for elucidation of the mechanism of action of staphylococcal enterotoxin. The ability of organisms other than *Staphylococcus aureus* to form toxic products in foodstuffs, able to cause food-poisoning of the toxin type, is therefore still not proven, though the available epidemiological and laboratory evidence is highly suggestive. The application by Wilson and Atkinson (1945) and Gillespie (1947) of bacteriophage typing, and by Hobbs (1944), Cruickshank (1943), Duncan (1944) and Murphy and Edward (1944) of serological typing of coagulase-positive staphylococci, to the investigation of outbreaks of toxic food-poisoning, afforded further convincing evidence of the importance of these organisms as causes of food-poisoning, and proved the identity of strains of staphylococci isolated from the nose and hands of food-handlers with strains isolated from the incriminated foodstuff and from the vomit or excreta of victims of the outbreaks.

Laboratory investigation of outbreaks due to staphylococcal enterotoxin demonstrated the importance of heavy nasal carriers of *Staphylococcus aureus* among food-handling personnel as the sources of food infection. *Staphylococcus aureus* was frequently cultured from the hands of heavy nasal carriers, and stressed the need for observance of personal hygiene and avoidance of unnecessary handling of food. Typing by agglutination or bacteriophage methods of strains of coagulase-positive cultures of *Staphylococcus aureus* isolated from vomit and dejecta of victims of the toxin type of food poisoning, from suspected food and from the hands and noses or skin lesions of persons preparing and handling the food, provided convincing evidence in several outbreaks (Barnstaple, 1943; Dorchester, 1943; Duncan, J. T., 1944) that the path of infection lay via the nose and hands or septic skin lesion of the food-handler to the food. Infection of the food was followed by rapid multiplication of the organisms under suitable conditions of temperature, and accompanied by the elaboration of enterotoxin in the food. The enterotoxin produced by *Staphylococcus aureus* is comparatively heat-resistant and subsequent cooking of the food, though it may kill the organisms or even render the food sterile, does not necessarily render it innocuous.

TABLE I

Outbreaks of Food Poisoning in England and Wales 1939–44
Classified in Relation to Cause

Year	No. of out-breaks	Cause of outbreaks						
		Salmon-ella infec-tion	Toxin presumed or confirmed		Nil found or no lab. investiga-tion possible	Chemical	Dysentery	
			On clinical, epidemio-logical and bacterio-logical grounds	On clinical and epidemio-logical grounds only			Sonne	Flexner group
1939	83	47	8	14	8	—	5	1
1940	161	122	5	27	1	—	4	2
1941	208	120	17	47	20	—	3	1
1942	281	104	12	44	114	4	2	1
1943	314	262	26	15	7	3	1	—
1944	496	454	10	14	17	1	—	—

Table I shows the increase in the number of outbreaks of the toxin type which occurred from 1941 onwards; these represent the outbreaks which came to official notice, but it is certain that many more outbreaks of the toxin type, mild in nature or confined to individual households, were never reported, and the figures may be taken to represent the general trend of increasing incidence from 1939 onwards. Some of these outbreaks involved large numbers of persons, particularly when the illnesses arose from infected food prepared and contained in communal restaurants and canteens attached to industrial establishments, schools, Service camps and training centres. The great increase in communal feeding that developed during the war years, the employment of untrained kitchen personnel lacking knowledge of the importance of personal and general hygiene in the handling of food, and the shortage of equipment and of adequate storage and refrigerator facilities, were important factors in facilitating many outbreaks.

Field investigations of a number of these outbreaks showed that the lapses which occurred most frequently were the partial preparation of food some hours before it was due to be served, the keeping of such food in warm kitchens or under conditions that promoted the growth of bacteria, the use of unclean utensils, excessive and unnecessary handling of food, insufficient hand-washing with inadequate facilities such as wash-basins, towels and soap, and on occasion the handling of food by personnel suffering from skin sepsis, especially of the hands and face or nose.

OUTBREAKS CAUSED BY SALMONELLA ORGANISMS

Table I shows the number of outbreaks caused by salmonella organisms which came to official notice year by year from 1939 to 1944, while Table II analyses them further, showing the number of cases involved in the outbreaks, the number of deaths and the salmonella types responsible. The number of outbreaks recorded in 1939 (47) was considerably less than in 1938 (72), but it is recognised that these figures do not represent the true incidence of salmonella infection throughout the country and there is little doubt that many outbreaks were not officially notified. Between 1923 and 1939 there had been a fairly steady rise in the recorded number of outbreaks of food poisoning due to salmonella; this was probably due more to the increasing recognition of salmonella than to any actual increase in the amount of infection. Up to 1942 the numbers of outbreaks recorded were within the limits of expectation, if the pre-war rise had continued at the same rate. In 1943 and 1944, however, the numbers of salmonella outbreaks showed an increase on a scale very much greater than could be attributed to improved diagnostic facilities, or to the rapid development of communal feeding in works and school canteens and restaurants, and investigations suggested that during the latter part of 1942 a fresh source of salmonella infection had been introduced.

During the years 1923–39 only 14 different species of salmonella were identified as the cause of food poisoning in this country, and reference to the Annual Reports of the Chief Medical Officer of the Ministry of Health shows that never more than nine species were isolated in any one year. These included such well-known species as *typhimurium*, *enteritidis*, *thompson*, *newport*, *cholerae-suis*, *morbificans-bovis*, *dublin*, *derby*, *stanley*, *london*, and *aberdeen*. These species con-

TABLE II

Distribution of Salmonella Types as Causes of Outbreaks of Food Poisoning in England and Wales 1923–44

Salmonella type	1923–39	1940	1941	1942	1943	1944	Total
S. typhimurium	234	38	65	35	108	185	665
S. enteritidis	54	17	10	11	24	55	171
S. thompson	49	19	20	9	19	20	136
S. newport	29	13	5	11	10	91	159
S. dublin	8	5	1	2	2	1	19
S. bovis-morbificans	8	2	—	3	6	3	22
S. cholerae-suis	14	1	2	3	1	1	22
S. stanley	3	—	1	—	—	—	4
S. aberdeen	3	1	1	—	—	—	5
S. london	1	9	—	—	—	—	10
S. derby	2	4	—	—	2	3	11
S. potsdam	3	2	2	—	—	—	7
S. senftenberg	3	2	—	1	2	1	9
S. eastbourne	2	—	—	—	—	—	2
S. gallinarum	—	1	—	—	—	—	1
S. newington	—	1	—	—	—	—	1
S. reading	—	—	3	—	—	—	3
S. anatum	—	1	1	2	4	4	12
S. montevideo	—	—	2	1	17	17	37
S. concord	—	—	1	—	—	—	1
S. oranienberg	—	—	—	10	30	36	76
S. bareilly	—	—	—	1	3	2	6
S. braenderup	—	—	—	1	—	—	1
S. essen	—	—	—	1	—	—	1
S. oslo	—	—	—	1	—	—	1
S. virchow	—	—	—	1	—	—	1
S. meleagridis	—	—	—	1	7	11	19
S. cardiff	—	—	—	1	—	—	1
S. chester	—	—	—	—	5	2	7
S. kentucky	—	—	—	—	2	1	3
S. javiana	—	—	—	—	1	—	1
S. san-diego	—	—	—	—	1	—	1
S. sundsvall	—	—	—	—	1	—	1
S. tennessee	—	—	—	—	4	2	6
S. muenchen	—	—	—	—	2	—	2
S. adelaide	—	—	—	—	4	—	4
S. give	—	—	—	—	—	1	1
S. new-brunswick	—	—	—	—	—	1	1
S. panama	—	—	—	—	—	1	1
S. pullorum	—	—	—	—	—	1	1
S. worthington	—	—	—	—	—	1	1
S. saint-paul	—	—	—	—	—	1	1
Not typed	15	6	6	9	7	13	56
	428	122	120	104	262	454	1,490

tinued to appear as the cause of food-poisoning outbreaks throughout the war years, but in the latter half of 1942 a number of new species, hitherto unknown in this country, began to appear, and their incidence continued to increase in 1943 and 1944. In 1942 no fewer than 18 different species were identified, which was double the number found in any one year up to 1939; 22 different species were identified in 1943 and 23 in 1944.

Among the new species most frequently encountered were *oranienburg*, *montevideo*, *meleagridis*, *bareilly* and *anatum*, and it was immediately realised that many of the numerous salmonella strains isolated concurrently from imported American spray-dried egg were similar in serological types. This article of food was imported during the early years of the war, but it was not until July, 1942, that the first retail distribution to housewives was begun. Investigations of the epidemiology of a number of these salmonella outbreaks, and bacteriological examination of numerous samples of imported spray-dried egg by the bacteriological laboratory of the Ministry of Food and by the Emergency Public Health Laboratory Service, confirmed the importance of this foodstuff as a possible source of salmonella infection in man. Of the salmonella types isolated from outbreaks between 1942 and 1944, many such as *typhimurium*, *newport*, *derby*, *anatum*, *montevideo*, *oranienburg*, *bareilly*, *muenchen* and *worthington* are among the types most frequently isolated in the United States from fowls (Edwards and Bruner, 1940, 1943). These birds constitute the greatest reservoir of salmonella infections among domestic animals in the United States. As spray-dried egg was at that time the most important source of first-class protein in the national diet, the Ministry of Food, on the advice of the Medical Research Council, drew up urgent recommendations to the bakery, confectionery and catering trades and to the retail consumer, calculated to diminish the risk of food poisoning from the use of dried egg. The many investigations of the bacteriology of dried egg, of salmonella infections of human beings associated with the consumption of dried egg, and of salmonella infection of pigs probably due to dried egg, were incorporated in a report (1947) of the Medical Research Council. This shows that the bacteriological examination of 7,584 samples of dried egg between February, 1943, and August, 1945, revealed the presence of living salmonella in 9·9 per cent.; the organisms were usually present in very small numbers and were never found to exceed 30 per gram. Among 840 strains of salmonella isolated from dried egg samples, 33 separate serological types were identified and only 16 strains remained unidentified. Table III, taken from this report, shows the types of salmonella identified among 840 strains isolated from 754 samples of dried egg; two or more serologically distinct types were isolated from 53 samples. The appearance of the new species of salmonella as causes of outbreaks of food poisoning coincided with the beginning of the retail distribution of spray-dried egg, and the species identified in many outbreaks were those which were most commonly isolated from dried egg. A number of the species of salmonella indigenous

TABLE III

Types of Salmonellae Isolated from Dried Eggs (840 *Strains*)

Type	No. isolated	Type	No. isolated
S. oranienburg	245	S. gallinarum	3
S. montevideo	139	S. derby	3
S. meleagridis	117	S. manhattan	2
S. tennessee	90	S. potsdam	2
S. bareilly	82	S. stanley	1
S. anatum	30	S. sundsvall	1
S. typhimurium	30	S. bredeney	1
S. newport	24	S. minnesota	1
S. senftenberg	8	S. muenchen	1
S. london	6	S. habana	1
S. worthington	5	S. bovis-morbificans	1
S. cerro	5	S. newington	1
S. thompson	5	S. litchfield	1
S. give	4	S. california	1
S. kentucky	4	S. horsham	1
S. oregon	4	S. rubislaw	1
S. cholerae-suis	4	Unidentified	16

to this country, such as *typhimurium*, *newport*, *london*, *thompson* and *derby*, were also isolated from dried egg samples, and there is little doubt that a considerable part of the increase in the number of outbreaks of salmonella food-poisoning from 1942 onwards was due to infection conveyed by imported dried egg. It was often difficult to obtain direct evidence incriminating dried egg as the source of infection in a number of outbreaks where the available data suggested this article of food as the origin, but the report gives details of four outbreaks in which the bacteriological and epidemiological evidence strongly supports the view that infection arose directly or indirectly from dried egg.

The salmonella types identified as the cause of food poisoning during 1943 and 1944 are further analysed in Table IV, which shows in relation to each type, the number of outbreaks caused, the total number of cases involved, and the number of cases diagnosed in the largest single outbreak. Twenty-eight different salmonella types were identified over the two years, 22 in 1943 and 23 in 1944. In 1943 at least 78 outbreaks and in 1944 at least 121 outbreaks were solitary cases; in many of them the infection could not be ascribed to the consumption of any particular food, and the vehicle of infection was therefore uncertain. Seven strains were the causes of outbreaks in which considerable numbers of persons fell victims—*Salm. typhimurium*, one outbreak of 60 cases; *Salm. newport*, one of 30 cases; *Salm. dublin*, one of 170 cases and one of 30 cases; *Salm. montevideo*, one of 100 cases; *Salm. oranienburg*, one of 50 cases; *Salm. meleagridis*, one of 26 cases; and *Salm. sundsvall*, one of 17 cases. In the earlier years of the war *Salm. typhimurium* was the cause of outbreaks involving 62 cases in a military unit, 31 cases in a dockyard and of 33 and 9 cases respectively in general hospitals. *Salm. thompson* caused 200 cases in one hospital, 17 cases in another and 10 cases in a third in which the source was traced to a carrier responsible for distributing food, while *Salm. enteritidis* was the cause of 11 cases, 3 of them fatal, in one outbreak. These large outbreaks occurred in industrial and military canteens, hospitals and restaurants and in most instances were traced to the purchase of food already infected, including dried egg.

TABLE IV

Distribution of Salmonella Types among Cases of Food Poisoning in England and Wales in 1943 and 1944

Salmonella types isolated and identified	1943 (22 types)			1944 (23 types)		
	Outbreaks	Cases	No. of cases in largest outbreak	Outbreaks	Cases	No. of Cases in largest outbreak
Typhimurium	108	276	60	185	254	15
Enteritidis	24	32	6	55	65	6
Thompson	19	45	21	20	20	1
Newport	10	17	7	91	277	30
Dublin	2	171	170	1	20	20
Bovis-morbificans	6	6	1	3	3	1
Cholerae-suis	1	1	1	1	1	1
Senftenberg	2	2	1	1	1	1
Derby	2	2	1	3	4	2
Anatum	4	4	1	4	4	1
Montevideo	17	121	100	17	20	4
Oranienburg	30	30	1	36	128	50
Bareilly	3	3	1	2	2	1
Chester	5	5	1	2	2	1
Meleagridis	7	76	26	11	11	1
Muenchen	2	2	1	—	—	—
San-diego	1	1	1	—	—	—
Adelaide	4	4	1	—	—	—
Sundsvall	1	17	17	—	—	—
Javiana	1	1	1	—	—	—
Tennessee	4	1	1	2	2	1
Kentucky	2	2	1	1	1	1
Give	—	—	—	1	1	1
New Brunswick	—	—	—	1	1	1
Panama	—	—	—	1	1	1
Pullorum	—	—	—	1	1	1
Saint-paul	—	—	—	1	1	1
Worthington	—	—	—	1	1	1
Not typed	7	10	4	13	50	7
	262	829	—	454	871	—

TYPES OF FOOD IMPLICATED AS THE VEHICLE OF FOOD POISONING

Of the outbreaks which came to the notice of the Ministry of Health during the six years 1939–44, information was given in 296 instances regarding the type of food suspected or proved to have been the vehicle

TABLE V

Types of Food Proved or Suspected as the Vehicle of Food Poisoning in England and Wales 1939–44 (296 Outbreaks)

(*a*) *Fresh, Pickled, Dried and Cooked Foods (221 Outbreaks):*

Type of food		Toxin	Salmonella	Chemical	Not Proven
		Type of food poisoning			
Pork products (7 outbreaks)	Ham	2	—	—	—
	Roast pork	—	1	—	—
	Pork pies	1	2	—	—
	Pressed pork	—	1	—	—
Meat products (103 outbreaks)	Meat pies	5	2	—	4
	Brawn	11	—	—	—
	Pressed beef	5	1	—	3
	Roast meat (cold)	23	—	—	37
	Gravy and soup	4	—	—	1
	Black pudding	1	—	—	—
	Stewed rabbit	—	1	—	3
	Pressed tongue	—	1	—	—
	Corned beef	—	1	—	—
Miscellaneous (111 outbreaks)	Marine products	—	—	—	25
	Eggs—duck	—	9	—	—
	,, —hen	—	1	—	—
	,, —other	—	1	—	—
	Sausages	7	2	—	28
	Milk	6	2	—	—
	Cheese	1	—	—	4
	Tomato juice	1	—	—	—
	Trifle	2	2	—	—
	Dried egg	1	10	—	—
	Beans	—	—	—	2
	Tomatoes	—	—	—	1
	Artificial cream	—	—	—	1
	Apple rings	—	—	3	—
	Tea	—	—	2	—
Total		70	37	5	109

(*b*) *Canned and Bottled Foods (75 Outbreaks):*

		Toxin	Salmonella	Chemical	Not Proven
Pork products		5	—	—	4
Marine products	Salmon	26	—	—	10
	Sardines	—	—	—	1
	Pilchards	—	—	—	1
	Cod roe	—	—	—	1
Canned meat		10	—	—	10
Potted meat		—	1	—	—
Milk		1	—	—	—
Soup		1	—	—	—
Peas		2	—	—	1
Bottled plums		—	—	1	—
Total		45	1	1	28

of infection. Table V has been compiled from the available data to show the types of food associated with these outbreaks. The causes of the outbreaks are classified into those of bacterial toxin type, those due to salmonella infection, and those due to chemical poisoning; while the remainder were not proven because the suspected foodstuff either was not available for laboratory examination, or when examined gave negative results. A majority of the cases falling into this last group were solitary cases of gastro-enteritis. The table also indicates the number of outbreaks associated with the consumption of various fresh, pickled, dried and cooked foods and the number of outbreaks in which infection was ascribed to canned and bottled foods.

Of the 296 outbreaks 221 (or 74·7 per cent.) were ascribed to the consumption of foods other than canned or bottled. One hundred and fifteen outbreaks were of the 'toxin' type and 70 (or 60·9 per cent.) of these were attributed to foods other than canned or bottled. Out of 38 outbreaks due to salmonella organisms, 37 were caused by foods other than canned or bottled. These figures are in general agreement with those reported by Savage in 1939, in a review of the relation of canned food to public health in this country between 1919 and 1937.

Six outbreaks due to chemical poisoning are recorded, and of these three were due to zinc in apples cooked in galvanized iron containers, one to sulphur dioxide in bottled plums, while the remaining two were associated with tea drunk by the victims, but unfortunately no material was available for examination.

An analysis of Table V shows that of 7 outbreaks due to pork products, 4 were due to salmonella infection and 3 were of the 'toxin' type. Meat and meat products other than pork were responsible for 49 outbreaks of the 'toxin' type and 6 outbreaks due to salmonella infection. It will be noted that most of the meat products associated with the 'toxin' type outbreaks were pre-cooked foods, served as a rule cold or reheated. The large number (23) of outbreaks ascribed to roast meat were in the main due to the meat being re-served cold one day or more after it had been freshly cooked. In one outbreak involving over 100 men in a military unit, roast beef had been served freshly cooked with no ill consequences, but the remainder of the same joint was served cold the next day and was followed three hours later by acute vomiting, diarrhoea and abdominal pains affecting only those who had partaken of the meat; samples of the beef examined bacteriologically yielded large numbers of coagulase-positive staphylococci. Experience has shown that freshly cooked meat is very rarely associated with food poisoning of the toxin type. Among the miscellaneous foods, 18 outbreaks were ascribed to 'toxin' food poisoning and 27 to salmonella infection. The importance of dried egg as the source of salmonella infection has already been discussed, and duck eggs, responsible for 9 outbreaks, are a well-recognised vehicle of salmonella infection, usually due to *Salm.*

enteritidis, or *Salm. typhimurium*, involving as a rule only the person who consumed the infected egg, unless it was used in the preparation of a mayonnaise or cake filling.

Seventy-five outbreaks were attributed to canned and bottled foods, of which 45 were of the 'toxin' type, and mainly associated with canned salmon (26 outbreaks) and canned meat (10 outbreaks), while only one outbreak was due to salmonella infection. The considerable number of 'toxin' type of food-poisoning outbreaks attributed to canned and bottled foods is not to be taken as indicative of lack of sterility of the contents prior to the can or bottle being opened. There is still a widespread belief that canned and bottled foods are fruitful sources of food poisoning, and it is not generally realised that food poisoning in this country from such foodstuffs is due to bacterial contamination of the food by handling *after* the container has been opened. Sterilisation is necessary for the preservation of canned and otherwise processed foods, and the bacteriological examination by the Emergency Public Health Laboratory Service during the war years of the contents of some thousands of samples of home and foreign canned foods, principally meats and pork products, showed that considerably less than 1 per cent. failed to pass the tests for sterility, and failure was usually attributable to damage to the container, or occasionally to imperfect sealing of the can. The tests for sterility were carried out at 37° C. and are not to be confused with tests carried out at 55° C. for the presence of organisms of the thermoduric or thermophilic type which cause spoilage. Such tests were necessary for canned foods to be sent to the Services in tropical regions, where temperatures might be such as to encourage the multiplication of thermophilic *Clostridia* and render the food unfit for consumption as regards appearance, taste and odour. A proportion of canned foods, mainly meat and vegetable stews and pies, failed to pass this test, and batches, from which samples were found to contain thermophilic or thermoduric organisms, were retained for home consumption. They could be eaten with impunity in Great Britain as air temperatures sufficient to encourage growth of the organisms and spoilage of the food are never attained in this country.

The foods found to be most commonly incriminated as vehicles of food poisoning of the 'toxin' type were (1) meat and meat products such as mutton and pork pies, brawn, pressed beef, stews, sausages, and gelatin coatings (the meat was nearly always in the form of made-up dishes); (2) soups, gravies, sauces and dressings; and (3) ice-cream, custards, pastries filled with artificial or real cream, custard-filled bakery products, trifles, and chocolate puddings. All these are suitable media for bacterial growth, especially of staphylococci and the other organisms such as *Proteus* aerobic spore-bearers, paracolon bacilli, *Cl. welchii*, *Cl. bifermentans* and streptococci, which on different occasions have been suspected as the cause of food poisoning.

PREVENTION

The investigation of outbreaks of food poisoning during the war years showed the size of the problem, the potential danger which may be present in the food itself, and the more easily preventable risks incurred during handling and preparation. The experience gained has led to the formulation of recommendations directed towards the prevention of infection of food by food-handlers, either directly or indirectly. These recommendations are based on the knowledge that bacterial contamination of food by manual handling is an everyday occurrence. War-time investigations have shown that while food may be contaminated from many sources, man is undoubtedly the most important reservoir of food-poisoning organisms, and that the skin of the hands may readily become infected from the nose, throat, bowel, or septic skin lesions. Most vegetative organisms are killed by the temperatures reached in cooking, always provided that care is taken to ensure that there is adequate heat-penetration to the centre of foods such as pies and made-up meats, which are very liable to bacterial contamination from the hands. It is also important to realise that the factors which encourage bacterial multiplication are time, temperature, moisture, and a suitable food. All these factors are, as a rule, necessary to produce a degree of contamination of food with pathogenic organisms heavy enough to give rise to clinical infection when the food is consumed. Infected dried egg, containing not more than 30 salmonella organisms per gram (see above) will not show any multiplication of the organisms while it remains in the dry state; and, as considerable numbers of these organisms are probably necessary to cause food poisoning, no harm will ensue when the egg is reconstituted if it is cooked and eaten at once. If, however, the reconstituted egg, now possessing sufficient moisture, is left standing in a warm kitchen or cupboard for upwards of six hours, the salmonella organisms will multiply sufficiently to cause clinical infection, especially if the egg is only lightly cooked as in an omelette or in certain dressings. Another factor of great importance in the prevention of food poisoning is the provision of adequate cold storage, noticeably lacking in most of the outbreaks investigated. Refrigerator temperatures do not, of course, kill bacteria but do prevent them from multiplying, and the application by food-handlers of knowledge concerning the factors promoting bacterial growth in foodstuffs cannot be properly carried out if refrigerator space is not available for the proper preservation of prepared or cooked foods and 'left-overs'.

Important among the recommendations directed towards the prevention of food poisoning are:—

(1) *Personal hygiene.* Handwashing after using the W.C. and before handling food or sitting down to a meal, a plentiful supply of running

warm water and soap and individual towels; avoidance of nose-picking and finger-licking; guarding the cough and sneeze with the handkerchief. Clean overalls.

(2) *Illnesses*. Among food-handlers illnesses should be reported at once; these include cuts, burns, scalds, septic sores, colds, sore throats, nasal and aural discharges, vomiting and diarrhoea. Infected persons should be suspended from duty and suitable specimens examined bacteriologically. If pathogenic organisms are found, the remainder of the kitchen staff should be examined.

(3) *Handling of food*. Avoidance of handling of food, especially prepared foods to be served cold, and in the absence of cold-storage facilities.

(4) *Clean food*, to be properly cooked, and kept in covered containers and in cold storage. Wrapped food and single-use containers are recommended.

(5) *Healthy employees* with clean medical histories; care of their health and welfare by the management.

(6) *Premises*. Adequate space, light and ventilation, washable walls and floors. Adequate washing facilities and W.C. accommodation. Wet dusting. Metal draining boards.

(7) *Containers, dishes and cutlery* to be kept in cupboards, covered racks and drawers when not in use.

(8) *Garbage cans* to be kept covered and in a good state of repair, and regularly sterilized with steam or disinfectant solution.

(9) *Fly proofing* of kitchens and food stores. Use of D.D.T.

(10) *Washing up*. A satisfactory and rigidly observed ritual for washing and cleansing food containers, dishes and cutlery. This includes a pre-rinse in warm water, followed by a detergent solution at 120–140° F., and a final rinse in water at 170–180° F. for 2 minutes or at 212° F. for 30 seconds. Dry by stacking and not by wiping with cloths.

One post-war development of the increased incidence of food poisoning has been the interest aroused among the staffs of public health departments and canteen and restaurant managements. At the instance of the Public Health Laboratory Service and the Central Council of Health Education courses of lecture-demonstrations on food hygiene were instituted in the Central Public Health Laboratory, London, for sanitary officers, and canteen and restaurant managers and cooks, and these were soon extended to the Provinces. The lectures and demonstrations were designed to indicate the causes and sources of food poisoning, the modes of spread, the steps to be taken when outbreaks occur, and the measures which should be introduced to prevent the occurrence of food infection. In order to facilitate teaching and to make the knowledge more widely available, films and film-strips on the subject of food hygiene were prepared. These illustrate faults in the handling, preparation, cooking, storage and serving of food and drink, and in the methods of cleansing and storing of food containers and cutlery. They also stress the importance of rectifying the faults shown, in order to attain higher standards of hygiene and to decrease the risks of food-borne infection.

TRICHINOSIS

Although, strictly speaking, it is not regarded as falling within the classification of food-poisoning, trichinosis must be mentioned, as it is essentially a food-borne infection. Up to 1939 only a few minor outbreaks had been reported in Great Britain during the present century. These included 4 cases in Devonshire in 1909, 13 cases and 4 cases at Milford Haven in 1922 and 1925 respectively, 2 cases at Smethwick in 1927, 5 cases at Swansea in 1930, 5 cases at Bath in 1935, 2 cases at Milford Haven in 1939, and 15 cases at Haverfordwest in the same year.

It was not till 1941 that the disease began to occur with increasing frequency, and during 1941 and 1942 more than 750 cases were recorded with 4 deaths. The largest outbreak occurred at the beginning of 1941 in the Wolverhampton and Birmingham areas involving about 500 cases; others were reported later from Penrith (50 cases), South-east London (24 cases), and Bedford district (14 cases). Other small outbreaks occurred, each involving from 1 to 5 cases. Inquiries into the outbreak in the Wolverhampton area (Jolly, 1941; Lee, 1941; Sheldon, 1941) brought to light the facts that (*a*) the incidence of the disease was mainly among working-class families and did not affect the better-class residential areas, (*b*) many people in the area were in the habit of eating raw or imperfectly cooked sausages in the form of sandwiches; and a history of eating raw sausage was obtained in about 50 per cent. of the patients. Further inquiries showed that sides of pork were injected with salt solution and pickled for as short a period as ten days before being marketed, whereas it is known that curing for forty days, followed by a period of smoking or drying, is necessary to destroy the parasitic worm in the muscle tissue. Two out of 8 rats caught in the Wolverhampton area during the period of the outbreak were found to be infected with *Trichinella spiralis*. At Penrith, 14 out of 66 rats from the communal refuse dump were found infected and, in a small outbreak at Carmarthen in 1943, viable trichina larvae were found in large numbers in the diaphragms of two rats caught in the vicinity of a piggery from which the infected animal had come.

Most of these outbreaks were due to the eating of infected sausage meat derived from pigs which it was no longer profitable to keep alive, and with the increasing scarcity of feeding-stuffs, more and more old pigs, which had a longer period to become infected and reinfected, were put on the market as the war progressed. Trichina larvae in infected meat are killed by a temperature of 137° F. (58° C.), and there is little doubt that the eating of raw or undercooked sausage meat, especially by industrial workers, contributed largely to the increase in the disease.

In the course of field investigations of the outbreaks, Miss M. R. Young, M.Sc., and Professor R. T. Leiper examined sections from the diaphragms of 472 patients who died in 1941–2 in hospitals from causes other than trichinosis. Some of the hospitals were in districts in which there was no evidence that cases or outbreaks of trichinosis had occurred. Trichina larvae were found in 10·8 per cent. of the diaphragms examined, indicating that the disease was much more widespread than had been suspected. Moreover, it is known that the disease may occur in a very mild form, and some outbreaks may, because of the mildness, escape diagnosis. This figure, although indicative of a higher incidence of infection in this country, is not so high as the 16·1 per cent. of diaphragms found positive after post-mortem examination of material taken as random samplings from 5,313 individuals in the U.S.A. (Wright, Kerr and Jacobs, 1943).

In addition to the clinical picture and epidemiological history, diagnosis of cases in most of the reported outbreaks was confirmed by (*a*) the presence of eosinophilia varying from 4 to 40 per cent., (*b*) muscle biopsy, (*c*) the finding of larvae in the blood in a few instances, and (*d*) skin tests using as antigen powdered trichina larvae.

Measures indicated for the prevention of the disease are destruction of rats, elimination from pigs' food of raw or inadequately cooked pork scraps, proper curing of pork for an adequate period, and education of the public on the danger of eating raw or undercooked pork, including pork-sausage meat.

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CHAPTER XXII

UNDULANT FEVER

By G. S. WILSON
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BEFORE the war, undulant fever was one of the less common of the infectious diseases in this country. Its exact incidence was unknown, partly because the disease was not notifiable, and partly because a considerable proportion of the cases were not diagnosed as such. Estimates based on serological evidence gave a figure of 400–500 cases a year for England and Wales (Wilson, 1932). In addition to clinical cases, there is evidence to suggest that a large amount of latent infection occurred among persons drinking raw milk. Examination of sera sent in for the Wassermann test, for instance, revealed the presence of agglutinins to *Brucella abortus* in a titre of 1/40 or over in an average of 1·5 per cent. of the samples. In specially exposed groups of the population, such as veterinarians and slaughterers, the proportion was between 13 and 20 per cent. (Topley and Wilson, 1946).

Most of the recognised clinical cases occurred in adults living in towns, and the incidence in males was about double that in females. Thus in 417 cases analysed by Dalrymple-Champneys (1938) in which the age was known, 357 (86 per cent.) were over 20 years of age, and of 427 cases in which the sex was known, 283 (66 per cent.) were males and 144 females.

The main source of infection was raw milk from cows suffering from contagious abortion. In only 32 of 321 cases in Dalrymple-Champneys's series, for which the relative information was available, did the occupation or the history of the patient suggest that infection might have occurred by direct contact with aborting animals, and in 22 of these cases the patient had also drunk raw milk. Laboratory infections were common, but formed only a fraction of the total number of cases.

INCIDENCE DURING THE WAR YEARS

So far as can be ascertained, the war had but little effect on the incidence of undulant fever. No general studies of the disease were made, and no figures were collected from which the comparative incidence could be estimated. Examination of the weekly reports furnished by the Emergency Public Health Laboratories shows that, during the years 1940 to 1945 inclusive, 311 cases were diagnosed. Nearly half of these were reported by the following laboratories: Oxford, Dorchester, Epping, Stafford, Northampton, Exeter, and Cardiff. These figures can give no indication of the real extent of the disease. The public health laboratories constituted only a small proportion of the total laboratories in the country, and were far less likely to receive samples of material from febrile cases than were the hospital laboratories; for these no records are available. Moreover, it is probable that, as before the war, most cases were not diagnosed at all, and no material was sent in to the laboratory for examination.

EFFECT OF EVACUATION

Before the war, London, in spite of its large population, was practically immune from undulant fever. About 98 per cent. or so of its milk supply was heat-treated, and the few cases of undulant fever that did occur were confined almost exclusively to persons who preferred raw milk (often tuberculin-tested), and to those who spent their holidays on a farm and were constrained to drink raw milk instead of the pasteurised product to which they were accustomed during the remainder of the year.

The war led to the evacuation of a number of schools from towns in which much of the milk supply was heat-treated to country districts in which it was not, and it was to be expected that undulant fever might become prevalent among the pupils under these conditions. There is some evidence to show that this surmise was correct. Elkington and his colleagues (1940), for example, describe an outbreak of *Brucella* infection in a school that had been evacuated to a small country town in Oxfordshire. Each of the 400 boys in the school was given a glass of raw milk daily from a local dairyman. Three to five weeks after the beginning of the term two boys developed undulant fever. Twenty-six other boys suffered from transient illness, usually characterised by mild fever, headache, malaise, and listlessness, and less often by abdominal pain, sore throat, nocturnal sweating, or a rash. Of these boys, 10 had serum agglutinins to *Br. abortus* in a titre of 1/20 to 1/1000 or over. Of 17 other boys suffering from chicken-pox, whose serum was examined for control purposes, 5 had agglutinins in a titre of 1/20 to 1/1000. It was clear that there had been an outbreak of *Brucella* infection in the school resulting in 2 recognised clinical cases, about 26 sub-clinical cases, and an unknown but considerable number of latent infections, amounting to probably about 30 per cent. of the boys. Examination of the milk supply revealed the presence of *Br. abortus*. The raw milk was replaced by a pasteurised supply, and no further cases occurred.

Another similar outbreak was described by Cruickshank and Stevenson (1942). Two boarding-schools for girls, normally situated in a large town on the South Coast, were combined and evacuated in May, 1941, to a country house on an estate in Devonshire. The girls, 54 in number, who had been accustomed to a pasteurised milk supply, were transferred to new surroundings where they drank raw milk from the home farm. One girl developed undulant fever in August and 3 others in November. *Br. abortus* was isolated from the blood of 3 of the cases. The first girl had a severe and protracted illness; the other 3 girls suffered from a milder illness, lasting in two instances for several weeks. Investigation revealed the presence of contagious abortion in the herd. The milk was subsequently pasteurised, and no further cases were reported.

Other schools and evacuated populations may have suffered in the same way, but the true nature of the infection may easily have been overlooked. The disease is so protean in its manifestations that unless cases conform to the classical type they are probably unrecognised, and no suspicion is aroused of the presence of *Brucella* infection in the numerous sub-clinical cases, suffering from influenza-like symptoms, that almost certainly occur.

BRUCELLA MELITENSIS INFECTION AMONG COWS

One strange and alarming incident occurred among cattle in the spring of 1940. Up till then no member of the *Brucella* group other than *Br. abortus* had ever been isolated from indigenously infected animals in this country. In April, 1940, however, Menton, who was in charge of the Staffordshire public health laboratory, isolated an organism resembling *Br. melitensis* from the milk of an accredited herd in the county. Its identity was confirmed by the reference laboratory at Oxford, and immediate steps were taken by the Ministry of Agriculture to investigate the mode of infection and prevent its further spread. Laboratory examinations revealed the presence of *Br. melitensis* in the milk of five of the cows. In view of the danger of spread to other animals, it was considered advisable to adopt a wholesale slaughter policy. Before this could be carried out, a special Brucellosis Melitensis Order had to be issued. This came into force on July 3, 1940, and the infected cows and all contact cattle, sheep, goats and swine were destroyed.

How the herd became infected was never discovered. A live vaccine supplied by a firm with German connexions had been used some time previously, and bacterial sabotage was suspected. No proof, however, of this could be obtained. From the medical point of view, the surprising feature was that, though some of the milk from the herd had been delivered raw to consumers, no human cases of undulant fever due to *Br. melitensis* could be traced.

It was hoped that the stringent control measures taken by the Ministry of Agriculture would succeed in stamping out the infection. Unfortunately, however, infection with *Br. melitensis* was discovered in two other herds in the neighbourhood during the war years, and in a fourth herd in 1947. The source of infection has so far remained obscure.

DIAGNOSIS AND TREATMENT

No special advances were made in either the diagnosis or the treatment of undulant fever during the war. Laboratory diagnosis was based chiefly on the presence of serum agglutinins, less often on the isolation of the organism from the blood or on the Brucellin skin test.

Just before the war Wilson and Maier (1939, 1940) carried out a number of careful experiments on guinea-pigs infected with *Br. abortus* to find out whether treatment with the sulphonamide group of drugs was able to eradicate infection. The results were disappointing, and suggested that, unless sulphanilamide or sulphapyridine was given for some weeks in a dosage bordering on the toxic limit, these drugs were unlikely to be of much therapeutic value in man. Experience during the war generally confirmed this conclusion.

Brucellin, injected intravenously, was used with apparent success in a number of cases, but patients varied in their response to it, and several failures were recorded.

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CHAPTER XXIII

HOSPITAL INFECTION AND AIRBORNE SPREAD OF INFECTION

By A. A. MILES
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EPIDEMIOLOGICAL POSITION IN 1939

HOSPITAL infection may conveniently be defined as infection acquired by a patient as a result of his submitting to any form of medical treatment, whether the treatment be actually given in hospital, or in a clinic or casualty dressing station. The infection may be of the respiratory or gastro-intestinal tract, or of wound, skin, or mucous membrane, and bacteriologically it implies the acquisition by a patient of pathogenic microbes that were not present initially. Two factors tend to increase the risk of added infection in hospitals and the like. First, a large variety of infected persons are concentrated there, and are herded with susceptible persons in a relatively small area. Secondly, the infected persons, being ill enough to require hospital treatment, are likely to be heavily infected, and are therefore prolific sources of the infecting microbe; and the susceptibles, being under treatment for another, perhaps debilitating disease, may be more susceptible than healthy persons in the population at large.

When the source and nature of the infecting microbe are known, added infections are, by definition, preventable. The history of hospital management in the last hundred years has been one of increasing recognition of the dangers of hospital infection and of measures to combat it. The readiness with which open wounds—whether accidental, surgical, or the physiological wounds of the post-parturient woman—became infected, inspired reforms that made the peace-time practice of surgery and midwifery comparatively safe. The segregation of those suffering from common fevers in special hospitals, where various forms of safe nursing could be applied, minimised some of the communal dangers of these contagious diseases.

The two decades before 1939 saw a concomitant improvement in our methods of identifying pathogenic microbes. Many bacterial species proved to be divisible into recognisably distinct varieties—'groups' or 'types'. Thus the pneumococci were so subdivided by American workers; the salmonella bacilli by Bruce White and Kauffmann;

Streptococcus pyogenes, first recognised in the United States as a distinct serological group by Lancefield, was divided by Griffith in England into over thirty types; and both cultural and serological types of the diphtheria bacillus were established by the work of McLeod and his colleagues. With bacteriological methods of this kind, it was possible to trace the spread of a particular type of microbe in a community, where previously it would have been indistinguishable from numerous members of the same microbial species.

The application of bacterial typing to hospital epidemiology in the years immediately before the war revealed unsuspected degrees of cross-infection by *Str. pyogenes* in midwifery practice (White, 1936), in scarlet fever wards (Allison and Brown, 1937), in wards for burns (Cruickshank, 1935), in oto-rhinological wards (Okell and Elliott, 1936), and in general children's wards (Wright, 1940); and by *C. diphtheriae* among children in fever hospitals (Glass and Wright, 1938). Though less obvious, added infection by *Staph. aureus* and *Str. pyogenes* had also been reported in surgical practice (see e.g. Devenish and Miles, 1939).

The primary sources of the infecting microbes are excreta and discharges from manifest cases of various diseases, or from healthy carriers. The upper respiratory tract contributes *Str. pyogenes*, *Staph. aureus*, pneumococci, meningococci, the bacilli of diphtheria and whooping cough, and viruses or presumed viruses, like the agents of measles, chicken-pox, rubella, mumps and influenza. From faeces, vomit and urine may come *Salmonella* and dysentery bacilli, protozoa like *Giardia*, and perhaps the causal agent of the so-called non-specific enteritis. The infected skin, conjunctiva, mouth, external genital tract, and infected wounds yield the many species of pathogenic microbes that infect these places.

The apparently healthy, or the 'silently infected', carrier is often a greater source of added infection than the manifestly diseased person, who can be more easily recognised as a source of infection and segregated; and prevention must include measures against the dangerous carrier, and against the spread of the carrier state, as well as the spread of disease. Hence the safest criterion of added infection is, in the last analysis, bacteriological and not clinical. In peace-time, the dangers of added infection were recognised chiefly in the fever hospital or the children's hospital, and were being met by improvements in hospital design and in the technique of isolation and barrier nursing (Harries, 1935; Dobbs and Kempthorne, 1938; McKhann, Steeger and Long, 1938).

In intestinal infections and the like, transmission must presumably be by indirect contact. In respiratory infections, on the other hand, the established view that transmission was mainly by contact or by the relatively large droplets projected from the mouth—a view derived from work in the first decade of the century—had recently been questioned by Wells (Wells and Wells, 1936), who claimed that transmission was commonly by minute particles (droplet nuclei) resulting from the partial drying of small droplets expelled from the upper respiratory tract; and by the work of White, of Cruickshank and Godber (1939), and of Allison and Brown, suggesting that dust was an important vehicle for *Str. pyogenes*.

The modes of transmission recognised as potentially important were thus: (*a*) contact–direct, or indirect by fomites; (*b*) direct droplet infection with a limited range of a few feet; (*c*) direct airborne, by droplet nuclei; and (*d*) indirect airborne, by the contamination of dust and its subsequent dispersal (Andrews *et al.*, 1940).

METHOD OF CONTROL AVAILABLE IN 1939

For the prevention of contact infections—surgical and gastro-intestinal—the elaborate prophylactic rituals of the operating theatre and the fever ward, handed down from the pioneers of the early years of the century with little fundamental modification, were held to be sufficient. Direct droplet infection was held to be controlled by masking, although the wearing of masks was by no means common, except in surgical and obstetric practice. Methods for controlling direct airborne infection were largely in the experimental stage. Masterman (1938) had, over a number of years, advocated the use of mists of sodium hypochlorite, which he showed to reduce the concentration of airborne bacteria, and had devised apparatus for their large-scale dispersal. More recently, Pulvertaft and his colleagues (1939), following Trillat, had investigated the action of a number of aerial disinfectants, including resorcinol dissolved in propylene glycol, on sprayed cultures of bacteria. In America, Wells (e.g. 1940) had studied the lethal effect of ultra-violet light of wavelength 253·7 mu on sprayed bacterial cultures, and a number of trials of ultra-violet light for disinfecting air had been started. There had been, however, no conclusive reports from Britain or elsewhere of the value of aerial disinfection in reducing the spread of disease; although in the light of the theories developed by Wells on the importance of 'droplet nuclei' in the spread of infection, there was good reason to regard such methods as useful. Specific methods for the control of dustborne infections had not been studied.

DEVELOPMENTS IN THE WAR YEARS

Wound Infections

The war intensified the problem of added infection in various ways. The depletion of trained civilian hospital staff by the demands of the fighting Services, the substantial reduction in numbers of available beds in large towns partly evacuated in readiness for enemy air raids, and their crowding in institutions in safe districts, diminished the efficiency of the hospital services and increased the likelihood of hospital infections. When the retreat of the British and French forces from Dunkirk, and later the air-raid casualties of the autumn and winter of 1940, threw on the civilian hospitals the burden commonly borne by the casualty clearing station and military base hospital, added infections were almost immediately detected. In hospitals where bacteriological studies were made, numerous cases of added wound-infection by *Str. pyogenes*, various intestinal gram-negative bacilli, and to a less extent *Staph. aureus* were revealed (Miles *et al.*, 1940; Spooner, 1941).

Analysis of the ward routines for handling wounds revealed many opportunities for the transfer of infection from wounds and from healthy carriers among the staff. A ward-dressing technique was devised (Medical Research War Memorandum, No. 6, 1941), which, by strict 'non-touch' technique, virtually eliminated the opportunities for contact infection, and which, by emphasis on the rapid disposal of soiled dressings in closed containers, reduced the opportunities for contamination of the air. By rationalisation of the dressing routine, and in particular by arranging for the staff to work as a dressing team rather than as individual dressers, the more rigorous precautions could be adopted without an undue increase in the time required. The efficacy of the new methods was proved in a number of instances by reduction both in the incidence of added infection, and in the healing time of the wounds (McKissock *et al.*, 1941; Logue and McKissock, 1946; Williams *et al.*, 1944/5; Clayton-Cooper and Williams, 1946). Gissane, Miles and Williams (1944) emphasised that the planning of the dressing station, so as to bring all the materials and equipment into easy reach of the dresser, facilitated the observance of the more rigorous routine. These measures were most effective in controlling infection with *Str. pyogenes*, and less with *Staph. aureus*. *Str. pyogenes* appeared to come from the wounds or the upper respiratory tract of other persons; on the other hand, in small industrial wounds that could be subjected to more intensive bacteriological study, *Staph. aureus* was most often introduced at the time of wounding, and was usually derived from the patient's own nose or skin (Williams and Miles). Over 70 per cent. of normal persons proved to be nasal carriers of potentially pathogenic staphylococci (Miles *et al.*, 1944; Williams, 1946); and, in the later stages of the war, it was possible to confirm, by bacteriological typing, the earlier indirect conclusions that the human skin is very commonly contaminated with the nasal *Staph. aureus*, and that these staphylococci are frequently introduced into the wound at the time of infliction. Consequently, the direct shielding of the already contaminated wound is unlikely to affect staphylococcal infection to the same extent as it does streptococcal.

Besides the revision of standard aseptic techniques, the confirmation in war conditions of gross contamination of dressings, bedclothes, ward furniture and dust with *Str. pyogenes* stimulated research on methods of reducing it; and simple dust-laying precautions were introduced into the dressing routine. The more elaborate measures for minimising dust were applied mainly to the control of the respiratory infections (see below); however in one type of wound—the extensive burn—over which it was difficult to maintain the local asepsis achieved in the orthodox handling of smaller wounds, airborne infection was clearly a major risk. In operating theatres, as well as in wards, the air might be heavily contaminated with wound pathogens, and safety was achieved only by the use of special dressing theatres through which a rapid current of virtually bacteria-free air was passed, washing away from the site of operation the bacteria released during the manipulation of the patient and his dressings (Colebrook *et al.*, 1944; Colebrook, 1946; Bourdillon and Colebrook, 1946).

There is, of course, a very high probability that the bacteria in the environment will contaminate the wound at the time of its infliction; and, though many of the contaminating species are saprophytes readily destroyed by the tissues, true infections often result. The measures designed to cure these infections of injury—proper wound toilet, the local application of penicillin and sulphonamide and sulphone drugs, and the protection of the wound by occlusive dressings and plasters—tend to minimise added wound infection.

The improved aseptic routines were also adopted in maternity homes. Cross-infection of the genital tract was never a major problem, but a relatively high incidence of staphylococcal infections, particularly of the breast in mothers and pemphigus neonatorum in infants, was recorded (Elliott, Gillespie and Holland, 1941; Duncan and Walker, 1942; Allison and Hobbs, 1947), and improved aseptic techniques were apparently effective in controlling such infections (Knott and Blaikley, 1944).

Healthy carriers were commonly recognised as potential sources of hospital infection, particularly in maternity homes. The importance of the nasal carrier of haemolytic streptococci, which had been recognised in a general way by workers in fever hospitals for many years, was later to receive great emphasis in the important studies of Hamburger and his colleagues (see e.g. Lemon, 1947).

The elimination or segregation of carriers, especially carriers of microbes like *C. diphtheriae* or the typhoid bacillus, is clearly desirable, but it may be impossible to eliminate all carriers of microbes like *Str. pyogenes*, *Staph. aureus*, or even the meningococcus, from a hospital staff, without disrupting the hospital economy. Though complete cure of the chronic-carrier state in either the respiratory or intestinal tract is often hard to obtain, curative measures may diminish the carrier state, and this may be useful in reducing the number of microbes the carrier disseminates into his environment. For this reason penicillin and sulphathiazole snuffs were used for nasal carriers of *Staph. aureus*, *Str. pyogenes*, and *C. diphtheriae* (Delafield, 1941; Delafield and Straker, 1941; Thomas, 1941; Goldman and Patterson, 1942).

Another example of contact cross-infection—syringe-transmitted hepatitis—is discussed in the section on hepatitis.

AIRBORNE INFECTIONS

Methods of investigating airborne infection. Of the three methods of aerial spread of bacteria—by large droplets, by droplet nuclei, and by contaminated dust—the second and third can be investigated by air-sampling. The old method of exposing plates of culture medium, though simple, had many disadvantages, and it was soon realized that for the thorough investigation of airborne infection, it was essential to have some method for estimating rapidly and accurately the number of bacteria-carrying particles present in the air. Wells (1933) had devised the 'air-centrifuge' and Hollaender and Dalla Valle (1939) the 'funnel-device', both depending on the impingement of bacteria-carrying particles on an agar surface. The disadvantages of these instruments were overcome in the 'slit-sampler' devised by Bourdillon, Lidwell and Thomas (1941), in which air was sucked through a narrow slit, from which it emerged at a considerable velocity and impinged on to agar on a slowly rotating petri dish. This instrument was estimated to collect more than 95 per cent. of airborne particles of 1·5/mu in diameter, an efficiency considerably greater than that of the air-centrifuge. It also had the great advantage of giving a time-discriminating record, so that fluctuation in the level of air contamination could be followed from minute to minute. The 'slit-sampler' proved a very valuable instrument for use both in laboratory and field investigations, and its use became the standard in Britain for estimating bacterial contamination of the air. It may be noted that samplers in which air was bubbled through fluid were used in much of the American work in this field.

Control of direct droplet infection. Bourdillon and his colleagues carried out much work on the design of masks, both for use in hospitals, and for large-scale distribution to people in air-raid shelters in the event of an epidemic of respiratory infection. For the latter purpose a cellulose acetate mask, hung loosely from a wire 'spectacle frame' was advocated. (Bourdillon *et al.*, 1948; Committee, 1940).

Control of dustborne infection. In the early years of the war haemolytic streptococci were responsible for a considerable amount of upper respiratory disease in the Armed Forces, as well as for much secondary infection of wounds. Workers from the National Institute for Medical Research at Hampstead and their colleagues in hospitals and military stations showed first that the treatment of floors with crude liquid paraffin—spindle oil—prevented the dispersal of floor-dust and its bacteria, including haemolytic streptococci, into the air during sweeping (van den Ende, Lush and Edward, 1940; Thomas, 1941). But clearly, in hospital wards, it was bed-making that led to the greatest bacterial contamination of the air, and blanket dust was very commonly infected with haemolytic streptococci. Attempts were therefore made to apply oil to fabrics, using in the first place a solution in some organic solvent such as technical white spirit (van den Ende, Edward and Lush, 1941; van den Ende and Spooner, 1941; Thomas and van den Ende, 1941). In small-scale field experiments this was effective in preventing contamination of air during bed-making, but the process was not practicable for routine use. The technical difficulties were soon overcome when it was found that technical white oils were as satisfactory dust-layers as liquid paraffin, and could be made into stable emulsions in water by the use of such substances as cetyl pyridinium bromide, cetyl alcohol, sodium lauryl, sulphonate and the like (van den Ende and Thomas, 1941). The great advantage of these oil-in-water emulsions was that they could be applied to bedding in the course of the ordinary laundry routine, and details of a large-scale method involving their use were described (Harwood, Powney and Edwards, 1944). Furthermore, some of the emulsifiers used had a marked bactericidal effect both *in vitro* and on blankets contaminated with moist cultures.

The development of these technical methods of dust control had been checked at each stage by field demonstrations of the reduction in air contamination that they produced. The first report in Britain of the study of their effect on clinical infections was that of Wright, Cruickshank and Gunn (1944), who oiled floors and bedclothes in a measles ward during an epidemic in which a high incidence of streptococcal complications was observed. They found that the treatment decreased the aerial pollution with streptococci that occurred during bed-making by 98 per cent. The incidence of complications due to type 6 streptococci was only 19 per cent. in the test ward compared with 73 per cent. in the control ward. Many other clinical trials have since been carried out in the United States, and practically all of them have confirmed the findings of Wright and her colleagues, that oil treatment of floors and bed-clothes reduces streptococcal cross-infection. Apart from Anderson, Buchanan and MacPartland (1944), no one has reported control of other upper respiratory infections by dust-laying methods; but the work of H. D. Wright and his co-workers (1941), who showed that diphtheria bacilli, like haemolytic streptococci, frequently contaminate floor and blanket-dust, suggests that the method might also be valuable in the control of cross-infection in diphtheria wards. Edward's (1941) work on the survival of influenza virus, suggests that dust-borne infection may also be important in this disease. Garrod (1944) demonstrated that haemolytic streptococci may persist for a considerable period in dust shielded from direct light.

Control of direct airborne infection. The risks of epidemics of respiratory disease among civilians crowded into ill-ventilated shelters stimulated a considerable number of investigations on the value of various aerial disinfectants. Workers at the National Institute for Medical Research were able to confirm earlier studies which had shown that sprays of sodium hypochlorite were lethal for airborne bacteria, and they upheld Masterman's view that the effective agent was hypochlorous acid gas as such, rather than a particulate 'aerosol' of sodium hypochlorite (Bourdillon, Lidwell and Lovelock, 1942; Edward and Lidwell, 1943; Elford and van den Ende, 1945). These workers also devised practical methods for spraying hypochlorite in shelters and the like, and action based on their findings was recommended in the report of Lord Horder's Committee (Committee, 1940; Bourdillon *et al.*, 1948). Challinor (1943) also confirmed the effectiveness of sodium hypochlorite sprays in reducing the bacterial content of the air of an occupied room. It was however realised that sprays of sodium hypochlorite were by no means ideal as aerial bactericides, owing to their lack of persistence, possible corrosive action, and the fact that they required a high relative humidity for optimum action. Twort and his co-workers reported extensive investigations of a variety of other substances, in particular resorcinol dissolved in propylene glycol (Twort, Baker, Finn and Powell, 1940; Twort and Baker, 1940; 1942; Baker and Twort, 1941; Baker and Twort, 1943/4). Until 1944 Twort adhered to the view that the sterilization by phenolic bacterial mists required collision between the infected particle and the bactericide particle, and much of the early work of this group aimed at making the aerosols persistent.

Robertson, in America, reinvestigated the action of resorcinol in propylene glycol, and showed that the propylene glycol was more efficient as an aerial bactericide than the resorcinol (Robertson *et al.*, 1942). This was the starting point of an immense amount of research in the United States on the mechanism of action of glycol, and on the use of propylene and triethyleneglycols in air sterilisation and the control of infection in hospitals and military stations. Duguid and Challinor, and Challinor and Duguid (1944) confirmed Robertson's work on the bactericidal efficiency, and the dependence on correct relative humidity, of propylene glycol vapour, but otherwise little further work on glycols was done in Britain.

Apart from a brief report by Middleton and Gilliland (1941), who obtained some indication that the intermittent use of a hypochlorite spray might decrease the incidence of upper respiratory sickness in an Army unit, and by Cruickshank and Muir (1940), who used a spray of resorcinol in propylene glycol to reduce the spread of streptococci among men convalescent from influenza in a fever hospital, no large-scale field trials of the effect of aerial bactericides on the incidence of sickness were carried out in Britain. British laboratory workers did, however, investigate a number of other possible aerial bactericides such as ozone (Elford and van den Ende, 1942), iodine (Raymond, 1946), and hydroxy acids, such as lactic acid (Lovelock, Lidwell and Raymond, 1944; Lovelock, 1945; Bourdillon *et al.*, 1948). Some of these, such as α-methyl-α-hydroxy butyric acid have the great advantage that an adequate bactericidal concentration can be obtained in the air of confined spaces by vaporization at room temperature, thus obviating the need for elaborate vaporizing apparatus and making it practically impossible to obtain too high a concentration in the air. The Air Hygiene team at the National Institute also carried out important researches into the action of a number of other methods of air purification, including ventilation, ultra-violet light, and heat, which were reported in detail in the Medical Research Council Special Report No. 262 (1948). The last of these methods was used for sterilising the effluent air from the laboratories in which the scrub-typhus vaccine was prepared at Frant (Buckland *et al.*, 1945).

Experimental and other investigations of airborne infections. In addition to the work on instruments for collecting airborne bacteria and the methods of control of airborne spread of infection already discussed, the team at the National Institute for Medical Research, working at first under the direction of the late Sir Patrick Laidlaw, made a very large number of important investigations into various aspects of air hygiene, such as animal-to-animal transmission of influenza virus under various conditions (Andrewes and Glover, 1941), and the quantitative infection by the respiratory route of animals with various bacteria, particularly *M. tuberculosis* (summarised in Bourdillon *et al.*, 1948). Duguid (1946) also carried out some fundamental work on the characterisation of the droplet spray from the mouth in sneezing, talking and so forth. Davies (1946) and Boyland, Gaddum and McDonald (1947) studied the extent to which airborne particles of various sizes penetrated the respiratory tract. Other workers at the Ministry of Supply Experimental Station studied the mechanism of inhalation infection (Barnes, 1947).

EPIDEMIOLOGICAL POSITION IN 1945–6

The history of hospital infection during the war was one almost wholly of refinement in methods of detecting added infection; of estimating its importance (Wright, 1945; Williams and Capel, 1945), and combating it. The history is confined mainly to isolated investigations, from the results of which recommendations for trial or general adoption were made, as in the Medical Research Council's War Memoranda (Nos. 6 and 11). How far these recommendations were adopted, and with what result, it is impossible to say at the time of writing, because few reports have emerged. Moreover, it is probable that many of the reports will provide only equivocal evidence of the value of measures to counteract cross-infection, for many remedies were tried at one time, and often in communities where much else was changing.

Some of these changes were recognised. Thus introduction of measures, such as active immunisation against diphtheria, reduce infection and also reduce hospital infection. Other changes were often unrecognised. For example, an increased awareness of many risks is likely to accompany the introduction of a particular prophylactic measure into a hospital routine. In the face of improved surgery, and the administration of antibacterial prophylactics like sulphonamides and penicillin, it would be difficult to gauge the contribution of any improvements of simple aseptic techniques to the reduction of wound infection. There is, moreover, a tendency to ascribe to one new measure success that properly belongs to another; consequently much time and money is spent unprofitably—and what is worse, the more effective measures are ignored. Even when the measure is beyond doubt successful, such as the penicillin 'umbrella' in the prevention of coccal and clostridial war-wound infection, there is a danger that the simplicity and success of the drug will lead to carelessness in asepsis that is indefensible in the light of the drug's limitations.

Again, though routine dosage with a sulphonamide may diminish the incidence of respiratory infection in a large closed community, there is an attendant risk of inducing drug-resistance in the prevalent epidemic bacterial strains (e.g. Delameter *et al.*, 1946). No one remedy is wholly effective, and in hospitals we cannot afford to ignore any of the possible routes and sources of added infection. Nor is the freedom from gross added infection necessarily good evidence of the adequacy of the preventive measures employed. Such freedom may mean either that there have been no infections of sufficient intensity or severity to test the preventive measures properly; or that added infection has not been recognised because bacteriological criteria are not available to supplement the clinical.

As an infectable community the hospital is a delicate and vulnerable organism, and even where the buildings have been designed to minimise the risk of contact and airborne infections, equipped to eliminate as rapidly as possible all the pathogenic microbes that are inevitably brought there, and manned by an intelligently trained medical, nursing, and laboratory staff, it requires a continual watch by clinician and bacteriologist, and a continual revision of preventive measures, to meet newly defined risks.

The contribution of war work to these definitions may be summarised as follows: (1) A more precise estimate of the reservoirs and risks of added infection by *Str. pyogenes* and *Staph. aureus*, and a wider recognition of the potential infectivity of microbes other than the common reputed pathogens—gram-negative intestinal bacilli, anaerobic streptococci and non-sporing bacilli, and members of the *Haemophilus* group. (2) A new emphasis on the ubiquitous opportunities for contact infections, particularly of wounds and of the gastro-intestinal tract. (3)

A considerable advance in our knowledge of the behaviour of airborne bacteria, of the ways in which they may be killed, and of the importance of contamination of floor and blanket dust in the spread of, at least, streptococcal infections—knowledge that was turned to practical account in their control.

Comparable advances were not made in knowledge of the mechanism of the spread of any other respiratory disease, though much American work in the war years has suggested that measles and perhaps also mumps and chickenpox, are commonly spread by droplet nuclei—a hypothesis that would explain the difficulty often noted of controlling the spread of these diseases in fever hospitals. Nevertheless, the advances in technical equipment, and in the understanding of the behaviour of airborne microbes, have opened the way for a renewed attack on the problem of the spread of respiratory diseases.

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CHAPTER XXIV

SMALLPOX

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THE records of the incidence of smallpox in various parts of the world during the war years are necessarily incomplete; information was not supplied regularly to the International Office of Public Health during this period. The author has not had access to the official records of smallpox in the British Armed Forces and consequently the following observations are based largely on the published reports of smallpox outbreaks among civilians and among the Armed Forces. As the disease was introduced into Britain after the end of the war by men returning from endemic areas abroad, these later outbreaks are considered in the following account because they were attributable to the war.

As was to be expected smallpox broke out among troops in various theatres of war where the disease was endemic or epidemic in the local populations. Outbreaks were recorded in India in 1942–3 (Leishman, 1944), in the Middle East in 1943 (Cottrell and Knights, 1943) and 1944 (Illingworth and Oliver, 1944; Easton, 1945), in Italy in 1944 (Jeans, Jeffrey and Gunders, 1944) and in Burma in 1944 (Black, 1945).

It was not surprising, in view of the occurrence of smallpox among men serving in the Forces, that the disease was introduced into Great Britain on many occasions during and immediately after the war. According to the Registrar-General's returns, in England and Wales one case was recorded in 1939, one in 1940, none in 1941, 7 cases in 1942, none in 1943, 16 in 1944, 4 in 1945, 55 in 1946, and 77 in the first six months of 1947. Of the 55 cases in 1946, 15 were infected either in India or en route from India, while 40 were infected in England (Maddock and Conybeare, 1946). Thirteen infected persons arrived in seven ships and two by air. All these cases, occurring in England and Wales during the war years and afterwards, suffered from the Asiatic form of the disease (variola major). The outbreaks in Scotland during 1942, comprising 103 cases and involving chiefly Glasgow, Fife and Edinburgh, were also of the major type. The first cases in the Glasgow outbreak occurred on a ship coming to the port from the East via Cape Town (Sutherland, 1943). Smallpox was introduced into Seattle in 1946 in the same way by an infected soldier coming in a troopship from Japan (Palmquist, 1947) and into France by an infected soldier arriving by air (le Bourdellis *et al.*, 1946).

Major epidemics of smallpox, however, occurred during the war years in countries which might not have been expected to be exposed to the risks of infection indicated above. In Turkey smallpox was epidemic between 1942 and 1945 with a peak during 1943, when 12,395 cases were notified (Tok, 1946). In June, 1943, it spread to the Northern province of Greece and by the end of the year 830 cases with 183 deaths were reported for the whole country (Kopanaris, 1945). Between June and December, 1944, 297 cases of smallpox were admitted to hospitals in Durban, South Africa. This epidemic apparently began among unvaccinated Africans but later chiefly affected the Indian population.

In various parts of the world where it occurs as an endemic disease with periodic epidemic outbreaks (South America, Africa, and South-East Asia) smallpox showed the usual fluctuation in incidence. It is perhaps of interest in relation to the importations of the disease into England and Wales from India during the spring of 1946 that the total of notified cases in that country for the year 1945 was over 250,000, more than twice the incidence recorded in 1939 and 1940. (World Health Organisation, Epidemiological and Vital Statistics Report, Vol. 1, p. 33.)

MORTALITY

As noted above, the outbreaks of smallpox occurring among civilians at home and among troops abroad were practically all of the variola major type with modified attacks in those protected by vaccination; consequently the mortality was high. In the outbreaks in Great Britain the case mortality was over 20 per cent., and in the reported outbreaks among troops serving abroad the haemorrhagic form of the disease was common among the unvaccinated. Attacks among vaccinated serving men were however sometimes so mild that they escaped detection, and such cases were the source of several small outbreaks in this country (Bradley, Davies and Durante, 1946; Maddock and Conybeare, 1946; Boul and Corfield, 1946). Mild atypical cases may also have been responsible for the spread of infection during the course of epidemics, for in many instances a history of contact between cases was difficult to establish. While the source of infection in most of the cases in the Fife outbreak could be traced (*Health Bull.*, 1943) this was not so in the outbreaks in Glasgow (Macgregor and Peters, 1942) Edinburgh (Sutherland, 1943) or on Merseyside (Peirce, 1947); in large urban areas the spread of infectious disease is notoriously difficult to trace.

The occurrence of illness among smallpox contacts without the appearance of the typical rash (*variola sine eruptione*) has long been recognised and was recorded in many of the outbreaks. The difficulty of determining the nature of such febrile illness in contacts who have been vaccinated some days previously has been stressed by Terrell (1942) and Napier and Insh (1942). That some of these febrile illnesses are due to infection with variola virus in relatively immune individuals is generally accepted, and serological evidence of *variola sine eruptione* in a nurse who had not been recently vaccinated was reported by Boul and Corfield (1946). Febrile illness like virus pneumonia was recorded among 7 smallpox contacts by Howat and Arnott (1944). Attempts to isolate variola virus from such patients by the relatively simple technique of cultivation on developing chick embryos, referred to below, might elucidate the nature of many of these cases.

SMALLPOX AND VACCINATION

While it is generally accepted that vaccination affords protection against smallpox, the immunity induced is by no means absolute. In the vaccinated, however, the mortality from smallpox recorded during the war years, as in the past, was generally much less than in the unvaccinated, and all degrees of modification of the typical clinical picture were reported among the vaccinated. Some striking instances of the difference in mortality among the unvaccinated and the vaccinated were reported. In the Merseyside outbreaks involving 31 cases, 7 of 9 unvaccinated patients died (Stallybrass 1947); in the remaining 2 fatal cases no evidence of vaccination was available. Among the 48 cases described by Easton (1945) 11 of 13 who were devoid of direct evidence of successful vaccination died, while of those successfully vaccinated before exposure to infection, 1 only died. In a smallpox outbreak among African troops in Burma, Black (1945) noted that of 6 men devoid of sign or record of vaccination, 4 died; of 20 patients with a history of vaccination but no scars, 7 died; while the remaining 40, who had good vaccination scars, all recovered. Moreover, there was a preponderance of mild attacks in the latter group. Of 68 cases occurring among troops in India in 1942 and 1943, Leishman (1944) reported that 8 of 11 unvaccinated patients died as against 2 among the vaccinated. In the Durban outbreak of 1944 among the 297 patients admitted to hospital, 82 died, the mortality being 39 per cent. in the unvaccinated and 8·3 per cent. in the vaccinated. (Durban annual report, 1945). Illingworth and Oliver (1944), however, record that of 100 patients, 33 who suffered from unmodified and haemorrhagic attacks had a record of successful vaccination. It is obvious from their paper, however, that these authors regard the 'immune reaction' as a successful vaccination. The fallacy inherent in this view has been commented upon by Marsden (1944, 1946), Boeck (1946) and others. As Marsden points out, vaccination histories are notably unreliable and the evidence of scars is more dependable. The recent observations of Coleman (1944), Stevenson (1945), Wolpe (1945) and Broom (1947) on revaccination have again shown the error of relying on 'no take' or on an 'immune reaction' as evidence of immunity. The importance of using a potent lymph and more than one insertion was also demonstrated by Horgan and Haseeb (1944). The practice of multiple insertions in face of an epidemic is one that is commonly recommended. In many of the reports of outbreaks among both civilians and troops the observation is made that vaccination after exposure to infection did not prevent the disease from developing; in several such instances fatal attacks occurred. Stevenson (1944) asserts that there is no justification for the opinion that vaccination within the first three days of exposure will invariably protect, and the observations of Marsden (1946) and others support this view. Stevenson also points out that the response of individuals to successful vaccination varies in respect of the duration of protection, a fact which is evident from observations on the severity of smallpox in the vaccinated. The simultaneous occurrence of variola and vaccinia in contacts vaccinated after exposure to infection may lead to errors in diagnosis. A diagnosis of generalised vaccinia in such cases may result in further spread of the disease as in the instances recorded by Peirce (1947) and Palmquist (1947).

The occurrence of smallpox in successfully vaccinated persons may be determined by a poor immunity response to vaccination on the part of the host, by rapid waning of immunity or by infection with an unusually virulent virus (Stallybrass 1947). Although the possibility cannot be excluded that strains of variola virus exist which are immunologically different from current strains of vaccinia, so that vaccination fails to give protection against them, there is no satisfactory evidence to support it. On the other hand, there is much evidence indicating the close immunological relationship between variola, vaccinia and alastrim and between strains of vaccinia from different sources (Horgan and Haseeb, 1939; 1945). In view of the reported occurrence of severe smallpox in vaccinated troops in the Middle East it was suggested that the vaccinia strains used to vaccinate men in England were less effective in producing immunity to smallpox than strains used on native populations in that region. A comparison of the vaccinia lymphs however showed no immunological difference between them.

POST-VACCINAL ENCEPHALITIS

In a review of post-vaccinal encephalitis, Stuart (1947–8) has reported its incidence in Britain during the war years. In Scotland in relation to the outbreaks of smallpox in 1942, when mass vaccination was carried out in the regions affected, there were 39 cases of post-vaccinal encephalitis with 14 deaths; 35 followed primary vaccination. The majority of the patients were between 5 and 16 years of age and symptoms of encephalitis usually developed ten to twelve days after vaccination. The incidence of this complication was: in Edinburgh and district, 1 : 21,000 vaccinations; in Fife, 1 : 8,000; and in Glasgow, 1 : 70,000. This is less than the incidence in the Netherlands during the years 1924–6 (quoted by Stuart). In England and Wales, during the War of 1939–45, 60 cases of post-vaccinal encephalitis with 31 deaths were reported. On the other hand, this complication had apparently not been seen in Morocco, although vaccination was widely practised there (Sicault, 1942). In Durban also, where over 450,000 vaccinations were carried out in consequence of the 1944 outbreak, no post-vaccinal encephalitis was recorded. No further information as to the cause of this complication has become available as a result of the war experience.

PATHOLOGY

It has been suggested that the clinical severity of acute haemorrhagic smallpox might be due in part to associated bacterial infection, but there is little evidence to support this suggestion. In 8 severe cases studied by Leishman (1944) blood cultures taken before or after pustulation were sterile. Downie and Dumbell (1947a) failed to grow bacteria from the blood on the fifth day of illness of a haemorrhagic case in which a diagnosis of acute meningococcal bacteriaemia was considered. Variola virus was recovered from the blood at this time, two days before death.

The leucocytosis commonly found in these severe cases (Illingworth and Oliver, 1944; Easton, 1945) is therefore not due to secondary bacterial infection, but is probably related to tissue necrosis and haemorrhage. From unbroken pustules in 15 cases Illingworth and Oliver failed to culture bacteria; Leishman working in India, however, recovered *Staphylococcus aureus* from the pustules of all 18 patients examined. Vesicle fluids or pus from 12 cases in England were examined by us in 1946 and 1947. Two specimens collected on the sixth day of illness contained *Staphylococcus aureus*; another taken on the tenth day showed a few *Staphylococcus albus*; the remaining 9 specimens collected between the sixth and twelfth days were sterile. Of the sterile specimens 1 was collected from an acute haemorrhagic case the day before death, and 2 were collected after death on the tenth and twelfth days from onset of symptoms. Septic skin complications are, however, not uncommon in smallpox, and it seems likely that the variable results reported from treatment with sulphonamides and penicillin, mentioned below, are attributable to the variable occurrence of septic complications in individual cases and perhaps in different outbreaks.

EXPERIMENTAL WORK ON THE VIRUSES OF VACCINIA AND VARIOLA

Although the viruses of variola and vaccinia are closely related immunologically, the latter perhaps being a variant of the former, the difference in virulence for individual hosts is fairly constant. The vaccinia virus which has diminished virulence for man is generally more virulent for other animals. Variola virus is less virulent for the rabbit on intradermal injection; on repeated passage in the testicles of rabbits Nelson (1943) failed to increase the virulence of his strain for the rabbit. The virus survived and, on transfer from the testicle of the tenth-passage rabbit, it produced lesions on the chorio-allantois of chick embryos characteristic of variola and different from those produced by vaccinia virus. In this tissue variola virus produces smaller lesions than does vaccinia and in contrast to vaccinia has much less lethal action on the embryo. Variola virus shows remarkable stability on the chorio-allantois even after 200 successive transfers (Nelson, 1943). It is also less virulent than vaccinia on intranasal instillation in mice (Nelson, 1939). The careful experimental work of Horgan and Haseeb (1939) on cross-immunity experiments in monkeys with the viruses of variola, vaccinia and alastrim confirmed and extended previous work in showing the close immunological relationships between the three viruses. North (1944) found that variola virus grown in chick-embryo membranes agglutinated adult-fowl red cells less readily than vaccinia virus. In experiments on the inhibition of this agglutination by antisera he thought that differences between antivaccinial and antivariola sera from human sources were demonstrable, but the differences were slight.

LABORATORY DIAGNOSIS

The outbreaks of smallpox which occurred during and after the war afforded opportunities for developing laboratory tests to assist in the diagnosis of the disease. It is true that in many cases the clinical picture is so typical that confirmation from the laboratory is unnecessary, but in many mild cases modified by previous vaccination clinical diagnosis may be a matter of great difficulty. The valuable help which the laboratory can give in these cases has been acknowledged by Sutherland (1943), Illingworth and Oliver (1944), Boul and Corfield (1946), Bradley *et al.*, (1946), Maddock (1946), Conybeare (1946) and Smith (1948). The relative value of various laboratory procedures at different stages of the disease has been discussed by van Rooyen (1946) and by Downie (1946, 1947). The techniques employed had all been in use before the war, but the laboratory facilities available in the localities where outbreaks occurred offered an opportunity to develop the various tests and assess their value.

The presence of typical elementary bodies in large numbers in smears from skin lesions was found by van Rooyen and Illingworth (1944), an extremely useful and rapid method of diagnosis in doubtful cases of variola. They have outlined the technique to be followed and stress the fact that the test can be of value as soon as the skin lesions appear, but does not give satisfactory results in the pustular stage of the disease. In cases of chickenpox elementary bodies are few in number and smaller in size. The flocculation and complement-fixation tests for detecting specific virus-antigen in vesicle fluid and in extracts of crusts are highly specific and serve to distinguish readily between chickenpox and atypical smallpox. These tests were of great practical value in the hands of Professor Tulloch during the outbreaks in Scotland in 1942. Like the examination of stained smears for elementary bodies, however, they do not serve to distinguish cases of generalised vaccinia from smallpox in recently vaccinated contacts. The isolation and identification of variola virus by inoculation of developing chick embryos was developed as a diagnostic test by Buddingh (1938) Markham and Bozalis (1939) and Bohls and Irons (1942). The technique has been described in detail by Downie and Dumbell (1947a). This method is much superior to Paul's test which it has replaced and is an extremely sensitive method for detecting variola virus in the lesions of patients. By its use variola can be readily distinguished from chickenpox, as the virus of chickenpox does not produce lesions on the chorio-allantois of chick embryos; moreover this is a simple laboratory test by which generalised vaccinia can be readily distinguished from variola. The test is useful at all stages of smallpox from the time the rash appears until all crusts have separated. By the use of this technique it has been shown that variola virus remains alive in smallpox crusts kept at ordinary room temperatures for over a year (Downie and Dumbell 1947b). The one drawback of the method is that two or three days are required before the results can be reported from the laboratory. The examination of patients' serum for antibody by serological methods was useful after the first week of illness in persons not vaccinated within the previous twelve months. The comparative value of these various diagnostic procedures in 61 cases of smallpox from which material was received in 1944–7 has been discussed by Downie (1947).

TREATMENT

In the outbreaks that occurred throughout the war years sulphonamides were used in the hope of lessening the severity of the disease in the pustular stage. In some later outbreaks penicillin was used. In Edinburgh in 1942, 14 patients received sulphonamide treatment without spectacular results. Cottrell and Knights (1943) gave an average total dose of 22·5 g. sulphanilamide to 11 cases, treatment beginning in the vesicular stage of the disease. They attribute to the drug a lessening of pyogenic infection and a modification of the suppurative process. In 4 very severe cases treated in Italy, Jeans, Jeffrey and Gunders (1944) found no disappearance of *Staphylococcus aureus* from the skin lesions after an average dose of 32 g. of sulphathiazole. After treatment with penicillin was instituted pronounced general improvement occurred in 3 of these cases within twenty-four hours. Leishman (1944) noted no apparent effect from sulphapyridine given to 10 successive severe cases from the fourth or fifth day onwards, a total average dose of 30 g. being given. Twelve cases were given sulphathiazole rather late in the disease (*Staphylococcus aureus* was cultured from the vesicles of 18 cases examined). One case with abscesses was much improved and in 5 others pustulation was inhibited or modified; pitting and scarring seemed to be prevented. Illingworth and Oliver, who failed to grow bacteria from the vesicle fluid of fifteen cases examined, were not impressed by the results of sulphonamide therapy. Sulphathiazole was given to the severe cases in the series recorded by Easton (1945). No effect was produced on the toxaemia but the impression was gained that complications were prevented and the pustular eruption diminished. Penicillin, 1,180,000 units, was given to 1 confluent haemorrhagic case but death occurred on the tenth day. Peirce (1947) states that sulphathiazole was of value in the pustular stage but had no influence earlier in the disease. Penicillin was given in doses of 125,000 units daily to five severely ill children but four of them died. In the 1947 Staffordshire outbreak of 30 cases, penicillin was given to most of the severely ill patients in divided doses, varying from 160,000 to 2,000,000 units per day (Smith 1948). While it was not suggested that this treatment influenced the virus infection, there was much less pus formation in the pustular stage of illness. Convalescent serum in doses of 30–50 c.cm. was given to three patients in Illingworth and Oliver's series, but all died. Easton records that 90 c.cm. of convalescent serum was given to one case without obvious result.

The results of treatment with sulphonamides on relatively small numbers of cases are obviously difficult to assess in view of the lack of observations on control series, and the marked variability in the course of the disease, particularly in vaccinated individuals. The varied results reported with sulphonamide treatment may have been due to variation in the degree of associated bacterial infections in different outbreaks. It seems to be agreed that neither penicillin not sulphonamides in the dosage used had any beneficial effect in haemorrhagic cases, or in the early toxic phase of other severe smallpox infections.

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CHAPTER XXV

STUDY OF INFLUENZA

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THREE major discoveries of practical importance in the study of influenza were made during the war years.

(i) Burnet (1940a, 1940b) found that chick embryos could be infected with influenza viruses by inoculation into the amniotic cavity; he was able in this way to obtain primary isolations from human material without recourse to ferrets or mice. Workers in the U.S.A. were less successful in such primary isolations, and those in Britain at first even less so. In more recent years the method has proved generally successful. All workers agree, however, that with adapted strains, virus can be obtained in high titre and relatively free from extraneous material in the amniotic and allantoic fluids of infected eggs.

(ii) Francis (1940) and Magill (1940) independently isolated from cases of human influenza a new type of virus, now known as Influenza B virus; this is serologically unrelated to Influenza A, the virus first described in 1933.

(iii) Hirst (1941, 1942), and McLelland and Hare (1941) independently discovered that influenza virus, particularly in infected chick-embryonic fluids, would agglutinate fowl red cells. This agglutination was specifically inhibited by appropriate antisera. These findings have been used as the basis of methods for titrating both virus and antisera, methods which have already proved their value in epidemiological studies.

EPIDEMIOLOGY

Before the war, major outbreaks of influenza in Britain had been occurring in the early months of every fourth year (1933, 1937), with minor prevalences in the intervening odd years (1935, 1939). In the winter of 1940–1, the anticipated large epidemic did not occur despite the overcrowding in air-raid shelters; only a minor outbreak appeared in England. Influenza A virus was responsible for a large part of this, but the viruses recovered were of low pathogenicity for animals (Andrewes *et al.*, 1941). In 1940 and 1942 no influenza-virus infections were recognised. In early 1943, again, there was a mild prevalence of influenza, and serological evidence indicated that virus B was the chief causative agent (Stuart-Harris *et al.*, 1943). Between April and September, 1943, virus A infection was detected in a number of localized outbreaks (East Anglia, Scotland and Northern Ireland), and this very unusual summer occurrence of the disease led up to a widespread epidemic of Influenza A in October (Andrewes and Glover, 1944). This was clinically mild, but the A-viruses recovered were adapted to ferrets much more easily than strains obtained in any year since 1937. The outbreak, which was over by December, 1943, was remarkable in occurring so early in the winter. No important outbreak occurred during the last eighteen months of the war.

In North America, Influenza A outbreaks have occurred roughly every other year, as in Britain. An A-epidemic occurred in the Eastern and mid-Western U.S. in November, 1943, shortly after the one in Britain began, and by December it had reached California. Just as over here, it was preceded by a small A-outbreak in May, 1943 (Salk, Menke and Francis, 1944). Most striking of all was the similarity in happenings in Britain and Canada: in both countries an outbreak at the beginning of 1943 was mainly due to virus B, but virus A turned up for the first time in a small localised outbreak in March-April, when the regular influenza season was over, (Hare *et al.*, 1943). Here also an exclusive A-outbreak appeared the next autumn.

IMMUNISATION

Formolised vaccines have been used in several trials conducted on a fairly large scale. A single subcutaneous dose of 1 c.c. has been used. Horsfall, Lennette and Rickard (1941) prepared a vaccine from desicated chick-embryo which had been simultaneously infected with the viruses of influenza and dog distemper. (Subsequent work indicated that this use of distemper virus conferred no advantage). This was tested on about 16,000 people by Horsfall *et al.*, (1941) as well as by other workers.

The results on various groups indicated at best a halving of the incidence of influenza, at the worst no benefit at all. Supplies of vaccine were sent to Britain and used for trials in 1940–1, but no influenza affected the groups under observation; so no conclusions could be drawn as to its value. In 1943, another formolised vaccine was tested; it was injected into 6,263 persons distributed in nine groups throughout the U.S.A.; 6,211 uninoculated persons served as controls. This vaccine was made from embryonic fluids from eggs and was concentrated ten-fold by adsorption to and elution from fowl R.B.Cs. The results were decidedly better than in earlier trials, the controls having an attack-rate of clinical influenza of 7·11 per cent., the inoculated 2·22 per cent.—a ratio of 3·2 : 1 (Commission on Influenza, 1944). One possible explanation of the improved result is that an epidemic of influenza occurred in most of the vaccinated communities two to four weeks after the inoculations, that is at a time when maximal immunity might be expected. Alternatively one may believe that it was particularly fortunate that a virus strain from one of the preceding minor outbreaks was available and could be incorporated in the vaccine. (The importance of minor antigenic differences among influenza strains is becoming increasingly recognised). Other trials have been made of formolised vaccines of several types; in these tests, vaccinated persons have been deliberately infected with influenza; most of them have shown better evidence of protection than have the large-scale field trials (cf. Henle, Henle and Stokes, 1943).

Burnet (1943) has urged that intranasally inoculated living attenuated virus offers the ideal method of immunisation, but no large-scale trial of such an agent has yet yielded an answer as to its value.

Smorodintzeff *et al.*, (1940) have reported good results in local passive immunisation against influenza by a spray of immune serum. Experimental trials of this method in the U.S.A. have not been encouraging.

OTHER WORK ON PREVENTION OF INFLUENZA

It is known that experimentally produced mists of influenza virus will infect animals and there is some evidence (Andrewes and Glover, 1941) that airborne 'droplet-nuclei' may serve as the transmitting agent from an infected ferret to a normal one several feet away from it. Ultra-violet light (Edward, Lush and Bourdillon, 1943), hypochlorite (Edward and Lidwell, 1943) and propylene glycol aerosols (Stokes and Henle, 1942) have been shown experimentally to be capable of destroying influenza-virus particles in such mists. Edward (1941) and others have found that influenza virus can persist for a fortnight on dust.

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CHAPTER XXVI

PRIMARY ATYPICAL PNEUMONIA

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DESPITE some statements to the contrary there seems little doubt that the clinical condition to which the name primary atypical pneumonia is now given, occurred and was recognised before the War of 1939–45. Drew, Samuel and Ball (1943) give a brief historical survey of this earlier work, from which it appears that the disease had been described in America, France, and Spain before 1939, and the papers of Scadding (1937) and of Ramsay and Scadding (1939) show that it was also occurring in this country. It has been referred to under a variety of names: catarrhal fever, soldier's pneumonia, disseminated focal pneumonia, atypical broncho-pneumonia, acute pneumonitis, interstitial pneumonia; the term 'primary atypical pneumonia, etiology unknown', proposed by the American Surgeon General in 1942, though possibly not very satisfactory, will be retained for the purpose of this article since it is the name by which the condition is best known to-day.

During the war there was a considerable increase in the prevalence of primary atypical pneumonia. At times it has assumed epidemic proportions of which the outbreak at Camp Claiborne in America so fully investigated by Dingle and his colleagues (1944) is a good example, and this increased incidence has provided both the stimulus and the opportunity to gain a better understanding of this disease.

CLINICAL PATHOLOGY

Blood-count

Neither the total nor differential leucocyte count shows any appreciable departure from normal. Dingle and his colleagues (1943) found total counts of between 6,000 and 10,000 in 62 per cent. of cases, with 10 per cent. above and 27 per cent. below those limits. In half their cases the polymorphonuclear percentage was less than 70. Drew, Samuel and Ball (1943), Meakins (1943), Campbell, Strong, Grier and Lutz (1943), Needles and Gilbert (1944), Turner (1946) and others have made similar observations.

Sputum

The persistent and sometimes harassing cough which is an early feature of atypical pneumonia is characteristically non-productive; only in the later stages of the disease, when resolution is beginning, is a specimen of sputum readily obtainable. Bacteriological examination of sputum as well as of the throat flora and of material obtained by bronchoscopy, has not revealed any bacterium, the presence or predominance of which suggested that it was aetiologically concerned. Dingle *et al.*, (1944) make reference to similar conclusions by other American workers. Kneeland and Smetana (1940) consider that the characteristic features of the sputum are the presence of mononuclear cells and a normal bacterial flora.

Reference should be made here to the non-haemolytic streptococcus isolated by Thomas, Mirick, Curnen, Ziegler and Horsfall (1943) from the lung tissue of 2 fatal cases of atypical pneumonia, and designated 'M.G'. Subsequently three further strains were obtained from the lung tissues and thirty-seven from the sputum in atypical pneumonia. It was also found in the respiratory tract in other infections as well as occasionally in normal individuals. Fifty-nine strains were studied (Mirick, Thomas, Curnen and Horsfall, 1944 a and b), and shown to be of a single serological type. It is capsulated and related serologically to *Streptococcus salivarius* Type I, with which it shares a capsular polysaccharide antigen (Mirick, Thomas, Curnen and Horsfall, 1944c). Thomas and his colleagues (1943) showed that convalescent-phase sera from atypical pneumonia contain, at times, agglutinins for streptococcus M.G. Though occurring concurrently with cold agglutinins (Eaton, 1945) the streptococcal agglutinins can be shown to be different by cross absorption (Dingle, 1945; Finland, Samper and Barnes, 1945). Since agglutinins for the streptococcus M.G. may fail to appear in a considerable percentage of cases of atypical pneumonia (Eaton, 1945), and the lungs in some fatal cases prove bacteriologically sterile (Golden, 1944), and that added to this, streptococcus M.G. is without pathogenicity for experimental animals (Mirick, *et al.*, 1944a), it would seem that this streptococcus is no more than an interesting and fairly common secondary invader in atypical pneumonia.

Cold agglutinins

The presence of cold agglutinins for Group O human erythrocytes in the sera of cases of atypical pneumonia was reported independently by Petersen, Ham and Finland (1943) and by Turner (1943) and the suggestion was made that this reaction might prove of diagnostic value. Cold agglutinins are present in low concentration (titres up to 1 in 16) in normal sera. They are known to occur in abnormal concentration with regularity in trypanosomiasis (York, 1910), and their presence in a considerable percentage of haemolytic anaemias has been recognised since the time of the early French workers on this condition. It is interesting to note that haemolytic anaemia associated with a high titre of cold agglutinins has been reported as a complication of atypical pneumonia

(Finland, Petersen, Allen, Samper and Barnes, 1945; Battaglia, 1947; Ginsberg, 1946). Further work by Turner and by Finland and their colleagues gave support to the belief expressed in their preliminary communications that the demonstration of an increase in cold agglutinins might be of help in distinguishing between primary atypical pneumonia and other respiratory infections. In the majority of cases in which atypical pneumonia had been diagnosed clinically cold agglutinins were found in the serum in increased quantity, and titres, usually over 1 in 80 and sometimes as high as 1 in 2,560 or over, were observed, whereas in a large number of control sera from normal individuals or from patients suffering from a variety of conditions, including infections of the respiratory system such as bacterial pneumonias, influenza, upper respiratory infections and pulmonary tuberculosis, cold agglutinins were either absent or present only in low titre (Turner, Nisnewitz *et al.*, 1943; Finland, Petersen, Allen, Samper and Barnes, 1945). Only exceptionally did any of the control sera show abnormal titres and even then they were not high. Among those repeating this work some obtained similar results. Humphrey (1944) found that 93 per cent. of 14 patients with atypical pneumonia developed cold agglutinins in abnormal amount whereas none of 80 controls did so, and Spingarn and Jones (1945) found titres ranging from 1 in 224 to 1 in 14,000 in all of 91 cases of atypical pneumonia. It is interesting to note that the latter workers put the upper limit of cold agglutinins in normal sera as 1 in 224, considerably higher than other investigators, and that they demonstrated cold agglutinins in titre ranging from 1 in 224 to 1 in 3,584 in 6 out of 7 cases of glandular fever; measles, scarlet fever and the orchitis of mumps provided occasional titres above the normal level. Favour (1944), on the other hand, found titres of 1 in 160 or over in only 18 of 46 cases of atypical pneumonia, and Horstmann and Tatlock (1943) found the test positive in 27 out of 43 cases. The American Commission on Acute Respiratory Disease (Dingle, 1944) obtained positive reactions in from 25 to 50 per cent. of cases and in a later communication, Dingle (1945) states that the proportion of positive reactons had varied from 30 to almost 100 per cent. in the different series examined. In the writer's experience only about a third of sera obtained from sporadic cases and different outbreaks contained cold agglutinins in a higher concentration than normal. The observation of Dingle (1945) that the percentage of sera showing a raised titre of cold agglutinins might vary from 30 to 100 according to the series examined suggests that only some, or possibly only one, of the agents producing the clinical picture of atypical pneumonia excite the production of cold agglutinins. In this connexion it is interesting to note that Eaton (1945) has drawn attention to the absence of any abnormal concentration of cold agglutinins in the sera from cases of atypical pneumonia due to viruses of the psittacosis group, an observation which the writer can confirm from a limited experience of this type of case. It would appear also that cold agglutinins are not increased in atypical pneumonia due to *Rickettsia burneti* (Caughey and Dudgeon, 1947). Eaton (1945) is of the opinion that an increased titre of cold agglutinins is probably confined to those cases of atypical pneumonia due to the virus isolated by him and his colleagues Meiklejohn and van Herrick (1944) which is pathogenic for the cotton rat and responsible for some 60 per cent. of cases of this condition; reference to this virus will be made again and in greater detail. Eaton (1945) has found that it is in those cases with cold agglutinins that one finds agglutinins for the indifferent streptococcus isolated by Thomas and his colleagues from cases of atypical pneumonia to which reference has already been made. Cold agglutinins occur at times in the absence of streptococcal agglutinins but if the reverse occurs it is rare. The two agglutinins can be shown to be distinct by cross-absorption (Dingle, 1945; Finland, Samper and Barnes, 1945). There seems to be general agreement that the development of cold agglutinins in atypical pneumonia follows the course characteristic of specific antibodies (Turner, Nisnewitz *et al.*, 1943; Humphrey 1944; Finland, Petersen, Allen, Samper and Barnes, 1945). Their increase is first detectable from the fourth to eighth day of the disease, a maximum is reached between the sixteenth and twenty-third day, and the titre falls again fairly rapidly in convalescence (Horstmann and Tatlock, 1943; Humphrey, 1944). They disappear gradually from sera stored in the refrigerator, but the titre can be maintained unchanged for six months if sera are stored at 70° C. (Favour, 1944; Finland and Barnes, 1945).

AETIOLOGY

The investigations of atypical pneumonia made during the war have clearly shown that the clinical condition to which this name is applied can be produced by a number of infective agents. Most of these are viruses, but *Rickettsia burneti*, the cause of Q fever, can give rise to this clinical picture as can *Coccidioides immitis*, so that it would seem incorrect to use 'virus pneumonia' as an alternative name for the condition. Primary atypical pneumonia would thus appear to be a syndrome and not a specific disease. Some would disagree with this statement. They would exclude cases due to viruses of the psittacosis group, as well as those caused by *R. burneti*, reserving the term primary atypical pneumonia for those cases, usually mild and often occurring in outbreaks and small epidemics, the majority of which appear to be due to the virus of Eaton *et al.*, (1944). Presumably their object is eventually to define a disease entity for which the use of the term primary atypical pneumonia would be reserved. Whilst agreeing that this attempt to break down the conglomerate mass of atypical pneumonias into a number of aetiological entities is a right and legitimate one, it should logically end in abandoning the use of this term except to describe a train of symptoms. Our knowledge of the causation of atypical pneumonia has not advanced sufficiently to do this. It is the opinion of the writer that, for the time being at any rate, the term primary atypical pneumonia should be used to describe a syndrome produced by a number of infective agents.

RÔLE OF VIRUSES OF THE PSITTACOSIS GROUP

It was recognised before the war that natural infection with the virus of psittacosis occurred in birds other than those of the parrot family. Infection in fulmar petrels on the Faroe Islands had been described. During the war it has been shown that infection of the domesticated pigeon occurs (Coles, 1940; Pinkerton and Swank, 1940; Meyer, Eddie and Yanamura, 1942; Andrewes and Mills, 1943); and Meyer and his colleagues have described human cases infected from this source. The domestic fowl (Meyer and Eddie, 1942) and the duck (Meyer and Eddie, 1947) have also been shown to suffer from infection with this virus and Baker (1942) has described a variety of cat pneumonia caused by a virus of the psittacosis group. The opportunity for infection of man is no longer as restricted as it was at one time thought to be. This is not the place to discuss the advisability of applying specific names to the viruses belonging to the psittacosis group. The viruses of psittacosis, ornithosis, meningopneumonitis, the virus S.F. of Eaton, Beck and Pearson, and the cat virus of Baker, though distinguishable from one another by certain means (Beck, Eaton and O'Donnell, 1944; Rake and Jones, 1944) are closely related and will be referred to as belonging to the psittacosis group. In 1941 Eaton, Beck and Pearson described a small outbreak of 6 cases of atypical pneumonia which was due to a virus of this group; 3 of them proved fatal. In addition to the severity of these cases other features of the outbreak were the absence of any connexion with disease in birds and the readiness with which the infection passed in man. Three of the infected patients were nurses who looked after the initial case and the other two were laboratory workers studying the virus. It is this virus to which the designation S.F. has been given (Eaton, Beck and Pearson, 1941). The readiness with which this virus passed in man is responsible for the suggestion that it represents a virus of the psittacosis group which has become adapted to man (Meikeljohn, Beck and Eaton, 1944); such a happening is rare in the case of human psittacosis of psittacine origin. Others have described atypical pneumonia caused by viruses of the psittacosis group (Favour, 1943; Smadel, 1943), and the question arises as to how important a part these viruses play in the causation of atypical pneumonia. Smadel (1943) found that 10 of 45 sporadic cases occurring in large urban communities of the Eastern States of the U.S.A. were due to psittacosis virus, and Meikeljohn, Beck and Eaton (1944) isolated viruses belonging to this group from the sputum or lung puncture material in ten out of 250 cases of atypical pneumonia. In papers reviewing the work done during the war Eaton (1943, 1945) concludes that probably less than 10 per cent. of all cases of atypical pneumonia are caused by viruses of the psittacosis group. This is in keeping with the writer's unpublished finding that 9 of 120 cases of atypical pneumonia occurring in this country during the war years had a high or rising titre of psittacosis antibody. In this respect attention should be drawn to the fact that, owing to the extensive sharing of antigens between the viruses of the psittacosis group and of lymphogranuloma venereum (Rake, Eaton and Shaffer, 1941; Eaton, Martin and Beck, 1942; Beck, Eaton and O'Donnell, 1944), serological tests in disease due to viruses of the psittacosis-lymphogranuloma group are not virus-specific but only group-specific. In relying on the complement-fixation test in the diagnosis of atypical pneumonia due to psittacosis virus one has to bear this in mind, and it is essential, as Smadel (1943) has insisted, to show a considerable excursion of titre of antibody—preferably a four-fold or greater rise in the active stage of the disease—if one is to conclude that the presence of antibody denotes active infection.

Rickettsia burneti (*Q fever*)

Interest in this agent as a cause of atypical pneumonia was first aroused when Dyer, Topping and Bengston (1940) isolated this rickettsia from the spleen of a fatal case; the infection was contracted in the laboratory. In the later years of the war considerable epidemics of Q fever, in which pulmonary consolidation was a constant feature, occurred in allied troops in the Mediterranean area (Robbins and Ragan, 1946). In the epidemic at Camp Patrick Henry, Virginia, in American troops returning from Italy, 90 per cent. of the 143 cases studied showed pulmonary infiltration. The source of infection in these outbreaks in the Mediterranean area was not ascertained. In eight outbreaks studied (Robbins, Gould and Warner, 1946) infection occurred about the same time and in the same locality in troops billeted in farm buildings, usually hay barns in which dust was abundant. There was no evidence suggestive of insect transmission. The incubation period was about 19 to 20 days. *R. burneti* was isolated from some of the cases by intraperitoneal inoculation of guinea-pigs at the bedside with 3 to 5 ml. of blood (Robbins, Rustigian, Snyder and Smadel, 1946). The same workers were also successful in infecting the embryonated egg direct from the patient by the inoculation of 0·5 ml. of defibrinated blood into the yolk sac, and the cerebro-spinal fluid was shown to be infective in one case by guinea-pig inoculation. These Italian strains of *R. burneti* were without apparent effect on mice when inoculated intranasally or intraperitoneally, but they could be maintained by guinea-pig or egg passage, and yolk-sac strains proved infective for white rats and hamsters (Robbins, Rustigian, Snyder and Smadel, 1946). Antigens prepared with Italian strains fixed complement with sera from both

American and Italian and Balkan cases of Q fever, but although antigens prepared from American strains fixed complement well with sera from American cases they reacted poorly with sera provided by cases of Q fever from the Mediterranean area (Robbins, Rustigian, Snyder and Smadel, 1946). In an experimental study of strains of *R. burneti* from Australian, American and Mediterranean sources Topping, Shephard and Huebner (1946) found that, whilst all gave complete cross-protection in the guinea-pig, American strains were less good antigens than the others when used for producing antisera. There is no evidence that Q fever occurred in Britain during the war.

The Virus of Lymphocytic Choriomeningitis

Smadel, Green, Paltauf and Gonzales (1942) described two somewhat unusual cases of lymphocytic choriomeningitis ending fatally, in which pulmonary consolidation occurred. In consequence this virus has received consideration as a possible cause of atypical pneumonia. Reimann, Havens and Price (1942) describe one of four cases of atypical pneumonia, all clinically similar, the serum of which collected on the 7th and 20th days gave strong protection against lymphocytic-choriomeningitis virus. Smadel (1943) obtained no evidence that this virus was concerned in the aetiology of any of the 45 sporadic cases of atypical pneumonia studied by him.

Virus of Weir and Horsfall Pathogenic for the Mongoose

This virus was isolated from patients with acute pneumonitis (Weir and Horsfall, 1940). It produced pneumonia in the mongoose and could be maintained with some difficulty by passage in this animal. No other species of animal proved susceptible. This virus has not subsequently been found in atypical pneumonia.

Feline Pneumonia Virus of Blake, Howard and Tatlock

In 1942 these workers reported having isolated a virus from cats ill with pneumonia in a household in which human cases of atypical pneumonia were occurring at the same time. The virus could be passed serially in kittens but would not infect mice, thus differentiating it from the cat pneumonia virus of Baker (1942), which was isolated by mouse inoculation and belongs to the psittacosis-lymphogranuloma group. Neutralisation tests with the patients' sera suggested that the human and feline cases in this household outbreak were of similar aetiology.

Virus of Stokes, Kenney and Shaw (1939)

This virus was obtained from the sputum of cases of atypical pneumonia by the inoculation of ferrets and mice. After several passages in mice the virus was lost and its relation to the human disease remains undecided.

Primary Virus Pneumonitis of Infants

Adams (1941) described an outbreak of primary atypical pneumonia which occurred in infants in the University Hospitals of the Minnesota Medical School. It was highly infectious and resulted in 32 cases in the first three months of 1937; 9 ended fatally. No virus was isolated, but the disease was attributed to an agent of this kind on account of its high infectivity, the absence of a bacterium which could be incriminated, and the histological changes found in the lung post-mortem. The pneumonia was of the interstitial type and cytoplasmic inclusion bodies were readily demonstrated in the bronchial and alveolar epithelial cells. The source of infection was not determined, nor have similar outbreaks been reported.

Virus of Eaton, Meikeljohn, van Herrick and Talbot

Eaton and his colleagues (1942) announced that they had been successful in isolating a virus from cases of atypical pneumonia by intranasal inoculation of cotton rats (Sigmodon hispidus) with sputum obtained early in the disease. Pneumonic lesions developed in the inoculated animals with considerable regularity and were absent from control animals receiving a variety of materials, including heated sputum, by the nasal route. Some difficulty was found in establishing this virus in the cotton rat, but six strains were apparently adapted. There was some doubt as to the identity of the established virus with that present in the starting material, since antisera made with the former neutralised it well, whereas the results with human convalescent sera were irregular and unconvincing. Subsequent work confirmed this doubt (Eaton, 1945), the virus apparently established in the cotton rat was, in all probability, latent in the animals. Eaton and his colleagues have, however, shown (Eaton, Meikeljohn and van Herrick, 1944) that by the amniotic inoculation of 12-day chick embryos with filtered sputum a virus can be isolated from atypical pneumonia. Unfortunately little or no change was visible in the infected embryo and one had to rely on inoculation of hamsters and cotton rats with the egg material to demonstrate the virus. Lung lesions developed in up to 75 per cent. of the nasally inoculated animals. Neutralising antibodies for this agent were demonstrated in sera from human cases of atypical pneumonia and their development followed the course characteristic of specific antibodies; a good case for this virus to be considered as a cause of primary atypical pneumonia in man seems to have been made. Others have claimed to have produced pneumonia in cotton rats with material from atypical pneumonia but have subsequently withdrawn their claims. Horsfall, Curnen, Mirick, Thomas and Ziegler (1943) produced lesions in the lungs of cotton rats by the intranasal inoculation of sputum, and, although these lesions were not maintained in passage, these workers thought that they were transmitting the infection, albeit not apparently, since the animals developed neutralising antibodies for the pneumonia virus of mice described by Horsfall and Hahn (1940). Subsequently it was shown (Curnen, 1944) that these antibodies could be evoked in the cotton rat by non-specific stimuli, and it was thought that the phenomenon could best be explained on the basis of latent infection of the cotton rats with P.V.M. virus. Similarly Rose and Molloy (1943) produced lesions in the lungs of newly-weaned guinea-pigs by the intranasal inoculation of sputum, and found that the condition could be passed to cotton rats. The absence of neutralising antibody for this virus in the sera of convalescents from atypical pneumonia led to withdrawal of the claim that the virus was causally connected with the human disease (Rose, 1944). Though doubt still exists that the virus of Eaton and his colleagues is responsible for those cases of atypical pneumonia not caused by known infective agents (viruses of the psittacosis group; *Rickettsia burneti*; lymphocytic choriomeningitis virus; *Coccidioides immitis*) there is good evidence that they are of virus aetiology. The absence of a demonstrable bacterial cause and the histological findings in the few cases that have come to post-mortem, to which reference will shortly be made, are points in favour of virus causation. In addition it has been found possible to reproduce the disease in human volunteers by means of filtered sputum (Dingle, 1945). Vance, Scott and Mason (1943) had failed to transmit infection to seven volunteers by means of filtered sputum and nasopharyngeal washings. In the first experiment made by Dingle and his colleagues (Commission on Acute Respiratory Diseases, 1945) the object was to see whether the disease could be transmitted in man experimentally. Pooled and unfiltered sputum and throat washings from seven cases of atypical pneumonia were sprayed into the nose and pharynx of twelve volunteers. Ten developed respiratory illness seven to twenty-two days later. Eight had fever and, of these, five developed some degree of pneumonia; three of the five showed a rise in the titre of cold agglutinins. The second experiment (Commission on Acute Respiratory Diseases, 1946), made to find out if filtered material was infective, was, inconclusive, since 3 of the 12 controls that were sprayed with autoclaved material developed atypical pneumonia. It was repeated with greater precautions to avoid the chance of cross-infection of the different groups; these precautions included the spraying of the three groups of volunteers out of doors and allowing intervals of several days between the inoculation of the three groups. The groups were strictly segregated geographically and the control group receiving autoclaved material was made the largest. The inoculum consisted of the pooled sputum and throat washings from 6 cases of atypical pneumonia. Twelve volunteers received unfiltered material, 12 received it after filtration, and 18 had the autoclaved inoculum. In each of the two first groups there were 3 cases of atypical pneumonia and 5 cases of minor respiratory illness. In the control group there was 1 case of minor respiratory illness, but since this man was known to have broken out of isolation on more than one occasion and to have gone into the room occupied by one of the volunteers who developed an illness diagnosed as 'suspected atypical pneumonia', his illness was of dubious significance. The incubation period in those men receiving the filtrate was twice as long (nine to fifteen days) as those getting the unfiltered sputum and throat-washings (five to eight days). There seems no doubt from this last experiment that primary atypical pneumonia of unknown aetiology can be transmitted experimentally in man, that the agent is filterable and, in all probability, a virus.

MORBID ANATOMY AND HISTOLOGY

Generally speaking the death-rate in atypical pneumonia has been low. Those cases due to a virus of the psittacosis group have usually been more severe than the rest and a fatal outcome in them has been more frequent. In these the post-mortem findings have been in keeping with those already observed in human psittacosis. In atypical pneumonia of undetermined aetiology there have, however, been fatal cases which have been made the subject of careful post-mortem examination (Needles and Gilbert, 1944; Glendy, Beaser and Hankins, 1945; Campbell, Strong, Grier and Lutz, 1943; Golden, 1944).

Lungs

In the majority of these cases the only noteworthy gross change has been in the lungs, which have presented the picture of an acute interstitial pneumonia. Usually there has been no excess of pleural fluid and the pleural surfaces have been smooth. The lungs have been large and there has not been any clearly palpable area of consolidation. On cut surface the affected areas have been deep red; and from the bronchial passages an exudate, which was either thin and blood-stained or viscid or even creamy, could be expressed. Where secondary infection had occurred a purulent bronchopneumonia or lobar consolidation was present (Golden, 1944), and, in the case described by Glendy, Beaser and Hankins (1945), abscess formation had begun. Microscopic examination of the affected areas showed thickening and infiltration of the alveolar walls with predominantly mononuclear cells. The alveoli contained an exudate composed of serum, fibrin, red corpuscles, mononuclear cells, occasional polymorphonuclear leucocytes and desquamated alveolar epithelium. Areas of collapse occur, and a feature of the alveolar exudate was the variation in its composition from one part of the lung to another. The bronchioles showed thickening and infiltration of their walls with mononuclear cells, an infiltration which tended to extend radially into the regional interstitial tissue (Golden, 1944). The contents of the bronchioles might consist of mucoid material containing desquamated and degenerate epithelial cells or be frankly purulent.

Central nervous system

In the patient described by Campbell, Strong, Grier and Lutz (1943), who died with an ascending flaccid paralysis, the cord at the level of the 8th to 10th thoracic segments showed extensive perivascular necrosis infiltrated with polymorphonuclear leucocytes. There were fibrin thrombi in the vessels and an overlying neutrophil meningitis. Peronne and Wright (1943) also describe a fatal case of atypical pneumonia with changes in the central nervous system, in this instance an encephalitis. The leptomeninges showed no gross change and the cerebro-spinal fluid was clear. On section the cerebrum showed numerous areas of dark brown colour and pinhead size in both grey and white matter. The cerebellum, pons and medulla appeared normal. On section these areas were seen to be perivascular foci of infiltration with astrocytes and microglia, usually associated with a ring of peripheral haemorrhage. The vessels of the leptomeninges and brain parenchyma were engorged, and scattered ring-haemorrhages without cell proliferation were even to be seen in both grey and white matter.

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CHAPTER XXVII

THE PNEUMOCOCCUS

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DURING the years immediately preceding the advent of sulphonamide therapy, particular emphasis was laid upon the importance of type-differentiation of the pneumococci. This was natural because of the rigid type-specificity of serum therapy, but with the introduction of the sulphonamides a few years before the outbreak of war, interest tended to shift from the antigenic complexities of the organisms to their behaviour *vis-à-vis* the new drugs. The war-time development of penicillin, while widening the field of inquiry, further stimulated research along this line of approach.

SENSITIVITY OF PNEUMOCOCCI TO CHEMOTHERAPEUTIC AGENTS

The sensitivity of pneumococci to the various sulphonamides and to penicillin was early established by *in vitro* tests, and it was soon apparent that such variations of sensitivity as did occur were quite independent of type-specificity. The treatment of experimental pneumoccocal infections in animals confirmed the value of the new chemotherapeutic agents. The war years provided unrivalled opportunities for clinical trials under strictly controlled conditions; on the whole the use made of these opportunities was disappointing, but several large scale investigations, carried out in different countries, firmly established the efficacy of sulphonamide therapy in pneumococcal infections, especially primary pneumococcal pneumonia and meningitis (Bortz, 1943; Flippin *et al.*, 1943; Luna *et al.*, 1941; Coleman, 1940). Trials of penicillin therapy on a comparable scale have not yet been undertaken and for this the war must be held directly responsible. In normal times the natural mode of approach would have been the careful comparison of sulphonamide and penicillin therapy on groups of strictly comparable patients. The initial shortage of penicillin, however, coupled with the need for returning wounded soldiers to the fighting line as quickly as possible, demanded restriction of its use to infections which were known to be relatively non-susceptible to the sulphonamides, and pneumococcal infections do not as a rule fall into this category. Nevertheless, a few adequate trials on series of cases of primary pneumococcal pneumonia, and a spate of reports on isolated and atypical infections left little doubt of the efficacy of penicillin treatment for most types of pneumococcal infection

(Tillett *et al.*, 1944). The sensitivity of most strains of the organism is such that treatment by local application is often brilliantly successful in cases where the focus of infection is accessible, such as cases of pneumococcal conjunctivitis or pneumococcal empyema.

Unfortunately pneumococci, like many other organisms, show strain variations in respect of sulphonamide susceptibility and, moreover, are capable of acquiring increased resistance upon prolonged exposure to the drug, a reaction which may occur in the treated patient (Lowell *et al.*, 1940; Frisch, 1941; Hamburger *et al.*, 1942; Schmidt, *et al.*, 1942). According to Hamburger and his co-workers this change does not usually occur during short-term therapy but only during prolonged administration, so that it is likely to affect the outcome chiefly in subacute and chronic infections such as unresolved pneumonia. Recurrent attacks of pneumonia are just as responsive to treatment as the primary attacks (Schwartz *et al.*, 1942).

Similar acquirement of resistance to penicillin, both *in vitro* and *in vivo*, has been demonstrated. Thus Schmidt and Sesler (1943) found that when two strains of pneumococci, types 1 and 3, were passaged through penicillin-treated mice they acquired greatly enhanced penicillin resistance, which was retained even after thirty consecutive passages through normal untreated mice. Fortunately all the available evidence goes to show that penicillin sensitivity and sulphonamide sensitivity are unrelated; neither natural nor acquired resistance to either of the antibiotics affects sensitivity to the other (Powell and Jamieson, 1942; Schmidt and Sesler, 1943; McKee and Rake, 1942; McKee and Houck, 1943). The investigations with pneumococci therefore provided additional evidence in support of the view that the modes of action of penicillin and sulphonamides on micro-organisms are distinct, suggesting that in refractory cases alternate treatment with each may be valuable.

In view of the established value of specific-serum therapy for lobar pneumonia one would have expected considerable advantage from its combination with chemotherapy. *In vitro* experiments indeed showed a synergic action, but Wright and Gunn (1940) concluded from a study of experimental type 3 infection in rats, not only that sulphapyridine was far more effective than specific serum, but that a combination of the two was no better than sulphapyridine alone. This conclusion derives some support from a number of clinical trials in America and by an unpublished series of cases studied by the author and his colleagues in Sheffield during the early years of the war, but much further work will be necessary before it can be unequivocally accepted.

In view of the revolutionary effect of penicillin on the treatment of infected war wounds it is not surprising that intensive efforts were made to discover other antibiotics of like nature. A substance closely resembling penicillin both biologically and chemically was obtained by McKee and

MacPhillamy (1943) from *Aspergillus flavus*. It possesses a high degree of activity against infections of mice with type 1 pneumococcus.

IMPORTANCE OF TYPE-DIFFERENTIATION IN EPIDEMIOLOGICAL STUDIES

Notwithstanding the concentration of interest on chemotherapeutic studies during the war there were notable advances in our knowledge of the antigenic complexities of pneumococci and the importance of type differentiation in epidemiological surveys. Although close on 80 types are now known, most epidemiological reports relate to the original 32 types of Cooper. Type incidence depends of course to a considerable extent upon time, season, locality and methods of examination, but a broad distinction can now be drawn between types which are predominantly 'carrier' organisms and those which are more frequently infective and virulent, the latter being mainly responsible for the exogenous infections of epidemic outbreaks. The precise factors which determine the relative virulences of different types are still unknown. It is perhaps significant that the convalescent-carrier rate is not significantly reduced by the routine use of sulphonamides in the treatment of pneumococcal pneumonia (Harris, 1943). Moreover, Harris found that heterologous types may be recovered following the disappearance of the organisms responsible for the pneumonia, and suggests that some types may have carrier qualities different from those of others. The report of cross-infection with a sulphadiazine-fast strain of a type 8 pneumococcus is not without interest in this connexion (Frisch *et al.*, 1943). As one would expect, the carrier rate for the virulent infective types rises during an epidemic; the rise may even precede the epidemic and have causative significances (Stebbins *et al.*, 1940; Smillie and Jewett, 1942).

MISCELLANEOUS STUDIES

Certain advances in our knowledge of the pneumococci made during the war may be noted briefly, although they were not directly conditioned by the war itself. Avery and his co-workers (1944) reported the first example of experimentally induced type-transformation by a chemically defined substance. A rough type 2 variant was transformed into a capsulated type 3 organism by means of a fraction of type 3 pneumococcus consisting of a polymerised form of desoxyribonucleic acid containing neither deletable protein, unbound lipoid nor serologically reactive polysaccharide. Chapman and Osborne (1942), Neter (1943) and Zepp and Hodes (1943) produced evidence that some pneumococcal types possess antigenic components in common with certain strains of *H. influenzae*. Several workers demonstrated hyaluronidase production by various strains of pneumococci, and McClean showed that the capsule of a type 1 organism, unlike the capsule of *Strep. pyogenes*, is resistant to destruction by the enzyme because it contains no glycuronic acid

(McClean, 1941; Meyer *et al.*, 1940, 1941; Humphrey, 1944). Strains of pneumococci which require CO_2 for growth, especially on first isolation, have been described (Khairat, 1940; Fleming, 1941) and the work of Kempner and Schlayer (1942) suggests that the growth-rate of most strains in either aerobic or anaerobic culture may largely depend upon CO_2 concentration; the practical importance of these findings is obvious.

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CHAPTER XXVIII

THE STAPHYLOCOCCUS

BY F. C. O. VALENTINE
M.R.C.P.

IN the history of the Medical Services in the War of 1914–18 the main problem of staphylococcal infection was stated. Twelve hours after wounding *S. aureus* was found in some 14 per cent. of wounds; by the fourth day it predominated in culture more often than any other organism, and in persistent wounds necessitating the patient's transfer to Great Britain it might be found in some 80 per cent. of cases. It was considered that infection might originate either from the patient's skin and fomites, particularly if wet dressings were used, from the air if the dressings were disturbed, or later, from infection carried by the hospital staff from patient to patient or originating in minor lesions among the staff themselves. It was also observed that generalised staphylococcal infection arising from war wounds was very rare.

Bacteriological investigations carried out during the War of 1939–45 demonstrated the same tendency for persistent wounds to acquire fresh secondary infections. (Table I: see also Williams and Miles (1945) for findings in civilian cases.)

TABLE I

Reference	Age of wounds when sampled	No. of cases	Percentage infected with *St. pyogenes*
Spooner (1941)	2 days	31	6·5
Spooner (1941)	2–21 days	13	69·2
Spooner (1941)	35 days	29	65·5
Miles *et al.*, (1940)	1–40 days	105	54·3
Pulvertaft (1943)		52	54·4

In the studyof the source of such secondary infections much assistance was obtained from work carried out in the inter-war period (see Blair's review 1939). In particular the acceptance of the production of coagulase as the hall-mark of the pathogenic staphylococcus, and the demonstration of the high carrier-rate in the general population, have played a fundamental part in explaining the frequency of infection in war wounds. Staphylococcal coagulase was first described by Loeb, 1903—4 and has been studied by many authors. In 1937 Cruickshank, finding its production to be constantlyassociated with that of α-lysin, recommended the coagulase test as the simplest routine investigation for pathogenicity in the staphyloccocus, and his view has won general acceptance. Human, or sometimes rabbit, plasma was used in dilutions up to 1 in 10. In 1943 Cadness-Graves and her fellow-workers showed that pathogenic strains in heavy suspension were instantly clumped in plasma, and they advocated this method as a presumptive test where many strains had to be examined. In 1944 Penfold used 25 per cent. human plasma in agar plates, and found that an opaque ring developed in the medium around colonies of pathogenic staphylococci. Later in the year Wilson Smith and Hale, investigating the mechanism of the reaction, showed that coagulase, itself heat-stable, united with a heat-labile secondary factor or activator normally present in human, rabbit and horse serum to form a thrombin-like substance converting fibrinogen into fibrin. In 1945 the same workers found that in human defibrinated blood the pathogenic staphylococcus is largely protected from phagocytosis by the fibrin which forms round the clumped cocci. In mouse or rat blood, containing no activator, phagocytosis took place as readily in plasma as in serum. This work would seem to show that coagulase plays a fundamental part in the pathology of staphylococcal infection and confirms the use of the test in the demonstration of pathogenicity.

In 1935 Dolman observed that staphyloccoci were present in the nose in several patients suffering from staphylococcal lesions elsewhere in the body. Thereafter, with the aid of the coagulase test, the carrier rate in the nose and on the skin of the back of the wrists was frequently investigated and the results, as compiled by Miles, Williams and Clayton Cooper (1944), are shown in Table II.

TABLE II

*Nasal and Skin Carrier Rates for Staphylococcus Aureus**
(Adults, not Clinically Infected)

Source	No. of cases	Percentage of carriers		
		Total nose	Total skin	Nose and skin
Hallman (1937)	158	39		
McFarlan (1938)†	132	35		
Devenish and Miles (1939)	40	45	5	2·5
Gillespie *et al.*, (1939)	159	43	20	13
Vierthaler (1940)	100		21	
Bartley (1941)	82	22	21	6
Smith (1941)	100	32	5	4
Martin (1942)	100		24	
Miles *et al.*, (1944)	479	47·4	18·4	11·7

(*) The authors restrict the term *Staph. aureus* to coagulase-positive staphylococci.
(†) Used α-lysin as criterion of pathogenicity but found 95 per cent. of lysin producers coagulase-positive.

Whereas the earlier series quoted were obtained from in-patients or hospital staff, the large number of cases investigated by Miles and his fellow-workers were obtained from out-patients and show the percentages to be found in the general population of Birmingham. Amongst their nasal carriers the skin was positive in 24·7 per cent. compared with 12·7 per cent. of those in whom the nose was negative; there is therefore a significant association between nasal carriage and skin carriage. Weekly nasal swabs, taken from 74 members of the nursing staff of a ward mainly reserved for septic cases, revealed that 64 per cent. were positive at some period, a figure significantly greater than that found in out-patients (47·4 per cent.) and indicating the spread of infection in a favourable environment. The facts quoted go far to explain the prevalence of staphylococcal wound infection, since in the nasal carrier the hands and clothes, especially the handkerchief, must frequently be contaminated. The cocci may reach the wound either from the patient's own skin or clothes or from the hands of those giving him first-aid. When the case reaches hospital, in addition to the risk from carriers, there is also the danger that cocci from infected wounds may be transferred through faulty surgical technique or by means of ward dust.

In the first years of the war there was no adequate means of demonstrating the transfer of individual strains of staphylococcus from one person to another. Cowan (1939), using slide cell agglutination, showed that about two-thirds of his pathogenic strains fall into three distinct types, and by further absorption of sera Christie and Keog (1940) were able to demonstrate nine sub-types. But the preparation of such sera was difficult and the number of different types somewhat low for the satisfactory identification of strains. Latterly, following the work of Fisk (1942) and Fisk and Mordvin (1944) in America, Wilson and Atkinson (1945) developed a method of typing by means of bacteriophage filtrates, which has been successfully employed in discovering the source of epidemics of staphylococcal infection and food-poisoning. It is clearly desirable that, when possible, both methods should be used in conjunction.

PREVENTION OF WOUND INFECTION

The work already quoted shows the ubiquity of pathogenic staphylococci in the ordinary human environment. In hospital, wounds which are already infected provide an even more dangerous source of fresh infection, on account of the number of cocci present and also their proved virulence. Actual contamination of wounds occurs by contact with soiled fingers, instruments, dressings or lotions; from the dust in the air of a ward, derived from infected blankets or plasters; and by infected droplets from mouth or nose.

The methods used to control wound infection are dealt with elsewhere and need only be summarised here. Surgical excision and cleansing of the wound on the operating table at the earliest possible moment is still essential. Where wounds had to be dressed in the ward an improved and simplified technique was developed to minimise the risk of cross-infection (M.R.C. Memoranda No. 6, 1941 and No. 11, 1944). Finally the evolution of chemo-prophylaxis progressed through stages in which the sulphonamides and acridine derivatives were used alone or in combination and were replaced during the last year of the war by penicillin when adequate supplies became available; the majority of wounds could then be successfully sutured on the arrival of the patient at the Base hospital and the risk of further infection finally eliminated.

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CHAPTER XXIX

SEROLOGICAL CLASSIFICATION OF STREPTOCOCCUS PYOGENES

By S. D. ELLIOTT
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EXPERIENCES of the War of 1914–18 showed that haemolytic streptococci were a frequent cause of wound infections. At that time little was known regarding the source or mode of spread of the infecting micro-organisms; such information could be found only through epidemiological studies which required some means of identifying individual strains of haemolytic streptococci in order that their spread from case to case might be followed. Although a multiplicity of serological types was suspected no method was then available for their rapid and precise identification. During the succeeding years, two workers in particular, R. C. Lancefield in America and F. Griffith in England, devoted much time to this problem and before the onset of the War of 1939–45 their methods had already been applied with success to the investigation of outbreaks of streptococcal infection.

THE GRIFFITH CLASSIFICATION

In 1934 Griffith defined 27 serologically distinct types of haemolytic streptococci and to this number subsequently added a further three new types. Most of these types had been isolated from acute human infections and several had been responsible for epidemic disease. The different types were distinguishable serologically by a simple slide-agglutination technique and, following Griffith's publication, this method was immediately applied with success by other workers studying streptococcal cross-infection in hospitals and schools. The outbreak of war in 1939 gave considerable impetus to field investigations of this kind. Owing to their multiplicity of type, haemolytic streptococci provided an admirable 'indicator' for the study of hospital infections. Hitherto unsuspected sources of wound infection, such as dust and faulty surgical technique, were unmasked and methods evolved for their elimination (Medical Research Council, 1941). The results of these epidemiological studies depended for their significance upon the precision with which different strains of the infecting micro-organisms could be identified. It soon became apparent that, in the identification of streptococci isolated from dust or from wounds, the slide-agglutination method had limitations. Many strains were encountered which, through an apparent absence of type-specificity, defied identification by this method. Their further study showed that loss of the type-specific antigen sometimes resulted in the unmasking of other antigens less specific in their reactions and the cause of cross-agglutination with antisera of heterologous type (Elliott, 1943; Lancefield and Stewart, 1944). Such possibilities had already been suggested by the work of Lancefield (1940) and it was as the result of her studies that the serological classification of the haemolytic streptococci was eventually placed on a sound immunological basis.

THE LANCEFIELD CLASSIFICATION

Lancefield (1940–1) approached the problem through her more general studies undertaken in an attempt to relate the cellular composition of haemolytic streptococci to their biological activity. She had already shown that, with few exceptions, streptococci causing acute infection in man were characterised by a single, specific, polysaccharide component. Serologically distinct polysaccharides characterised streptococci isolated from other sources, such as animal infections, and on this basis a broad classification into groups was postulated (Lancefield, 1933). Streptococci responsible for acute disease in man were designated Group A; to this group all except four of the Griffith type strains were found to belong. Lancefield's earlier work with Dochez and Avery (1919) clearly demonstrated the existence of distinct serological types among streptococci of human origin, and it had been shown that these induced a type-specific immunity in experimental animals. The streptococcal cell-component responsible for this type-specificity was shown by Lancefield (1928) to be a protein antigen, serologically distinct for each type and inducing the production of specific, protective antibodies when injected into experimental animals. To distinguish it from the group specific carbohydrate or 'C substance', the type-specific protein was called the 'M substance' from the characteristic matt appearance sometimes exhibited on blood agar by colonies of streptococci possessing this antigen.

It was against this background and in response to the mounting wartime interest in the epidemiology of streptococcal infections that Lancefield and her colleagues at the Rockefeller Institute evolved a method for the 'typing' of Group A streptococci. This method was based upon the identification of the type-specific M antigen. A technique had already been described (Lancefield, 1928) for the extraction of the M antigen from the intact micro-organism. Type-specific precipitating antisera were prepared corresponding to the Griffith type strains, in addition to 16 new types isolated in America, and a convenient and economical method for carrying out the precipitation tests was devised (Swift *et al.*, 1943).

COMPARISON OF METHODS OF AGGLUTINATION AND PRECIPITATION FOR 'TYPING' STREPTOCOCCI

When a large series of Group A strains was examined by the agglutination and precipitation methods, in parallel, the results showed close agreement. The advantages of the precipitation method were twofold; first, the difficulty of obtaining streptococcal suspensions suitable for use in agglutination tests was eliminated; secondly, in the precipitation method, only one component of the streptococcal cell, the M antigen, was under scrutiny whereas, in the agglutination tests, other surface antigens also took part and caused confusing cross-reactions. On the other hand, a number of cultures were encountered which, although apparently readily identified by the agglutination method, yielded extracts which reacted weakly or not at all with the type-specific precipitating antisera. It has been shown that another component of the streptococcal cell, the T antigen, may cause agglutination in homologous antiserum (Lancefield, 1940). This antigen, although, like the M antigen, a protein, is destroyed by the procedures usually adopted for extraction of the type-specific substance (Lancefield and Dole, 1946). Streptococci which have lost the M antigen and retained the T antigen, therefore, agglutinate but fail to yield extracts which precipitate in antisera of homologous type. In some types the T antigen is type-specific; in others, a serologically indistinguishable T antigen is shared by a number of different types (Elliott, 1943; Stewart *et al.*, 1944). Identification of this antigen is, therefore, not always a reliable guide to the identity of the streptococcus.

ANTIGENIC VARIANTS

The masking of one antigen by another has already been mentioned. Thus, strains known to contain T antigen may fail to agglutinate in anti-T serum. In some instances this is correlated with the presence of large amounts of M antigen; susceptibility to T agglutinins appears when these cultures are subjected to slightly unfavourable conditions, such as growth at room temperature (Elliott, 1943; Lancefield and Stewart, 1944). Conversely, in the case of type 1, M agglutination may be blocked by the presence of T antigen.

Streptococci sometimes appear to lose their capacity for elaborating the M substance. Cultures which have undergone this form of antigenic degradation are described as 'glossy' on account of the characteristic appearance of the colonies produced on solid media. Little is known of the factors influencing this antigenic loss. It sometimes occurs under the conditions of prolonged sub-cultivation on artificial media (Todd and Lancefield, 1928). It may also occur *in vivo:* serial cultures taken from patients convalescing after acute infections have, in a number of cases, shown a progressive loss of the M antigen (Rothbard). It seems likely that the difficulty frequently experienced in the precise identification of strains isolated from the throats of chronic carriers, from wound infections and from dust is also due to the common occurrence of 'glossy' organisms in these situations.

Enzyme action is one factor sometimes responsible for loss of the M substance. Under suitable conditions, streptococci may produce an extracellular proteolytic enzyme which destroys the serological reactivity of the M antigen (Elliott, 1945). It appears that the enzyme is derived from an inactive precursor which, in broth culture, is transformed by an auto-catalytic reaction into the active proteinase (Elliott and Dole, 1947). Under certain conditions, such as growth at room temperature or in the presence of iodoacetate, this reaction is inhibited so that little or no active proteinase is produced and the M antigen remains intact. Mouse-virulence of group A streptococci is associated with presence of the M substance (Lancefield 1940–1).

Serial passage through mice of non-virulent proteinase-producing streptococci results in the selection of virulent variants rich in M substance and unable to produce either the proteinase or its precursor (Elliott, 1945).

Occasionally, strains are encountered which have lost the T antigen (Elliott, 1943; Lancefield and Stewart, 1944). In one instance, such a variant appeared in a strain which had been cultivated for many years upon artificial media. Very rarely, variants have been isolated in which the group-specific polysaccharide has been lost (Wilson, 1945). Nothing is known of the factors which influence the appearance of such antigenic variants.

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CHAPTER XXX

ENCEPHALITIS IN THE BRITISH ISLES

By the late J. McINTOSH
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THE term encephalitis is used here to include only those forms of inflammatory brain disease which appear to be either directly due to attack by a virus or less directly associated with virus disease. However as no virus has been transmitted to animals from any of the human cases occurring in this country it is only possible to form an opinion as to the nature of the disease on histological grounds.* Using this criterion it has been possible to distinguish at least five different forms of human encephalitis among those which have been observed in the British Isles during the war years. None has occurred in epidemic form, and the only advances in our knowledge of encephalitis have been, first, the description by Weston Hurst (1941) of the form called by him acute haemorrhagic leuco-encephalitis, and secondly the recognition of two forms occurring in subacute ingravescent form, mostly in children, (*a*) the inclusion-body encephalitis of Dawson (1933, 1934) and (*b*) the subacute sclerotic leuco-encephalitis of van Bogaert (1945). These three last diseases have been very rare, but a few cases of each has been observed in the London district.

1. *Post-infectious encephalomyelitis.* While no epidemic of this condition has occurred, the large numbers of primary vaccinations, both in young persons joining the Forces and in association with the outbreaks of smallpox in Scotland, have resulted in a considerable number of cases of post-vaccinal encephalomyelitis. The incidence of this sequela in relation to the number of primary vaccinations of adults and older children has not been higher than usual. In the Glasgow epidemic Anderson and McKenzie (1942) estimated that half a million of the population had been vaccinated within a period of two months, and only seven definite cases of encephalitis or encephalomyelitis with two deaths were observed. This gives an incidence of one case of encephalitis in 70,000 vaccinations. In Fifeshire, Fyfe and Fleming (1943) reported nine cases of encephalomyelitis with four deaths among about

* The fallibility of a purely histological diagnosis even in so characteristic a virus disease as poliomyelitis was shown by the Trinidad outbreak of rabies reported by Weston Hurst and Pawan (1931).

75,000 vaccinated persons. All these patients were children between the ages of three and seventeen years and none had been vaccinated in infancy. They found that immune serum obtained from animals was of no value in treatment, but they appeared to obtain good effects from large doses of human serum obtained from recently vaccinated subjects.

In addition to post-vaccinal cases, other cases of this histological type of encephalitis have followed measles and other exanthemata, and coryzal disease which may have been of influenzal character.

The authors were asked by the Ministry of Health to examine post-mortem material from a few such cases; in all they examined eight cases of post-vaccinal encephalomyelitis, three cases of encephalomyelitis following measles and three cases following a coryzal infection. These cases presented no noteworthy features.

2. *Acute encephalitis*. The material submitted to the authors or collec- lected by them in the course of their hospital work also included eight cases of acute encephalitis which appeared to be due to a neurotropic virus, i.e. the grey matter was primarily and almost exclusively affected. Six of these cases occurred in young adults and two in children of 9 and 16 years. The cerebral cortex was in most cases severely affected and the brain stem was also affected in varying degree, but the special attack on the substantia nigra, which was so commonly seen in encephalitis lethargica during the years it was epidemic, was never observed. The cerebellum was always free from lesions in the cases where it was examined. The spinal cord showed a minor degree of inflammatory infiltration in the most severe cases. Extracts of glycerinated brain from five of these were inoculated intracerebrally in rabbits and mice without result.

3. *Inclusion body encephalitis*. (Dawson). Three cases of the form of subacute encephalitis described by Dawson (1933, 1934) in America were observed in the London districts during the war. A report on these cases was published in *Brain* (Brain, Greenfield and Russell, 1948). These cases ran a progressively ingravescent course and were fatal in about three months. Two showed, at some stage of their illness, the myoclonic jerkings described by Dawson in his cases. Post-mortem examination showed some sclerosis of the cerebral cortex with much degeneration of nerve cells, and perivascular and more diffuse inflammatory reaction. Type A inclusion bodies were seen in the nuclei of degenerated nerve cells in the cortex, brain stem and in one case in the cervical cord, as well as in occasional nuclei of cells of oligodendroglial type. Inoculation experiments with material from two of these cases were without result.

4. *Subacute sclerosing leuco-encephalitis* (van Bogaert). In 1945 van Bogaert described under the above name a form of subacute encephalitis, which he had observed in three children in Belgium. Clinically the disease ran a subacute progressive course of three to six months,

characterised by loss of speech and progressive dementia associated with epileptiform attacks and muscular spasms. *Histologically* there was a subacute diffuse inflammation of the grey and white matter of the cerebral hemispheres and brain stem, associated with some degree of demyelination and sclerosis of the centrum ovale of the cerebral hemispheres as well as gliosis of the cerebral cortex. The description of this condition has resulted in the identification of some fatal cases of subacute encephalitis occurring in this country during the war as being of similar type (Rosanoff, 1947). Most of these also have occurred in children. No animal inoculations were made from material of this type. It is probable that other forms of encephalitis may occur in subacute ingravescent form, e.g. encephalitis lethargica.

5. *Acute haemorrhagic leuco-encephalitis*. In 1941, Weston Hurst described in South Australia a form of inflammation of the brain which he called acute haemorrhagic leuco-encephalitis. The disease came on after infections of the respiratory tract, and was fatal in a few days. Post-mortem, the disease was found to be confined to the white matter of the cerebral hemispheres, especially in their central areas, the frontal, occipital and temporal poles, but the cortex was spared. It was characterised by fibrinoid necrosis of the walls of the blood-vessels, with perivascular oedema and demyelination, petechial haemorrhages and an inflammatory exudate in which polymorphonuclear cells were abundant in the early stages. A case of this kind was reported by Henson and Russell (1942), another was referred to by Russell (1943), and the authors have examined a similar case. The condition in all was almost identical with the cases described by Weston Hurst, when allowance was made for the duration of the disease. In two cases the encephalitis came on after an acute respiratory infection. In one case there were early inflammatory changes in the pons.

Poliomyelitis did not assume epidemic proportions in this country during the war. The sporadic cases which occurred presented no unusual features. Nor was there evidence that any of the forms of encephalitis which have recently occurred in endemic or epidemic form in the United States (Eastern and Western types of equine encephalomyelitis), Russia (tick-borne encephalitis) or the Far East (Japanese B type), has occurred in this country. This immunity is probably due to the fact that neither an animal reservoir, nor suitable insect vectors are present in the British Isles. However, the close serological relationship of the virus of Russian tick-borne encephalitis to 'louping ill' in sheep, and the evidence that the latter disease may produce a mild encephalitis in man under conditions of laboratory infection, makes it possible that an occasional case of encephalitis in man may be due to the virus of louping ill.

Cases of meningo-encephalitis associated with virus pneumonia have also been reported (Holmes, 1947).

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CHAPTER XXXI

A NOTE ON LEPTOSPIROSIS

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WEIL'S disease occurred sporadically among soldiers, as among civilians, in Great Britain from 1939 onwards. In a report on the prevalence of the infection up to 1942, Gardner (1943) placed the risk of military service in Great Britain as equal to that of agriculture, with eight cases each out of a total of 58, and second only to mining, which provided twelve.

It was not until the invasion of Normandy that any considerable outbreak was reported. Resulting, as it appeared, from bathing, washing, shaving and teeth-cleaning with infected water, 39 definite cases, and a probability of up to 100 less certainly diagnosed ones, were reported by Bulmer (1945), while two other cases were recorded by Carragher (1945), and Cross (1945). In Bulmer's series there were only three deaths, but it must be remembered that the 'population' observed was young and fit, and so would be expected to show a relatively low fatality. In the majority of cases the diagnosis was clinched by the demonstration of specific antibodies in the blood serum, and in a good number *Leptospirae* were revealed in the urine or blood by dark-ground microscopy.

Later on, among patients suspected of Weil's disease in the British Liberation Army in France, Buckland and Stuart (1945) found three whose blood-serum agglutinated either *L. sejroe* or *L. grippotyphosa*, while giving no reaction with *L. icterohaemorrhagiae*, thus proving the occurrence of the milder and non-icteric forms of leptospiral infection, or mud fever, among the troops.

In the scantily accessible foreign literature there is a reference to Weil's disease in Leningrad in 1942 (Viskovsky, 1944), and two to mud-fever in France (Mollaret, 1943), and Lapland (Stuhlfurth, 1943).

The war saw also the first application of penicillin in the treatment of leptospirosis. Although the Oxford penicillin team (Abraham, *et al.*, 1941) had reported a strain of *Leptospira* as insensitive to the drug, later observations of Alston and Broom (1944) showed susceptibility to be the rule. Meanwhile Heilman and Herrell (1944), and Alston and Broom reported a favourable therapeutic effect of penicillin on guinea-pigs experimentally infected with *L. icterohaemorrhagiae*. This was subsequently extended by Larson and Griffiths (1945) to mice, and with *L. canicola*, to hamsters. Success in the treatment of guinea-pigs has also been obtained in Denmark (Borg Petersen, private communication), but it must be noted that other workers have reported an almost negligible effect (Augustine *et al.*, 1944). Differences in the virulence of the strain used, in dosage and length of treatment, probably account for these discrepancies. While there can be little doubt that penicillin has a therapeutic effect in some circumstances, we cannot yet be sure what those circumstances are. It is, however, clear enough that very early treatment is necessary to get satisfactory results.

Treatment of human patients is described by Bulmer (1945) and others but no claim is made to have proved its efficacy.

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CHAPTER XXXII

ADVANCES IN HAEMATOLOGY

By R. G. MACFARLANE
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GENERAL

CONSIDERABLE advances were made in many branches of haematology and related subjects, both by workers directly concerned with some part of the war effort, and by those who were able to carry out independent research in Service or civilian life, despite the difficulties caused by the war.

This section is limited, however, to those aspects of haematological research not covered by other contributors, and will therefore omit reference to the activities of the blood transfusion services, the haematological effects of nutritional toxic substances, irradiation, and environmental changes such as those encountered in special Service conditions of altitude, pressure or temperature.

It must also be emphasised that even the remaining aspects cannot be covered comprehensively. Much valuable work has not been published except in the form of confidential or restricted reports, and much still awaiting publication is not available.

PHYSIOLOGY

Histiogenesis of Haemic Cells. The increased frequency of marrow biopsy as a diagnostic procedure has greatly facilitated the understanding of maturation processes in normal and abnormal bone marrow. Terminological confusion, at first acute, is becoming resolved; the term 'megaloblast' for instance, is now being generally accepted as referring to the abnormal erythroblast occurring in cases of liver factor deficiency, or in early foetal life. Important contributions to this subject were made by Gilmour (1941) who studied normal haemopoiesis in the foetus and newborn; by Oliver P. Jones (1943) who clarified the 'megaloblast question', and by Israels (1941) who described the main disturbances of the normal process of red-cell development. Duran-Jorda (1943) advanced an ingenious, if improbable, theory of haemopoiesis, in which plasma cells are considered to be the precursors of erythrocytes.

Possibly the most considerable advance was the application of physical methods such as micro-spectography, and of micro-histochemical reactions, to the problem of the relationship of morphology to function in haemic cells, and the changes occurring during normal and pathological maturation. This work, which was largely carried out by Caspersson (1940), Caspersson and Schultz (1940), Dustin (1942, 1944), La Cour (1944), Thorell (1944) and White (1947), has established that the basophilic material of developing red cells is probably ribonucleic acid, and has led to the chemical identification of a number of structures hitherto known only by their staining reactions.

Another line of approach, which may well develop rapidly with the aid of these new methods, is that of marrow tissue-culture. The elaborate apparatus designed by Osgood for such culture has been modified by Plum (1947), who has reported good results with it. Similar studies are being carried out by Fieschi and Astaldi (1946). The maturation of reticulocytes and the growth-factors they require have been studied also by Plum (1942 *a*, *b*), and Jacobsen and Plum (1943).

The life span of the red cell in the normal circulation and in a variety of pathological states has been the subject of a large number of publications. The application of the Ashby technique on the one hand and the use of radio-active and stable isotopes on the other, has separately established the normal life span with close agreement. The subject has been discussed by Callender *et al.*, (1945), and by Loutit (1946).

Function of the Lymphocyte. Among the numerous investigations of leucocytic functions, the attention directed to the lymphocyte has yielded significant results. Barnes (1940) demonstrated the presence of a number of potent enzymes. Sanders, Florey and Barnes (1940) drew attention to the normal rapid production and utilisation of these cells, Sanders and Florey (1940) demonstrated the effects of, and the processes of regeneration after the total removal of lymphatic tissue. This was followed by the work of Dougherty *et al.*, (1944), Harris *et al.*, (1945) who showed the important part played by the lymphocyte in the formation of antibodies.

Estimation of Haemoglobin. Concern regarding the possible defects of war-time feeding resulted in the establishment of a number of nutrition surveys, which included estimation of haemoglobin levels of different sections of the community. This in turn led to investigation of the meaning and accuracy of the results obtained, particularly those by the Haldane-Gowers method which is commonly used in this counting. The error of this method has been investigated by Macfarlane (1945), and in a later series of experiments a number of other clinical methods have also been examined (Macfarlane, King and Wootton, 1948). A significant finding (King *et al.*, 1944; Macfarlane and O'Brien, 1944) is that the Haldane haemoglobin standard thought to represent 13·8 g. haemoglobin is actually equivalent to 14·8 g., a difference that goes far to explain the discrepancy between English and American normal haematological values. During the course of this work a small visual photometer, using the neutral grey wedge principle, has been developed for clinical haemoglobinometry which it is hoped will dispose of some of the errors inherent in existing methods (Macfarlane *et al.*, 1948). The instrument has been described by King (1947). A similar principle was also used in an instrument designed by Duffie (1942).

Normal Haematological Values. Findlay (1946), as the result of an extensive investigation carried out during the war years, clarified the changing blood-picture of the normal infant. Haemoglobin levels in a number of sections of the population were recorded (M.R.C. Special Report, Series No. 252) and by McIntosh and Morris (1941), Davidson *et al.*, (1944), Dobbs *et al.*, (1944), Yudkin (1944) and Fullerton *et al.*, (1944). The normal level of serum iron, an important indicator of iron deficiency, was established by Powell (1944).

BLOOD COAGULATION

The war years saw a considerable application of the hitherto rather academic aspects of blood coagulation. The discovery of dicoumarin by Link and his co-workers (Campbell *et al.*, 1941; Campbell and Link, 1941; Stahlmann *et al.*, 1941) provided an anticoagulant substance that has since been widely used in the treatment and prophylaxis of thrombotic and embolic states (Butt *et al.*, 1941 ; Bingham *et al.*, 1941; Allen, 1947). Heparin has also been most valuable in the same conditions, and particularly for the prevention of thrombosis during vascular surgery (Murray, 1940; Crafoord and Jorpes, 1941; Quick, 1942).

Certain products of blood coagulation have also had an extensive application. Macfarlane (1943) used sheets of human fibrin prepared from decalcified plasma as a dressing for burns. Though only partially successful in this respect, the method was improved and extended by American workers, who produced fibrin dressings in the form of sheets and 'foam' which could be used with human thrombin as haemostatic applications, and for filling up cavities remaining after surgery, particularly of the brain (Bering, 1944; Ferry and Morrison, 1944; Woodhall, 1944).

On the more academic side, a considerable contribution to the theory of blood coagulation has been made by Owren (1947), who, working in enemy-occupied Norway, showed that normal blood coagulation requires at least one factor additional to the four required by classical theory (thrombokinase, prothrombin, calcium and fibrinogen). He has called this factor 'factor 5' and its recognition has already clarified a number of confusing discrepancies that have arisen in attempts to put the coagulation factors on a quantitative basis for practical purposes of assay. (See Macfarlane, 1948.)

ANAEMIAS

Nutritional. Concern that the war-time diet of the population of Great Britain and other countries might be less than adequate for basic needs naturally resulted in the organisation of numerous surveys of the state of nutrition. Haemoglobin levels formed an important index in such surveys and one is dealt with at length by a number of authors in a comprehensive M.R.C. publication 'Haemoglobin levels in Great Britain and Ireland in 1943. M.R.C. Special Report Series, No. 252'. Individual surveys were also carried out by Davidson and his co-workers (Davidson *et al.*, 1942, 1943, 1944), Mackay and her associates (Dobbs *et al.*, 1944; Mackay *et al.*, 1942; Wills *et al.*, 1942; Yudkin (1944) and Fullerton *et al.*, 1944). In general, these surveys did not reveal any serious deterioration of haemoglobin levels in Great Britain during the war years.

Pernicious Anaemia and related conditions. The procedure of sternal marrow-puncture developed during the war years from a rarely performed and specialised operation into a routine diagnostic investigation. In consequence, the understanding of the group of anaemias due to liver-factor deficiency has become generally clarified and it is accepted that the characteristic marrow change in such conditions is that of megaloblastic, as opposed to normoblastic development of the red cells. Contributions to the practical application of this recognition have been many and fruitful. Davidson *et al.*, (1942) described the morphological changes occurring during successful treatment of patients suffering from pernicious anaemia, and Thomson (1944) described the early megaloblastic changes in such patients.

Refractory Anaemias. Both Bomfoord and Rhoads (1941) and Davidson and his co-workers (1943) investigated anaemias resisting treatment with liver extract, paying particular attention to the marrow pictures. Davis and Davidson (1944) found that a proportion of such cases resistant to liver by injection responded to crude liver preparations ('protolysed liver') given by mouth, a contribution of considerable importance. Davis *et al.*, (1943) had previously found such preparations effective in Addisonian pernicious anaemia.

Pernicious Anaemia of Pregnancy. A further condition recognised with greater clarity during this period was the so-called pernicious anaemia of pregnancy, an often severe anaemia complicating late pregnancy or the early puerperium. The work of Segerdahl (1941), Miller and Studdert (1942), Davidson *et al.*, (1942), Fullerton (1943) and Callender (1944) has established this condition as being probably due to an acute temporary deficiency of liver-factor.

The Anaemia of Sprue. A megaloblastic anaemia associated with deficient fat absorption due to a group of disorders occurring in this country variously termed 'coeliac disease', 'idiopathic steatorrhoea' or 'non-tropical sprue' became recognised during the war years as of frequent occurrence. Two such cases, with acute exacerbations, were mentioned by Macfarlane (1942). The more familiar 'tropical sprue' was studied during the war in India by Black, Bound, and Fourman (1947) with particular reference to the improvement of fat absorption by the administration of liver and yeast extracts, the latter being the more effective in this respect.

Dimorphic Anaemia. Trowell (1942, 1943) drew attention to the blood-picture of an anaemia due to a deficiency both of iron and the liver factor, occurring in African natives, and the relative failure of response to administration of either of the two deficient factors separately. Such a condition may also occur in this country.

Haemolytic Anaemias. The study of abnormal haemolysis has been facilitated in the past few years by the application of new haematological methods. One of the most important of these is the measurement of the rate of destruction of transfused cells in the circulation of the patient, as described by Brown, Hayward Powell, and Witts (1944); thus differentiating between a general lysis of red cells of whatever origin, and that affecting the patient's cells only. Attention was also drawn to the importance of spherocytosis and increased mechanical fragility in the mechanism of haemolysis by Shen and his co-workers (1943, 1944), and to the possible importance of lyso-lecithin by Singer (1941) and Singer *et al.*, (1941). Interest has also been aroused by the prevalence of certain iron-containing inclusions in the red cells of patients with abnormal haemolysis, and in animals. These inclusions have been studied by Pappenheimer *et al.*, (1944, 1945), Case (1945), Gruneberg (1941), and Doniach *et al.*, (1943), the red cells containing such bodies being called 'siderocytes'. Their significance has not yet been determined. Maegraith and his co-workers (1943), studying the haemolytic anaemia of blackwater fever, put forward a generally applicable hypothesis of a normal equilibrium between a haemolytic tissue factor and an anti-haemolytic plasma factor, disturbance of which, in favour of the former, leads to abnormally active haemolysis. Fairley (1941) reviewed his important discovery of methaemalbumen and its clinical significance.

Toxic Haemolytic Anaemia. The important toxic effects of a large number of solvents and other noxious substances, used for industrial or war purposes, as potentiators of haemolytic and aplastic anaemias are dealt with in another volume. Here it is only necessary to mention the haemolytic reactions sometimes occurring, particularly in children, as a result of chemotherapy. The danger of the sulphonamide drugs in this respect was reviewed by Trier (1941).

Haemolysis associated with cold agglutinations. The association of cold agglutination with haemolysis *in vivo* was described by Dameshek (1943) and the greatly increased mechanical fragility of cells agglutinated or *in vitro* was demonstrated by Stats (1943). The occurrence of gangrene of the extremities in patients with this abnormality was also recorded by Stats and Bullwood (1943).

Blackwater Fever. In addition to the work of Maegraith *et al.*, already mentioned, Foy and his co-workers (1941, 1945) made observations on the survival of normal cells transfused into patients suffering from blackwater fever, and of the cells of such patients transfused into normal individuals. From the results of this experiment it appears that some process occurring in blackwater fever irreversibly damages the cells in the patient's circulation, whether his own or transfused, so that they are subsequently haemolysed in his own or in the normal circulation.

Sickle-cell Anaemia. The haematological aspects of sickle-cell anaemia were discussed by Bauer (1940), with particular reference to the occurrence of sickling of the red cells with decreasing oxygen tension. Winston Evans (1945) made an extensive investigation of the condition during war-service in West Africa, and came to the conclusion that the so-called 'anaemia' is usually precipitated by some intercurrent infection or disease. The occurrence of thrombosis, however, due to impaction of sickled cells in the capillaries, is a real feature of the condition, irrespective of anaemia.

Target-cell Anaemia. Considerable interest has been taken in the red-cell abnormality that gives rise to the 'target cell' in blood films. In particular this seems to be a feature of Cooley's anaemia. Examples of this and related conditions were described by Dameshek (1940), Diwani (1944) and Fawdry (1944). Behrod (1941) studied the target cell, and Miller *et al.*, (1942) and Singer *et al.*, (1941) discussed the relation of the appearance of target cells to splenic function and haemolytic states.

Acholuric jaundice. Dacie (1941, 1943) studied the mechanism of haemolysis in cases of acholuric jaundice, with particular reference to the changes in red-cell fragility produced by splenectomy, and the occurrence of the autohaemolysis in certain cases.

Nocturnal Haemoglobinuria. Dacie and Richardson (1943) showed the importance of small changes in *p*H on the haemolysis of blood *in vitro* from cases of nocturnal haemoglobinuria. Ham and Horack (1941) also discussed this point, suggesting that the periodicity of the haemolytic process *in vivo* is due to changes in *p*H of the blood during sleep. Dacie and Firth (1943) showed that transfusion with normal cells may reduce the haemolysis of the patient's own cells.

Aplastic Anaemia and Neutropenia. Aplastic anaemia arising from undue exposure to chemical agents and irradiation as a result of war conditions is dealt with elsewhere. Toxic agranulocytosis or neutropenia is now a more frequent danger than previously, because of the increase in the use of chemotherapeutic and other drugs with depressing action on the genesis of the granulocytes and other haemic cells. Newcomb and Deane (1944), Rubenstein (1944) and Ferrer *et al.*, (1945) described the occurrence of agranulocytosis in patients treated with thiouracil, and Ferguson (1944) recorded cases following arsenic therapy. Parke (1944) and Arrowsmith *et al.*, (1944) discussed the danger of the sulphonamides in this respect, and Smith *et al.*, (1944) described an improvement in the treatment of agranulocytosis effected by the use of penicillin. Mettier (1940) reviewed the conditions in which the bone marrow is replaced by some other tissue, as in carcinomatosis, osteosclerosis, myelosclerosis, and myelomatosis, and the changes in the blood picture that result. Wiseman and Doan (1942) drew attention to a condition they call 'primary splenic neutropenia' which is distinct from Banti's disease, and which is benefited by splenectomy. Rogers and Hall (1945) and Salzer *et al.*, (1945) also described similar cases, cured by splenectomy.

Infections. Saifi and Vaughan (1944) studied the anaemia so often associated with severe or prolonged infection, concluding that it is partly due to an interference with the synthesis of haemoglobin.

Weingarten (1943), Emerson (1944), Apley and Grant (1944) and Menon (1945) described cases of 'tropical eosinophilia', a condition characterised by eosinophilia, leucocytosis, and lung changes suggestive of tuberculosis.

Finucane and Phillips (1944) and Smith (1941) recorded epidemics of 'infectious lymphocytosis', a symptomless condition characterised by a considerable lymphocytosis without glandular enlargement or positive Paul Bunnell reaction. The lymphocytes are apparently normal small lymphocytes, in contradistinction to the abnormal forms seen in glandular fever. Turner (1943) described the occurrence of high-titre cold agglutinins in atypical pneumonia, and Meyer and Thewlis (1944) studied the blood picture in this condition. Rose (1945) described the occurrence of cold agglutination in kala-azar.

GLANDULAR FEVER

There are a large number of papers relating to this subject, and space does not allow reference to all.

The differential diagnosis was discussed by Spark (1942) and an analysis of the frequency of occurrence of the many clinical and pathological features was made by Kilburn and Steigman (1942). Other contributions to the general literature were made by Warren (1941) and McGillivry (1944) and a large epidemic described by Halcrow *et al.*, (1943). Reyersback and Lenert (1941) described cases without clinical symptoms, and Randolph and Gibson (1944) drew attention to the fact that abnormal lymphocytes resembling those found in glandular fever may also occur in allergic states. In most of the above cases, the Paul Bunnell reaction was positive at some time, but in an epidemic described by McFarlane and Macfarlane (1943), though the clinical and haematological findings were typical glandular fever, the Paul Bunnell reaction was negative in all cases. As regards complications of glandular fever Zohman and Silverman (1942) described the occurrence of encephalomyelitis, Lloyd (1944) that of thrombocytopenic purpura, Darley *et al.*, (1944) recorded spontaneous rupture of the spleen, and Carlile and Blackford (1942) the occurrence of anaemia. Gall and Stout (1940) studied the histology of lymph-nodes in this condition, observing the presence of the characteristic 'glandular fever cells' in their sections.

LEUKAEMIAS

Apart from case-reports, there was little of importance in the field of leukaemia in the literature of the war years, with the exception of the interest in the effects of X-rays and other irradiations in the production, and in the treatment of leukaemia. Clinical experience with radio-active phosphorus in the treatment of polycythemia, leukaemia and Hodgkin's disease was reviewed by Fitz-Hugh and Rhodes (1942) and Hemplemann *et al.*, (1944). Leukaemia as a whole was reviewed by Haden (1944). Menkin and Kadish (1943) studied a leucocytosis-promoting substance extracted from inflammatory exudates, associated with a globulin substance, and Miller and Turner (1944) considered that the urine of patients with myeloid or lymphatic leukaemia contains a myelopoietic or lymphopoietic substance respectively.

THE HAEMORRHAGIC STATES

The mechanism of haemostasis was discussed by Macfarlane (1941) who concluded that vascular contraction is an essential part of normal haemostatic function. Watson (1941) failed to confirm the finding of Troland and Lee that splenic extracts from cases of human thrombocytopenic purpura depress the platelets count in animals. Rose and Bryce (1941), however, obtained some confirmation of the original finding. Russell and Page (1940) and Gorham *et al.*, (1943) described several cases of thrombocytopenic purpura caused by sulphonamides, and Reid (1940) recorded a case of haemorrhagic thrombocythaemia, a condition resembling purpura haemorrhagica but with a platelet count raised above normal. Ungar (1944*a*, *b*) studied the effect of trauma and various drugs on the bleeding-time in rabbits, and Scarborough (1941) showed that blood transfusion increased the capillary resistance in normal subjects. Scarborough (1940) discussed the significance of deficiency of vitamin C and vitamin O in man. Rapaport and Klein (1941) also described cases of apparent vitamin P deficiency with positive capillary resistance tests that returned to normal after dosage with vitamin P.

Coagulation defects have given rise to considerable interest. As mentioned above, Owren (1947) described a haemorrhagic condition due to the absence of a hitherto unrecognised factor required for normal coagulation, that he has named Factor 5. It is probable that cases described by Rhoads and Fitz-Hugh (1941) and Austin and Quastler (1945) are also examples of this deficiency, though they were regarded as 'idiopathic hypo-prothrombinaemia' by these authors. Cases of congenital absence of fibrinogen were described by Witts (1942) and Henderson *et al.*, (1945). A patient with a demonstrable circulating anticoagulant leading to delayed clotting and haemorrhage was recorded by Lozner *et al.*, (1940).

VITAMIN K DEFICIENCY

Occurring in a variety of conditions this has been studied by a number of workers. Lehmann (1944) described the use of vitamin K prophylactically in a large series of new-born babies. Karke *et al.*, (1940) and Collins and Hoffmann (1943) drew attention to a less familiar cause of the deficiency, that of impaired absorption in such cases as sprue, steatorrhoea, or chronic diarrhoea.

HAEMOPHILIA

Advances in the treatment of haemophilia were made by the use of plasma fractions prepared by the Cohn process. Occasionally, repeated transfusion of whole blood, or such fractions, may induce a 'refractory' state in the patient (Munro and Jones, 1943). Quick (1941) introduced a simple and effective test for haemophilia, which is useful in distinguishing those cases with a nearly normal coagulation time. Andreassen (1943) published a considerable monograph on haemophilia as it occurs in Denmark. As regards the clotting defect itself, Tocantins (1943 *a*, *b*) claims to have demonstrated an excess of some inhibitor of coagulation and regards this as the most likely explanation of the failure of coagulation in this condition.

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CHAPTER XXXIII

PENICILLIN

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THE discovery of penicillin by Fleming[1] dates back to ten years before the war; its exploitation as a chemotherapeutic agent began only in 1940 and developed into perhaps the most remarkable achievement of the war period. This second stage of its evolution was the work of Florey, Chain, and their colleagues at Oxford, who had embarked before the war on a programme of re-study of promising antibacterial substances of living origin; before examining penicillin they had already studied lysozyme with unpromising results.

THE OXFORD ACHIEVEMENT

The essential first stage in this advance was the devising of a method of extracting penicillin in an active and stable form[2]. The first full report,[3] from which it was unmistakably clear that a major therapeutic discovery had been made, appeared in 1941. By this time the Oxford workers had overcome the difficulties of cultivating *Penicillium notatum* on a large scale (by laboratory standards) and extracted from these cultures a quantity of penicillin sufficient not only for the systematic study of its properties by laboratory methods, but also for the treatment of five patients by the systemic route as well as for local application in a number of others. A unit of activity had been defined (on which an international standard was based more than three years later), and the degree of activity against many species of bacteria was determined; it was shown that this activity persisted in the presence of serum, blood and even pus, and was uninfluenced within wide limits by bacterial numbers; lack of toxicity was shown by experiments with leucocytes and fibroblasts. Absorption, distribution and excretion were studied in man, and finally, following successful therapeutic experiments in mice, the material was administered by continuous intravenous injection to five cases of staphylococcal pyaemia with striking therapeutic effect.

This material was much more grossly impure than was suspected at the time and its potency was only about 40 units per mg. Pure penicillin, which has an activity of over 1,600 units per mg., was not to be obtained until three years later, but by 1942 the Oxford workers[4] had so purified their product that it had an activity of 500 units per mg., and demonstrated the important fact that as purity increased toxicity diminished. The study of penicillin in this country remained almost entirely confined to Oxford until early in 1943, and a report[5] of the achievements there up to this time records the successful treatment of ten severe staphylococcal infections (the majority originating in an osteomyelitis and six having positive blood cultures), promising results in actinomycosis, the substitution of three-hourly intramuscular for continuous intravenous injection, and the successful treatment by local application of mastoid wounds, sinuses, septic fingers, and superficial infections of the eye.

EARLY COMMERCIAL PRODUCTION

During this period of two years (1942–3) the way was being prepared for more widespread use. At an early stage Florey visited the United States of America and persuaded the authorities there to undertake the commercial production of penicillin. To this, and to the far greater resources of the United States of America, particularly at this time when Britain was already fully engaged in war production and undergoing heavy aerial bombardment, is due the fact that by far the greatest part of all the penicillin produced hitherto has been American. Nevertheless, British manufacturers also entered the field, if at a rather later stage and on a much smaller scale, and achieved a steadily increasing output which at first served the purposes of research at many centres besides Oxford, and by the end of the war was fully supplying the more serious civilian needs of this country.

DISTRIBUTION AND CONTROL

In both of the countries, then exclusively concerned in the study and therapeutic exploitation of penicillin, the entire output was taken by the government in order that it should be allocated to the best advantage both in furthering knowledge and in curing disease. The National Research Council was given this responsibility in the United States of America, and the Medical Research Council in this country. The M.R.C. Penicillin Clinical Trials Committee was formed in March, 1943, and began by allocating such supplies as were available for further general therapeutic study to four main centres, the University of Oxford, and St. Bartholomew's, St. Mary's and the Middlesex Hospitals, London. Other quantities were allocated to individuals or institutions for specific purposes. There was at this time no possibility of treating all cases in which penicillin was indicated, or even all those in which only penicillin was likely to save life; even patients with staphylococcal septicaemia had repeatedly to be refused treatment because supplies were inadequate. The object of these therapeutic studies was further to define the scope of penicillin treatment—to study its efficacy in conditions which had not hitherto been treated but should for aetiological reasons respond, and particularly to devise improved methods of administration. All other considerations had to give way to this, and it was not until many months after this study began that all those patients for whom penicillin appeared necessary in order to save life could be accepted for treatment.

The ethical questions which had to be faced and somehow resolved during this period were perplexing and disturbing to a degree probably unprecedented in the whole history of medicine. Apart from the conflict between the research and humanitarian motives, there was a complicated choice in the application of penicillin for well established therapeutic purposes. The same quantity would cure a single case of staphylococcal septicaemia, 20 of gonorrhoea, and—by judicious local application[6]—400 of septic infection of the hand. If the patients suffering from gonorrhoea were fighter pilots or commandos, and the hand-infections were in industrial workers engaged in essential war production, their claims under war conditions in competition with a single possibly useless civilian whose life was threatened were indeed difficult to assess. Another decision with ethical aspects taken at a high level but questioned at others was so to restrict publication, particularly on the chemical and production side, that the enemy should not be enabled to make penicillin and so hasten the recovery of his casualties. As one member of the Penicillin Clinical Trials Committee remarked, this attitude would presumably have been viewed with extreme disfavour by Hippocrates.

LINES OF INVESTIGATION

It is outside the purpose of this account to trace all the ramifications in the evolution of penicillin treatment: its results are now common knowledge. It is necessary only to indicate trends, and these led in several distinct directions. Some groups of workers, or organised bodies of workers in separate institutions, advanced knowledge by treating numerous cases of infections known to respond to penicillin treatment, and so defined optimum dosage and factors making for success or failure: included in their series were usually some patients with illnesses differing in some way if not entirely from any treated by this means before. Combined reports of such organised studies [7] [8] [9] [10] gave an informative picture of what penicillin could do in conditions for which it is most clearly indicated in civilian practice.

At the same time the pharmacology of penicillin was further studied,[11] and further laboratory methods were developed which were necessary for the proper control of treatment [12] [13] [14]: these included methods of assay in blood and other body fluids of penicillin itself, and methods of determining the sensitivity to penicillin of individual strains of bacteria isolated from patients to be treated. There was little experimental therapy in animals at this stage, perhaps because clinical success had been so brilliant that there seemed no need for it, but mention should be made of McIntosh and Selbie's[15] early studies of the prophylaxis of experimental gas gangrene, in which penicillin was shown to be considerably more effective than proflavine or sulphonamides.

Two other trends of major importance call for separate and more detailed consideration: they are the application of penicillin to the treatment of war wounds, and the development of new therapeutic applications and techniques.

THE TREATMENT OF WAR WOUNDS

Although the treatment of battle casualties with penicillin was begun by Pulvertaft[16] in Cairo, then Deputy Assistant Director of Pathology, Middle East, as early as 1942, with very short supplies of locally prepared crude culture filtrate, and was later amplified by small supplies of penicillin released from the United Kingdom, trials on a large scale were first begun when Florey and Cairns went to North Africa in early 1943 with this purpose in view. The report on their work[17] during this expedition is one of the most interesting documents of the war and a milestone in the evolution of penicillin treatment. What they did in co-operation with local R.A.M.C. personnel may be described briefly. When a preliminary study had shown that the treatment of well established chronic wound sepsis was disappointing, attention was diverted to recent wounds. Casualties in the fighting then going on in Sicily were given insufflations of penicillin-sulphanilamide powder in the forward area: definitive surgical measures combined with penicillin treatment were carried out on their arrival at a base hospital in Tripoli or Sousse, usually from three to twelve days after wounding. Soft-tissue wounds, if necessary after further treatment by insufflation, were sutured over tubes through which a solution of penicillin was instilled twice daily. Compound fractures were given a five-day course of systemic treatment by three-hourly intramuscular injections: systemic treatment combined with antitoxin and surgery was also employed in gas gangrene. The evidence that penicillin used in this way achieved a large measure of control over sepsis was impressive in bulk and dramatic in detail: sceptics who complained of the absence of a comparable control series of cases were silenced by later developments. Supplies to this theatre of war—at that time the only one in which British troops were engaged in the Western hemisphere—were maintained, though with the utmost difficulty and only by absorbing the greater part of the meagre output. The original methods, with the emphasis on local treatment if possible, were continued and amplified[18]. Statistical proof[19] of the effectiveness of penicillin, used in a dusting powder in conjunction with sulphathiazole, was not obtained until much later control-studies were carried out during the battle for the Gothic Line.

Powder insufflation of wounds before suture, followed by irrigation through tubes after closure, still continued to give good results in soft-tissue wounds[20] [21]. Similar treatment was maintained for head wounds[22]. Other methods employed successfully were injection of penicillin solution into the pleural cavity in order to treat an established empyema associated with wounds of the chest [23] [24] or for the prevention of it. The treatment of suppurative arthritis, particularly of the knee, by opening and washing out the joint and closing it over a tube through which penicillin solution was afterwards instilled,[18] proved highly satisfactory. Local application of penicillin was also adopted for the treatment of burns and abdominal wounds. Systemic treatment continued to be employed for gas gangrene[25] and compound fractures[26] [27] [28].

The necessity imposed on the British Army and British investigators generally to use penicillin economically was perhaps a blessing in disguise. It compelled them to devise techniques for local application, and the results of such application are now recognised to be much better in some cases than those of systemic treatment. This is particularly true of infections involving closed cavities: the injection of penicillin solution directly into such a cavity produces a high concentration which is sustained for many hours—even, in the pleural cavity, for two or three days. American policy throughout has been to use the systemic route much more freely: supplies available to the United States Army, even in 1943, were such as to permit an expenditure of penicillin for the treatment, both of battle wounds and of disease generally,[29] which was lavish by our standards.

TREATMENT OF BATTLE CASUALTIES IN THE FINAL CAMPAIGN IN EUROPE

By June, 1944, the American output of penicillin was on a scale sufficient to allow of practically unlimited supplies being put at the disposal of both British and United States Services, and economy now ceased to be the influential factor that it was in the North African Campaign. At the same time a complete reorientation of policy occurred inasmuch as systemic prophylactic administration was now the method in favour and was to be adopted as early as possible after wounding. This, of necessity, entailed parenteral administration in advance surgical centres and casualty clearing centres. It was fully realised that on these levels regular three-hourly injections would be impossible. Fleming was therefore approached and asked if he could suggest a dose that would keep down the number of injections by at least one half. Finally, after consultation between General Poole, Brigadier Porritt and Professor Fleming, the decision about dosages and times was arrived at. The curious figure of 90,000 units as an initial dose in the forward area, and 45,000 units five-hourly during transit was chosen because in the early stages of the campaign one tablet of penicillin contained 9,000 units, and thus 90,000 units per ampoule. It was realised before the campaign began that systemic prophylactic treatment to all casualties was impossible, even though supplies of penicillin were now generally increased. Systemic treatment by conventional methods and dosage was continued in hospitals on this side of the Channel for varying periods at the discretion of the surgeon. By agreement with the special M.R.C. Committee on Gas Gangrene a list of the types of cases that should receive penicillin was drawn up, and for the first ten to fourteen days prophylaxis was confined to these "gas gangrene prone" cases.

Whenever possible, during quiet periods orthodox therapeutic dosages were adhered to, this quite often in forward units between offensives, the most popular method in static units being the continuous intramuscular drip. By the end of June and early July the supply position was so precarious that daily supplies were used up as they came in, and units were advised to keep supplies for our wounded only, unless the medical officer was convinced that a prisoner would die, or unless the medical officer had strong moral scruples. In the later stages of the campaign, when supplies again became more generous, no discrimination was made between our wounded and those of the enemy who had fallen into our hands.

In the absence of controls it was impossible to state, except in the most general terms, what were the results of this policy. That serious sepsis was exceedingly uncommon, and that wards full of wounded men had for the first time in history little or no characteristic odour was testified on all hands. The mortality from wound infections was certainly almost nil, but a great deal of the credit for this is due to rapid evacuation, excellent surgery, and other features of an organisation which far exceeded in efficiency anything in previous war experience. Statistical evaluation of results, so far as this is possible in the circumstances, is still in progress: there is published information about the effect on the incidence of gas gangrene as seen in one busy transit hospital(30) and from another comes a general account(31) of the effects of penicillin in 1,500 cases.

The evolution of penicillin treatment for both war wounds and other purposes is reflected in handbooks issued by the various Services(32) (33) (34) containing official instructions for its use.

EXPANDING THERAPEUTIC APPLICATION

The last two years of the war also saw the development of the therapeutic use of penicillin in civilian practice. At the beginning of this period experience was almost confined to a handful of cases of severe staphylococcal infections, together with some examples of local use. What bacteria were susceptible to penicillin was known: it remained to test its clinical effect in the many different forms of infection, involving different parts of the body, for which these bacteria are responsible. These studies were the foundation of now familiar practice, and only their main outlines need be traced. The treatment by intrathecal injection of suppurative meningitis, first employed by Fleming(35), was thoroughly studied at an early stage by Cairns(36). Among infections of the lung, sulphonamide-resistant pneumonia(37) and empyema, lung abscess and actinomycosis(38) were successfully treated, and post-operative infection following lobectomy or pneumonectomy was prevented[39]. That a small amount of penicillin will go a long way in treating septic infections of the hand was shown by Florey and Williams[6]. The conditions governing success in the difficult sphere of osteomyelitis were studied by authors too numerous to mention: a special example in which notable success was achieved was the treatment of osteomyelitis of the jaw[40]. The treatment of burns, first studied by Bodenham[41] gained widespread favour, and therapeutic possibilities were defined in diseases of the skin[42]. The introduction by McGregor and Long[43] of penicillin pastilles initiated the local treatment of conditions of the mouth and throat, particularly striking results being obtained in Vincent's infection.

The treatment of venereal disease is a subject in itself. (See Chap. V.) The expectation based on the very high susceptibility to penicillin of the gonococcus *in vitro*, that gonorrhoea would be rapidly cured was not merely fulfilled: the rapidity of effect astonished even the most sanguine. At first confined to sulphonamide-resistant cases among valuable fighting personnel such as air crews,[44] the penicillin treatment of gonorrhoea eventually became routine practice in the Army, justifying itself by ensuring immediate return to duty. The saving of hospital time was also a powerful motive behind the Service use of penicillin for treating syphilis which became general in the days of plenty at the closing stages of the war. That penicillin has an action on *T. pallida* and apparently cures syphilis[45] was first shown by American workers: subsequent developments cannot be followed here, and indeed the ideal method of treatment is even now not agreed.

Only when the supply position had generally improved—that is about the beginning of 1945 in Britain and rather earlier in the U.S.A.—was it possible to embark seriously on the treatment of subacute bacterial endocarditis. It was then found[46] [47] [48] that a prolonged course would achieve at least temporary cure in a majority of cases.

IMPROVEMENTS IN TECHNIQUE

Some of the innovations mentioned above involved or depended on innovations in the technique of administration. Apart from these, constant efforts were made to diminish the discomfort and disturbance occasioned by systemic treatment. The introduction of the continuous intramuscular drip [49], and refined apparatus for automatic delivery of the daily dose in a small volume by this route[50], were means to this end which have found favour in many quarters. It was soon discovered[51] that this method demands care in the choice of rubber tubing used, some synthetic samples causing marked loss of potency in penicillin solution passing through them. An alternative was to employ single injections, but somehow to prolong the effect of each in order to diminish their frequency. A valuable example of such a proceeding is the injection of a large dose (100,000 units) into the infected pleural cavity: this secures not only a local effect, but the maintenance of an adequate blood level for twenty-four hours[52]. Florey and Heatley, who showed this, also postulate that an adequate dose of sufficiently pure penicillin to secure twelve hours' systemic effect could be given without harm intrathecally in cases of meningitis. Other measures employ intramuscular injection, but delay absorption by various means including chilling and the use of vasoconstrictors: the best studied of these is the suspension of solid penicillin in a mixture of peanut oil and beeswax, as originally advocated by Romansky and Rittman[53]. The possibilities of administration by the mouth also began to be explored before the war ended, and a flood of papers appeared claiming pre-eminence for various methods of protecting penicillin against the action of gastric acid. The truth in this matter is even now not yet clear, but there is so far no hope of obtaining a given effect by this route except by a dosage at least four times as great as that which will secure it by parenteral injection.

Countless writers have emphasised that the use of penicillin is no substitute for good surgery. Further than this, it carries special dangers of its own if aseptic technique is in any way faulty. In the treatment of wounds by the local application of penicillin, cross-infection with resistant Gram-negative organisms is peculiarly liable to occur[54]: in dealing with head wounds this may even result in a fatal *Ps pyocyanea* meningitis[55].

OTHER LINES OF ADVANCE

The rapidly growing penicillin literature of this period embraces other aspects of the subject which here call for only brief mention. Much has been written about commercial production and assay, although manufacturers, ostensibly for reasons of security, have maintained silence on later improvements in methods of extraction and purification. Chemical studies, which are understood to have culminated in the certain definition of the formula of penicillin, have also remained unpublished.

In the excitements of clinical trial, study of the process by which penicillin acts on bacteria was at first somewhat neglected, but it is now known that penicillin is bactericidal as well as bacteriostatic[56], and the peculiar conditions necessary for this effect have been clearly defined[57], but its mechanism is still unknown.

These revolutionary achievements, which seem to have put the sulphonamides in the shade, and count at least for as much as they do in the chemotherapeutic conquest of microbic infection, fall entirely within the period of the war: indeed they are almost exactly contemporaneous with it. To the major share in invention, production and therapeutic application taken by Great Britain, the United States of America and Canada, must be added the contribution of Australia, where commercial production was organised so efficiently that penicillin of good quality was available not only for the Forces, but for almost unrestricted sale to the medical profession in general, before the end of 1944. This position had not been reached in Great Britain even at the end of 1945. No other country produced significant quantities, and the enemy appears never to have attempted to do so.

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