Battle casualties, incidence, mortality, and logistic considerations, by Gilbert W. Beebe and Michael E. De Bakey.

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BATTLE CASUALTIES

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INCIDENCE, MORTALITY, AND LOGISTIC CONSIDERATIONS

By

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SURGEON GENERAL'S FOREWORD

As IN the art and science of medicine all advances in the provision of an organized medical service are dependent on experience. Sometimes this experience is the product of planned research while in other instances it is born of opportunity. In either event, however, the step from experience to advance is not an automatic one; critical observation, evaluation, and sound reasoning are essentials in the chain. Forward steps in medical science commonly are the immediate result of planned research in which all or at least the major elements of the study may be predetermined and controlled. This direct approach cannot be applied broadly in the determination of provisions for the care of battle casualties. Beyond such determinations as may be based on the status of scientific knowledge, main reliance must be placed on lessons drawn from the largely unpredictable and uncontrolled experiences of medical service in war. Data obtainable from such a source cannot be expected to be entirely ideal from the viewpoint of either precision or adaptability to all variety of desirable studies. Nevertheless, as this volume demonstrates, even routine professional observations recorded during the course of combat medical service may later be assembled and subjected to critical analysis and study and may thus become the partial basis for future planning.

The authors of this volume have employed official records and reports of the U. S. Army Medical Service as the basis of their work. They have presented discussion regarding the sources of their data in such manner as to enable the reader to reconstruct and weigh the discussions, conclusions, and views which are expressed by them.

This volume has immediate and material value as a well organized source of factual information on battle casualties and as a potential partial basis for medical planning. It has even greater value in demonstrating a resourceful method of approach to such planning. As such it may well serve as both a guide and a stimulus to those who must make future provision for the accumulation of data on wounded and for putting them to practical use to the end that provisions for medical care may always reflect lessons obtainable from experience. Doctor Beebe and Doctor De Bakey have made a valuable contribution to medical literature applicable both to military medicine and to organized civil medical service.

R. W. BLISS
Major General, U.S.A.
The Surgeon General
United States Army

FOREWORD BY BRIGADIER GENERAL ALBERT G. LOVE

THE MEDICAL services of our armed forces during World War II were most efficient. It is a record to which the several Corps and enlisted men may point with pride. Its effective operation required careful administrative, professional, and logistical planning with many rapid modifications to meet existing and changing conditions. It also required the intelligent and sympathetic cooperation of the several Corps, as well as those responsible for the logistic and professional operations.

It is understood that the experience of our medical services in former wars was of material assistance in the planning, training, and at least initial operations. Similarly such experience during World War II is the one reliable basis upon which to plan for such a service in any future war. It is appreciated that, as formerly, organization and operation must be modified rapidly and radically to meet the then existing and changing conditions.

Colonel De Bakey and Captain Beebe had wide experience in preparing for the timely publication in *Health*, and in other ways, digests of narrative and statistical reports that came into the Office of the Surgeon General of the Army. They, and others associated with them, thus made available to many others the experience of competent observers. They have assembled for this publication much valuable material so that it may be available now for medical planning. They have utilized their extensive experience, training, and careful study in preparing the discussion and interpretations. There is a very valuable contribution by Colonel Edward D. Churchill who made such outstanding contributions to the literature of military surgery during the war and who rendered such distinguished service as a surgeon.

The authors and Colonel Churchill are making available here experience that should assist our medical planners also to estimate more accurately than formerly the requirements for medical specialists and supplies. Such planning is most essential if we are to provide an adequate medical service for both our military forces and civilian population.

Albert G. Love
Brigadier General, U.S.A., (Ret.)

PREFACE

PLANNING and evaluation of surgical care for the wounded in modern warfare require a broad background of factual information, much of it statistical in nature, which is not ordinarily part of the equipment of the surgeon trained in civilian medicine. Continuing an active collaboration begun in the Office of the Surgeon General, U. S. Army, early in 1943, the authors have endeavored to bring together in a single volume data and concepts on the incidence, mortality, evacuation, and hospitalization of battle casualties, and on the need for surgical specialists in forward areas — material considered essential for the surgeon who must plan for the care of large numbers of battle casualties. Because of its practical emphasis the contents of the volume apply almost entirely to World War II; comparatively little space is devoted to historical discussions and comparisons. Some of the sections are revisions of material published during the war for the benefit of higher medical and logistic headquarters, and first appeared in the Surgeon General's report, *Health,* a classified report of quite restricted distribution and now virtually inaccessible. Although written for the medical specialist, the book should be of interest to all whose military interests and duties involve estimation of battle casualties or preparation of plans for their movement and care. In addition it may be useful to the military surgeon interested in the solution of certain problems concerning battle casualties by providing a background of statistical data along with some of the significant factors affecting them. An effort has also been made to point to targets for research or other activities designed to reduce mortality, to facilitate early return to duty of men wounded in battle, and to achieve more efficient utilization of personnel and facilities.

Military medical statistics which are the product of war are inevitably crude and inexact. Part of the discussion in the volume is necessarily devoted to critical scrutiny of source-material, but it is not often that anything more rigorous than the method of comparison can be applied. The authors have proceeded on the premise that a formidable collection of partly unreliable data could not be spurned in the absence of truly reliable observations but must be forced to yield whatever truth it might contain. In large part, therefore, the book is a compilation of medical observations made under conditions which do not inspire complete confidence in their accuracy, but to which the authors have brought whatever military, medical, and statistical judgment they could command. A secondary objective has been to point up deficiencies in methods of collecting medical data about casualties in the hope that they might be improved.

The technology of modern warfare is so fluid that the adaptation of medical logistics must be a flexible, living body of principles and procedures rather than a rigid corpus of doctrine. Accordingly, no effort has been made in these pages to develop a manual of solutions to particular military medical problems. Rather, emphasis has been placed upon providing the surgical planner with the reference data and salient relationships needed to devise plans for the care of battle casualties under conditions which may, at best, be only partly recognizable in terms of the past. Nor has it been the authors' purpose to discuss the surgical management of battle casualties or elements of medical logistics on which there already exist ample data in readily available form. The contents of the volume reflect an effort to fill major gaps in the material needed for planning and evaluating the care of battle casualties rather than a desire to produce a systematic medical treatise on battle casualties.

In preparing the present volume the authors in large measure have merely brought together and placed in focus the observations of hundreds of Medical Department observers in World War II, together with those of many others concerned with personnel and casualty statistics in the Army. Without the efforts of these men and the massive reporting system of the Army, the present volume would have been impossible. They are its authors, the undersigned its editors.

During World War II General Albert G. Love, U.S.A. (Ret.) was Director of the Historical Division, Office of the Surgeon General, and he gave generously of his time and advice in guiding many of the earlier studies. His encouragement was partly responsible for the decision to prepare the present volume. The authors were assisted in their war-time analyses by Mr. Daniel I. Rosen who by virtue of this fact has indirectly written significant parts of this volume. Mr. Carroll I. Leith, Jr. prepared the material on the incidence of battle casualties in relation to military occupational specialty and to type of tactical activity, and reviewed the entire manuscript, adding much that is of value. He and Mr. Frank A. Reister verified all computations and did a great deal to insure whatever accuracy and completeness the volume may possess. Mr. Eugene L. Hamilton and Mr. Arthur J. McDowell have reviewed the volume and made valuable suggestions as to its content. Dr. Edward D. Churchill has kindly consented to the publication here of his thoughtful analysis on the evacuation of the wounded and his excellent proposal of a standardized topographical classification for the distribution of wounds. Nancy Weyl of the Medical Illustration Service of the Armed Forces Institute of Pathology lent her skill in preparing the statistical charts.

GILBERT W. BEEBE, Ph.D.
MICHAEL E. De BAKEY, M.D.

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CHAPTER I

INTRODUCTION

EACH WAR, indeed each campaign, has its own surgical problems, but despite differences in weapons, tactical situation, logistic support, and the like, there are certain facts and relationships which are of value in predicting the nature and extent of the surgical load which will ensue from any planned military action. Some of these, such as the distribution of hits among the several body regions, appear to be relatively invariant despite great differences in the military situation. Others, such as the casualty rate for a particular echelon, are extremely variable and require for their tentative prognostication a wide variety of facts about the military situation. Had there existed early in the war a comprehensive and well-formulated plan of investigation a better basis for planning would have been at hand during the war and it might have been possible now to present a more or less definitive matrix of factual data which would minimize the chance of error in forecasting surgical needs. Made available without the guidance of a satisfactory plan, and subject to all the deficiencies entailed thereby, the information accumulated during the past war is nevertheless voluminous, and its comprehension is essential if planning for surgical care in military operations is to be much better than guesswork. The chief sources of the present work have been after-action reports, historical reports of tactical units, and histories and special reports of their medical staffs, as well as the medical histories of hospitals and other medical units. Inadequacy of plan and pattern governing their content, lack of uniform definitions and concepts, and erratic submission all served to rob these reports of much of their potential value. Use has also been made of tabulations based on the Individual Medical

Records* of the war, but these are still not sufficiently complete to form the basis of the discussion, and for some major points, e.g., analysis of unit casualty rates, these records are of little value in any case. It is the purpose of the present work to summarize available information in such fashion as to render it most readily usable by those concerned with planning and administering programs of surgical care for battle casualties.

The most general, and often prior, need for information concerns the incidence of hits (a term which is used here to denote the killed, those who died of wounds, and the living wounded), the proportions killed and wounded, and the proportion of the wounded who die of their wounds. Mortality rates are especially important in evaluating advances in surgical practice and in the administrative provision of surgical care. Another major concern is the basis for determining evacuation policy and schedule at any echelon of medical care. The evacuation policy governs the flow of patients from one echelon to the next. It defines the maximum length of time after original admission for which patients are to be held at the echelon in question in the expectation of return to duty there; patients are evacuated if they are expected to require more than a stated number of days of care; otherwise they are retained. The evacuation schedule specifies how soon after original admission patients earmarked for evacuation are to be evacuated, with due regard for their transportability and their specific needs for surgical or medical care. Flowing directly from information on the incidence of wounded are estimates of the magnitude of the surgical load, both as a whole and according to the need for specialized care. Finally, a preview of the size and composition of the surgical load permits prediction of the

*The Individual Medical Records comprise the following forms: the Medical Report Card, WD AGO 8-24; the Emergency Medical Tag, WD AGO 8-26; and the Field Medical Card, WD AGO 8-27. These forms, one or another of which is prepared by each medical installation treating a patient, are essentially similar in content, the latter two being field forms so designed as to facilitate their use in connection with patients' evacuation. In fixed hospitals, or in non-fixed hospitals when clinical records are prepared, the Individual Medical Record is an abstract of selected information from the clinical record; in other instances it serves as the complete medical record. In all instances it includes identifying information (name, serial number, etc.), certain classification data (rank, length of service, age, etc.), a listing of all diagnoses made, a listing of operations or operative procedures performed, nature and date of admission and disposition of the case, and certain other data.

need for specialized surgical personnel, that rare commodity whose efficient utilization must be a prime determinant of surgical policy in wartime.

For more than a century warfare has presented the surgeon with injuries which have been fairly similar in nature. Changes have occurred not so much in the traumatic consequences of weapons as in surgical skill and resources. Even the large-scale aerial warfare of World War II did not produce radically different surgical problems, although the incidence of burns among civilian residents of fire-bombed cities must have been all out of proportion to their incidence elsewhere. The end of World War II, however, also marked the end of an era in military surgery, for the implications of atomic warfare are revolutionary. The entire concept of echelon-space, with its extremes of front-line action and Zone-of-Interior security, may be outmoded. Planning for atomic warfare must envisage massive obliteration of strategic rear areas, both military and civilian, and must start from an understanding about the responsibility for civilian care. It must contemplate an instantaneous flood of casualties such as no battle ever produced, and thus stress mobility and speed of assignment of both medical and surgical personnel. Were the armed forces made responsible for civilian care, an adequate surgical plan would require a policy for mobilizing the entire surgical personnel of the nation, with provision for its instantaneous employment on a disaster basis. The varieties of surgical care required under conditions of atomic warfare would differ from those customarily encountered in the victims of fast and slow missiles. Large numbers of radiation, blast, and particularly burn injuries pose additional problems of surgical management. Since knowledge of the specific effects of atomic weapons is incomplete, the possibility of entirely new methods of handling both blast and burn injuries cannot be excluded, but in any event the focal importance of traumatic surgery, with its specialization in terms of body-region, does not apply to the same degree to care of victims of atomic explosions. In many other respects atomic warfare may have little effect upon the organization and administration of surgical care, but it is plain that the experience of World War II cannot be carried directly into a war in which atomic weapons are used. Despite this contingency, the experience of the past must not be discarded, because some solid point of departure is necessary even under changing conditions, and also because conventional combat of the World War II variety would surely figure prominently in any future war, even if atomic weapons were also used; atomic weapons would simply superimpose new forms of injuries upon the standard pattern of trauma observed in conventional combat.

Failure to foresee the extensive needs for a wide variety of significant and up-to-date medical and casualty statistics, and to arrange for their collection, either before the war or during its early phases, not only forced into being a mass of *ad hoc* data gathered by different units in the field, but also denied to the Surgeon General's Office that systematic fund of reasonably comparable data which should form the basis of the present work. At this writing, as was true throughout the combat period, one must perforce rely upon a multitude of source-materials of varying excellence, often without assurance as to their comparability or even essential accuracy, using the principles of internal consistency and agreement with related observations to govern their selection or rejection. The key statistical records in the reporting system of the Medical Department, the Individual Medical Records, are not available for processing in Washington until after disposition of the case, and under combat conditions their unit designations are incomplete. For accurate diagnosis, and for data on disposition, time lost, and geographic area of admission, however, they are unexcelled. Whenever pertinent tabulations based on these records have been available, they have been used. Another record of importance has been the AG casualty card, both as processed by various administrative headquarters overseas and as summarized by The Adjutant General in the report *Battle Casualties of the Army* which appeared monthly during World War II. Reports of tactical units have been invaluable in piecing together the casualty picture of the various campaigns or for other purposes requiring identification of particular combat units. Other important sources have been the Statistical Health Report (WD AGO Form 8-122, formerly WD MD Form 86ab), and the ETOUSA report[1] of admissions prepared by all medical units of clearing station or higher level. These reports have permitted the preparation of certain of the more valuable distributions and the

[1]ETOUSA MD Form 323, the Combat Medical Statistical Report.

computation of correlation coefficients between the incidence of wounded and of other types of admission. Various other special reports, including wartime radios of preliminary casualty counts, have also been utilized. The limited attempts made by the Office of the Surgeon General late in the war to encourage collection of superior casualty statistics by The Adjutant General and by the various theater headquarters had no substantial effect on the data actually made available. For example, attempts were made to have casualty reports for units accompanied by appropriate strengths, to have casualties subdivided by campaign or major operation, to have tactical assignments of units (divisions or separate task forces) designated in casualty reports, and to have divisional combat-days included in divisional casualty summaries. The Surgeon General endeavored to inspire the collection of basic observations on the wounding power of weapons and other questions in the realm of wound ballistics, but only one major study in this area resulted. This was the analysis, under the direction of Colonel A. W. Oughterson,[2] of 1,788 casualties during the Bougainville Campaign. Except for the problem of incidence perhaps the chief sources of information on wounds and their care have been the various special studies initiated by individual medical officers and units.

Certain differences in definition must be faced in handling the World War II casualty data of the Army. Counts of wounded in the Statistical Health Report cover all men losing a day or more of time whether or not admitted to hospital, but prior to a change issued in December 1944 additional cases carded for record only (men losing no time) were also included. Procedures of The Adjutant General, however, dictated the exclusion of the living wounded who were not admitted to hospital but who did lose some time in more forward installations. Because of an apparent lack of uniform instructions as to what constituted a hospital, however, theater practice seems to have varied in this respect. The magnitude of the excluded fraction is unknown, but it is of interest to note that The Adjutant General's report, *Battle Casualties of the Army*, dated 1 July 1946, gives 599,000 wounded for the entire war period in contrast to 641,000 reported to The Surgeon

[2]*Wound Ballistic Report*, Bougainville Campaign 1944, unpublished manuscript by Col. A. W. Oughterson, *et al.*, on file in SGO, Historical Division.

General in the Statistical Health Report. The TAG count is probably low in the sense that a significant number of the 31,000 carried by The Adjutant General as "missing in action" from the 1942 Philippine Campaign were probably also wounded, whereas only about 1,800 wounded *per se* are recorded for that campaign by The Adjutant General. However, the Statistical Health Report excludes this experience altogether. The difference between the two sources varies widely among theaters, being two percent for the European, ten for the Southwest Pacific, seventeen for the Mediterranean, twenty for the Pacific Ocean Areas, and fifty-six percent for the Asiatic theaters, in comparison with seven percent for all theaters, when TAG counts are taken as 100 percent.

For the Statistical Health Report, the Individual Medical Records, and TAG reporting, the instructions are to report the wounded so as to include not only victims of direct enemy action but also men injured en route to or from combat missions.[3] AG reporting procedures excluded those superficially wounded who returned to duty from aid stations and the like without losing time, as did the Statistical Health Report after December 1944. There is little information on the probable size of this fraction, but that it may be large is suggested by a study [cf. Table 22, p. 79] of the casualties occurring during the first half of 1944, prepared by the Medical Statistics Division, SGO, from the Individual Medical Records. This gives excesses of 16 percent for the Southwest Pacific and for the Pacific Ocean Areas, and 27 percent for the Mediterranean when all wounded (including the carded-for-record-only, who lost no time) are compared with those who lost time. However, in the case of the Mediterranean Theater the actual count in the Statistical Health Report was higher than this comparison suggests, 40,000 in contrast to 36,000 losing time and 46,000 in all, according to the Individual Medical Records. The Adjutant General's count for the interval is 37,000, very close to the number losing time and 8 percent below the count of the Statistical Health

[3]For example, paragraph 28c of AR 40-1080, dated 10 December 1943, states in part that the term battle casualty "will include traumatisms occurring as a result of a hostile act of a military enemy or occurring while immediately engaged in, going to, or returning from a combat mission, whether or not directly due to enemy action." Later revisions incorporated the same thought. A case of frostbite sustained by Air Force personnel is probably included as a battle casualty in both TAG and Statistical Health Report counts.

Report. The extent to which such differences pervade all the casualty reports will not be known until the Individual Medical Records are tabulated in final form, but it may be presumed that all presently available casualty counts are rather imperfect and often not sufficiently comparable to sustain small differences.

A problem more fundamental to surgery is the difficulty of distinguishing those who died of wounds from those who were killed in action. The distinction is a difficult one, however, because men who are severely wounded on the battlefield include, in addition to those who die instantaneously, a number who will die quite quickly almost regardless of treatment as well as other groups with increasingly better chances of survival provided they receive prompt, expert surgical care. The net result is that many who die of wounds die so soon after wounding that there is considerable opportunity for choice between the two mortality classifications. Errors in the counts may not sensibly disturb the estimates of the killed but they have an important bearing on estimates of the number who died of wounds because of its relatively small size. One finds among TAG directives no evidence of an attempt to define the two categories and to supervise reporting accordingly. In view of the continuing importance, to the Medical Department, of accurate counts of the number who die of wounds, it would appear desirable to improve TAG reporting in this respect. Army regulations[4] for preparing the Individual Medical Records, which also state the basic concepts involved in the preparation of the Statistical Health Report, define "died of wounds" as the wounded who expire *after reaching an aid station.* Those who were seen alive but who died *before reaching an aid station* are termed "killed in action," as are those killed instantly. These concepts are sufficiently clear for operating purposes but have no constant biological meaning because of the variable circumstances determining the length of time required to get a casualty to an aid station. The Adjutant General's total for died of wounds is, in round numbers, 26,700, whereas the figure from the Statistical Health Report is only 20,600. Of course, the counts of killed in action provided by medical reports are of no particular value because there is no sure mechanism for bringing the killed into the medical reporting, whereas The Adjutant General's re-

[4]AR 40-1025, 12 Oct. 1940, and 12 Dec. 1944.

sponsibility for personnel accounting and notification of next-of-kin demands that all necessary safeguards be taken. The Adjutant General's count of killed is 175,000 although the total from the Statistical Health Report is only 93,000. Obviously the killed, as well as the missing in action, cannot be studied from medical sources prior to reconciliation with TAG sources. In the processing of the Individual Medical Records in the SGO, care has been taken to complete the count of killed by using records of The Adjutant General.

Table 1

COMPARISON OF BATTLE CASUALTY COUNTS FROM TAG SOURCES AND STATISTICAL HEALTH REPORT, U. S. ARMY IN WORLD WAR II

Type of Casualty	Number of Casualties	
	TAG Counts*	Statistical Health Report
Covered by Medical Department		
Wounded or injured in action	599,000	641,000
Died of wounds	(26,700)	(20,600)
Killed in action	175,000	93,000
Total	774,000	734,000
Not covered by Medical Department		
Missing in action	175,000	——
Grand Total	949,000	——

*Include first Philippine Campaign, excluded from Statistical Health Report. Less than 1,650 killed, 175 died of wounds, and 1,825 wounded are involved, however, as virtually all the 35,000 casualties there have been carried in a missing status.

Both the Medical Department and the Adjutant General's Department have their own individual needs for information about battle casualties, needs which may well require different definitions and methods of collecting battle casualty counts. It would seem highly desirable, however, that there be a further integration of the two reporting systems sufficient to obviate any conflicts between the resultant series and to provide a consistent pattern into which both sets of data might fit.

At many points understanding of wounds and the wounded is incomplete without information on the killed. Characteristic areas of medical concern include prevention of casualties (exemplified by the medical interest in body armor), effectiveness of weapons, and location of wounds. Despite the high importance of information on the killed, the Army completed only three scientific studies of the killed in World War II: the wound ballistics study on Bougainville[2] already referred to, Hopkins' study[5] of 66 killed on New Georgia and in Burma, and a study of 1,000 killed in Italy.[6] Except for these three studies covering about 1,400 cases there are only fragmentary tabulations of Emergency Medical Tags, usually restricted to the location of major wound and to the causative agent believed responsible. Although at this writing only preliminary tabulations of Individual Medical Records for the first half of 1944 have been made, ultimately a fairly systematic appraisal of most of the killed should be possible from the standpoint of agent and location. Outstanding tabulations of data of this kind are to be found in the reports of the XXIV Corps covering its Leyte and Okinawa experience in which about 5,000 were killed, and of the 33rd Infantry Division in the Philippines. Such data are of general descriptive value but they fail to approach in significance the careful observations made in the course of the three special studies. Determination of the cause of death, and of the nature and extent of ballistic damage, is essential if one is to think in terms of protecting men, whether by training or by special equipment. More also needs to be known of the general characteristics of the killed, e.g., their training and combat experience, if progress is to be made in the field of prevention. A more exclusively medical aspect of this problem is encountered at the point where one considers who survived in World War II to reach medical care, and how many of those who are listed as killed might have been saved by conceivable, if not immediately feasible, devices or administrative arrangements. The surgical consultant of the Third Army, for example, estimated in 1945 that a large number of those listed as killed actually die of exsanguination. He considered that many deaths could be prevented if each man had a radio or other equipment for registering his need for immediate medical attention, and that this should involve no objectionable compromise of security. In this area, as in so many others, the need for research teams ap-

[5]Hopkins, James H.: *Casualty Analysis—New Georgia and Burma, 1943-1945*, unpublished report on file in SGO, Historical Division.

[6]Tribby, W. D.: *Examinations of One Thousand American Casualties Killed in Action in Italy*, undated report, unpublished, on file in SGO, Historical Division.

pears to the authors to be so important that failure of the Medical Department to provide for them must have cost dearly. No effort so huge and so complex as the surgical care of hundreds of thousands of wounded should have been expended without adequate provision of top-flight scientific investigators free to select and work on major problems affecting the provision of that care. In part this came from the unnecessarily wide gulf between civilian investigators and medical officers, and from the inability of the Army to devise a sufficiently flexible system for utilizing medical officers in investigative work.

The available data on causative agents are both fragmentary and quantitatively poor except as they are found in such special studies as that made on Bougainville. The nature of the wound does not reliably indicate the agent in enough cases, nor does the wounded soldier himself often enough know what hit him, for the entries on routine medical records to have great accuracy. One can only use what information the war has provided and attempt to indicate both its value and its limitations.

When data on location of hits or wounds are assembled from summary field reports, as they must be if the implications of an aggregate casualty load are to be understood, it is found that they suffer from lack of an accepted demarcation of broad body-regions. Not only is there a variable set of body-regions used in different reports, but there is evidence that the same category, e.g., chest, or upper extremities, does not always represent precisely the same body-region. When such reports are being combined and compared, rather arbitrary decisions must be made in order to allocate certain unconventional rubrics, e.g., "spine" or "back." Finally, if differential mortality rates are to be used as guides to surgical planning, wounds must be classified in more detail than routine statistical compilations can be relied upon to provide, especially with regard to such information as the organ or type of tissue involved, whether the wound is perforating or penetrating, etc., as is done in Individual Medical Records. These difficulties are not peculiar to the preliminary reports on the World War II experience of the U. S. Army, but apply to analyses of its previous experience and doubtless to data reported for other armies. There is evident need for a standard classification of body regions if useful comparisons are to be made.

Prediction of battle casualties is hazardous at best. Although the experience of the U. S. Army in World War II covers a great range of military operations of widely varying size over many types of terrain and against enemy forces of different strength, fire-power, and tactical advantage, it is well-nigh impossible to distinguish the influence of many individual factors known to be highly significant. One of the most important of the more elementary considerations concerns the concept of time which is employed, especially for such echelons as the division or the small task force. It is so important because such units are not necessarily in combat on each calendar day of a particular interval, and because intensity of combat itself often varies appreciably from day to day. Obviously, the simplest procedure is merely to ignore days of no combat and to refer casualties and strengths to "combat" days only. Unfortunately, even this crude correction was not often made during the war period, and one is almost always forced to analyze casualties in relation to calendar time. The definition of combat time is surely not easy, but early recognition of the importance of the problem would have led to the formulation of a workable definition for standard tactical units. Divisions, for example, are committed and taken out of the line in such fashion that these events are relatively unmistakable and well recorded. Even so elementary a distinction as this would permit far more accurate and usable predictions of casualty-loads than can be made from calendar data only. This is merely one example of many in the field of casualty analysis. Except for such work as could be performed in the Office of the Surgeon General, in the small statistics section of the Headquarters Army Ground Forces in Washington, and in one or two theater headquarters, there was very little analysis of the World War II casualty experience of ground forces during the combat period. Its importance was largely unrecognized. The reporting system of The Adjutant General was set up and administered on an accounting basis, with a view to the compilation of correct aggregates for units of great size, e.g., theaters and the separate arms and services, but without regard for the essential determinants of variation in casualty rates and for the ways in which they might have been evaluated.

In the analysis of various campaigns there occurs a related problem involving definition of combat time. For example, the

Saipan phase of the Marianas Campaign began on 15 June 1944, and the island was declared secured on 9 July. However, mopping-up was active for the 14 days following, and sporadic casualties were sustained for many months thereafter. The date selected for terminating the campaign will have a significant effect upon the casualty rate set down for it. Thus, when "landed" strengths are used without correction for evacuation, the rate for wounded, based on the 25 days ending 9 July 1944, is 6.3, whereas it is 4.7 if the period is extended to 23 July, and 3.7 for 30 July. This problem is a characteristic one in all the campaigns against the Japanese and can be solved only by arbitrary procedures. Use cannot be made of the dates in War Department General Orders which are published as a basis for making combat awards. For example War Department General Order #105, for 1945, gives the interval 15 June 1944 to 2 September 1944 for the Marianas Campaign, although Saipan was "secure" on 9 July, Tinian on 1 August, and Guam on 10 August. It is essential that the strength at risk be segregated more accurately than the General Orders would permit.

Variables of equal or greater significance in producing variation in casualty rates include such factors as the following:

1. Ratio of enemy to U. S. strength
2. Weapons employed, and ratio of enemy to U. S. firepower
3. Experience and training of troops, both in general and in particular types of combat
4. Terrain
5. Tactical advantage and excellence of plan, enemy and U. S.
   a. Availability of prepared positions
   b. Possession of terrain advantages, e.g., high ground
   c. Intelligence
6. Tactical and strategic support, both air and naval
7. Logistic support

It would be a research task of tremendous magnitude to cull from available Army reports the desired information on such points so that campaigns or phases thereof might be analyzed in their terms, and much of it would not be available. Official Army thinking appears not to have extended to this type of analysis, so that no provision seems to have been made to gather the required information systematically. Some British data[7] of this type were pub-

[7] *Army Operational Research Group Reports*, British Army, the War Office, London.

lished during the war. Although the medical officer has a vital interest in casualty forecasts, it hardly seems appropriate that his knowledge should be expected to cover these tactical points, which are the province of the battle-wise commander. He should, however, be in a position to check such estimates as other staff officers may be charged with making so that his own plans may be the more securely grounded.

CHAPTER II

INCIDENCE OF HITS AND WOUNDS

RELATIVE INCIDENCE OF BATTLE AND NONBATTLE CASUALTIES

Admissions

THE ONLY available official counts of U. S. Army battle casualties in World War II appear in preliminary reports of The Adjutant General. According to the 1 July 1946 revision of his report *Battle Casualties of the Army,* the U. S. Army sustained 949,000 battle casualties during the war. Of these 175,000 were killed in action, 599,000 were wounded, and 175,000 were captured or missing in action. In contrast, the nonbattle admissions to sick report [including all those hospitalized or losing time in quarters] number roughly 15,000,000 for disease, and 2,000,000 for accidental injury of one kind or another, during the calendar period January 1942 to August 1945, inclusive. These data appear in Table 2 separately for the Zone of Interior and major overseas theaters. For the war period the wounded represent about 3 percent of all admissions, and from 0 to 14 percent in the individual theaters of operation. For all overseas theaters combined, 79 percent of the admissions were for disease, 13 percent for injury, and 8 percent for combat wounds. The European Theater had both the highest incidence of wounded and the lowest incidence of disease. In the Mediterranean Theater the admission rate for wounded was about 74 percent of that in the European, whereas for disease it was 155 percent, and for injury 130 percent. Battle casualties were negligible in the Africa-Middle East, Asiatic, and American Theaters.

War-period averages such as those of Table 2 mask short-term variations of great importance in any consideration of the proportion of battle and nonbattle admissions. These are shown in Figures 1 and 2, where the separate panels are drawn to the

Table 2

Admissions for Battle and Nonbattle Causes, U. S. Army, January 1942 Through August 1945

Command	Number of Admissions in Thousands				Percentage of Admissions			Admissions per 1,000 Men per Year		
	Total	Disease[1]	Injury[1]	Wounded[2]	Disease	Injury	Wounded	Disease	Injury	Wounded
Total Army	17,480	14,876	2,005	599	85	12	3	666	90	27
Continental U. S.	9,868	8,854	1,014	0	90	10	0	652	75	0
Overseas Theaters										
Total	7,612	6,022	991	599	79	13	8	689	113	68
European	2,685	1,939	360	386	72	14	14	545	101	108
Mediterranean	1,478	1,183	183	112	80	12	8	847	131	80
Pacific	2,333	1,935	302	96	83	13	4	785	122	39
American[3]	591	494	96	1	84	16	0	610	119	1
Other	525	471	50	4	90	9	1	928	98	7

[1]Based on Statistical Health Report, WD AGO Form 8-122 (formerly 86ab); final data from Individual Medical Records not yet available.

[2]Based on *Battle Casualties of the Army*, 1 July 1946; includes WIA for December 1941, and the few cases after August 1945; a final report is scheduled for the future.

[3]Includes North and Latin America, and Alaska.

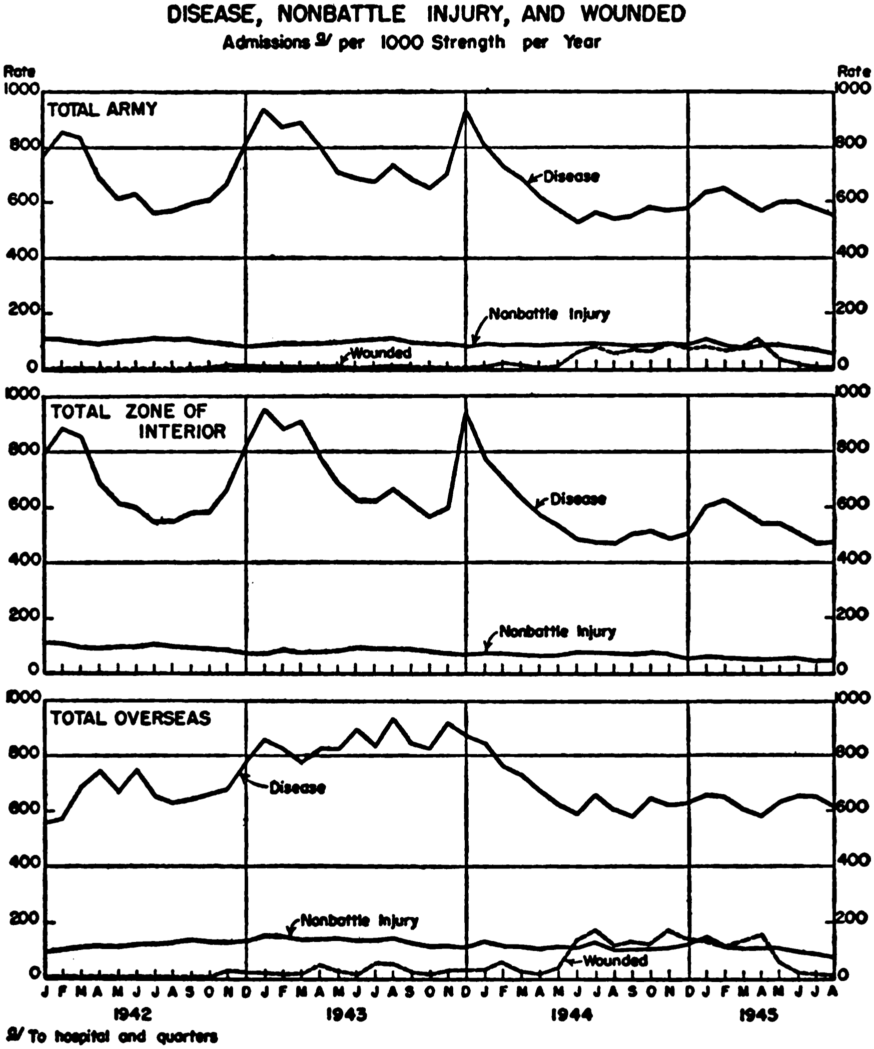


Fig. 1.

same scale to facilitate comparison. In the overseas panel of Figure 1 it will be noted that the admission rate for wounded approximated or exceeded the rate for nonbattle injury only at the height of the combat phase. After D-Day in France there was relatively little variation in the casualty rate, although the absolute numbers increased somewhat as the overseas strength was built up. At its peak in July 1944, the admission rate for wounded was

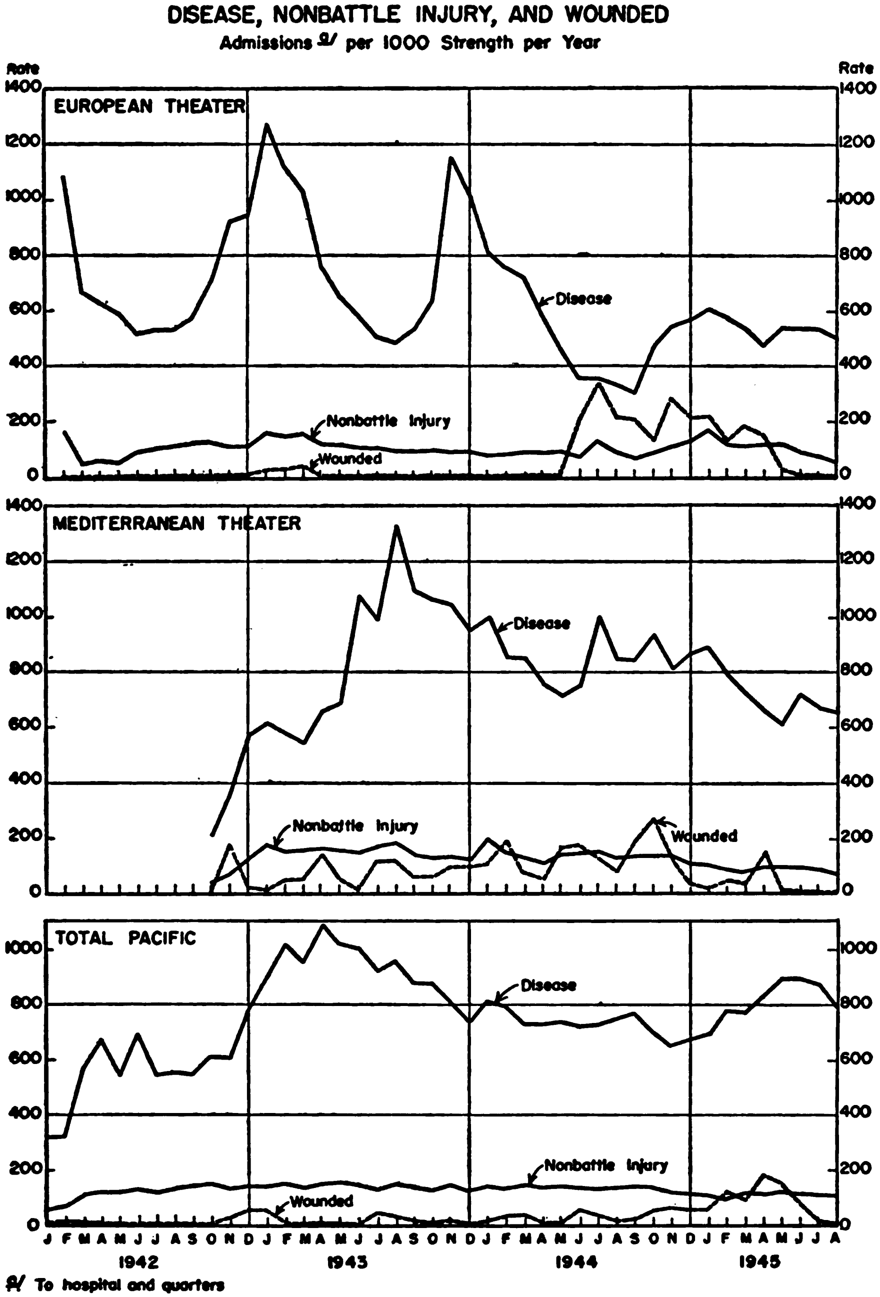

DISEASE, NONBATTLE INJURY, AND WOUNDED
Admissions a/ per 1000 Strength per Year
Rate
Rate
EUROPEAN THEATER
MEDITERRANEAN THEATER
TOTAL PACIFIC
Disease
Nonbattle Injury
Wounded
1400
1200
1000
800
600
400
200
0
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A
1942
1943
1944
1945
a/ To hospital and quarters

Fig. 2.

Table 3
SUMMARY OF DEATHS IN WORLD WAR II, U. S. ARMY,
JANUARY 1942 THROUGH AUGUST 1945

Cause of Death	Number of Deaths	Percentage Distributions		
		Battle Deaths	Nonbattle Deaths	All Deaths
Battle[1]				
Killed in action	175,407	74.0		58.0
Died of wounds	26,706	11.3		8.8
Other[2]	34,936	14.7		11.6
Total	237,049	100.0		78.4
Nonbattle				
Aircraft accidents	21,821		33.5	7.2
Other accidents	22,014		33.8	7.3
Disease	14,243		21.8	4.7
Other[3]	7,141		10.9	2.4
Total	65,219		100.0	21.6
All Deaths	302,268			100.0

[1]Battle deaths are for the entire war period, including December 1941 and the few occurring after August 1945.

[2]There were 9,901 nonbattle deaths among U. S. POWs taken by the Japanese in SWPA, and 1,431 by the enemy in other theaters; there were 23,042 declared dead after having been first declared missing in action, of which 16,876 were Air Force personnel; and there were 562 reported dead after having been first classified as missing in action. These figures may be changed slightly in any final report issued by The Adjutant General.

[3]Homicides, suicides, executions, and drownings.

about one-fourth of that for disease among troops abroad. In Figure 2 the experience of the European Theater is seen in its true light. A remarkable depression in admissions for disease carried the rate to about 300 in September 1944, after the rate for wounded had risen to about 325 in July. Throughout the active combat period in Europe the wounded greatly outnumbered the admissions for accidental injury and exercised relatively more influence upon the total admission rate than was true of any other theater during the war. Only the three major theaters are shown separately in Figure 2, with SWPA and POA combined into one.

Deaths

There were about 302,000 deaths[1] among U. S. Army personnel during World War II, of which 78.4 percent were battle and 21.6 percent nonbattle in origin. In Table 3 the total numbers of deaths

[1]*Battle Casualties of the Army*, CFM-10, 1 July 1946, and *Strength of the Army*, STM-30, 1 February 1949, and 1 August 1949.

during the war is broken down into the main groups of importance. The killed in action account for 58 percent of all deaths in World War II and for almost seven times as many deaths as the wounded. Their importance would be even greater if the 34,936 "other" battle deaths, among prisoners of war and the missing in action, were allocated according to such categories as killed, died of wounds, died of injury, died of disease, and deaths from homicide, suicide, execution, and drowning.

In Table 4 the World War II data on mortality are compared with those for earlier wars in which the U. S. Army participated.

Table 4

COMPARATIVE MORTALITY IN VARIOUS WARS, U. S. ARMY

War	Battle Deaths			Nonbattle Deaths			All Deaths
	Killed in Action[1]	Died of Wounds	Total	Disease	Injury[2]	Total	
A: NUMBER OF DEATHS							
World War II	210,343	26,706	237,049	14,243	50,976	65,219	302,268
World War I (1917-1918)	37,568	13,691	51,259	51,447	4,421	55,868	107,127
Philippine Insurrection	823	241	1,064	4,874	1,063	5,937	7,001
Spanish War	272	107	379	4,795	288	5,083	5,462
Civil War							
North	69,982	44,775	114,757	233,789	10,982	244,771	359,528
South[3]	------	------	95,000	------	------	165,000	260,000
Mexican War	1,049	508	1,557	10,982	395	11,377	12,934
B: DEATHS PER 1,000 MEN PER YEAR							
World War II	9.0	1.1	10.1	0.6	2.2	2.8	12.9
World War I	12.0	4.4	16.4	16.5	1.4	17.9	34.3
Philippine Insurrection	2.2	0.6	2.8	12.9	2.8	15.7	18.5
Spanish War	1.9	0.8	2.7	34.0	2.0	36.0	38.7
Civil War							
North	21.3	13.6	34.9	71.2	3.4	74.6	109.5
South[3]	-----	-----	-----	-----	-----	-----	-----
Mexican War	9.9	4.8	14.7	103.9	3.7	107.6	122.3

[1]Includes deaths among prisoners, and all the World War II battle categories except DOW.

[2]World War II data include the 2.4 percent homicides, suicides, executions and drownings as deaths from injury.

[3]Data on the losses sustained by the South are incomplete.

There were more than four times as many battle deaths in World War II as in World War I, and more than both sides sustained in the Civil War. There were more nonbattle deaths in the longer, far-flung conflict of World War II than in World War I, but only one-sixth as many as the Civil War produced. On a rate basis the picture is very different, World War II having been fought with the lowest over-all death rate in the history of the U. S. Army. This result, of course, reflects primarily the amazingly low death rate from disease, which was but 4 percent of the World War I value, and less than 1 percent of the estimate for the North in the Civil War. When the annual death rates are compared for battle causes, it is seen that the World War II rate is but 62 percent of the World War I rate, both the KIA and DOW components being lower.

Noneffectives

Perhaps the most useful single measure of the loss of military manpower is the noneffective rate, obtained as

$$\frac{\text{Total sick-days for a period x 1,000.}}{\text{Total man-days available for that period}}$$

Official noneffective rates for the entire war period have not yet been issued, but the interim estimates of Table 5 will suffice to show the relative importance of battle casualties as a cause of noneffectiveness. These provisional figures for the period January 1942 through August 1945 were derived from the Statistical Health Reports count of admissions and days lost. Rough estimates of the average days lost per case are 16 days for disease, 29 for injury, and 101 for wounded. Since thousands of wounded remained in hospital for many months after August 1945, the average of 101 days is not a good estimate of the expected number of days lost by wounded for the entire period of their noneffectiveness. The figures for disease and injury are hardly affected by this type of bias. For the present purpose, however, it is war-duration averages which seem most meaningful. The lesson of the table is that the proportionate manpower losses for the war-period are: 66 percent for disease, 16 for nonbattle injury, and 18 for wounded. In rate form the average losses are 28.5 per 1,000 men per day for disease, 7.0 for nonbattle injury, 7.9 for wounded, and 43.4 for all causes.

Table 5

APPROXIMATE DAYS LOST AND NONEFFECTIVES PER 1,000 MEN PER DAY, JANUARY 1942 THROUGH AUGUST 1945

Cause	Number of Admissions	Days Lost		Noneffective Rate
		Per Admission	Total	
Disease	14,876,000	16	233,647,000	28.5
Injury	2,005,000	29	57,471,000	7.0
Wounded	640,000	101	64,520,000	7.9
Total	17,521,000	20	355,638,000	43.4

The noneffective rate as ordinarily computed excludes losses from death, separation for disability, and missing in action. A rough estimate for the KIA and DOW is that the 202,000 deaths represent a loss of 2.5 million man-months or 76 million man-days, from the day of death to the end of the war in August 1945. This is 1.2 times the total lost by the wounded and about one-fifth the total for disease, injury, and wounded. The average loss per battle death was 12.4 months, and half occurred after some time in October 1944. A parallel computation was made for nonbattle deaths, except that it was assumed that the nonbattle death rate did not vary from month to month, and it was found that the nonbattle deaths lost an average of 19 months (half the exposure-months of the war occurred before some day in February 1944) and an aggregate of 37 million man-days. Table 6 gives a summary of days lost both from noneffectives and from deaths. The total loss is 469 million man-days, or about 6 percent of all the man-days potentially available. As a manpower-loss rate this is 56.5 per 1,000 men per day, well above the figure of 43.4 given in Table 5 before the adjustment for deaths. As may be seen from the table, battle losses amount to 30 percent of the total when deaths are brought into the picture, as against 18 percent when only the living noneffectives are considered. An adjustment for the missing would increase the figure of 30 percent to 40 percent, and the rate of 56.5 per 1,000 potential strength per day to 65.2. A similar adjustment for disability separations would further increase the manpower-loss rate from 65.2 per 1,000 potential strength per day to 115.1.

Table 6

APPROXIMATE DAYS LOST FROM ADMISSIONS AND DEATHS, JANUARY 1942 THROUGH AUGUST 1945

Cause	Noneffectives	Deaths	Total
A: MILLIONS OF DAYS LOST			
Disease	234	8	242
Injury	57	29	86
Battle[1]	65	76	141
Total	356	113	469
B: PERCENTAGE DISTRIBUTIONS			
Disease	66	7	52
Injury	16	26	18
Battle[1]	18	67	30
Total	100	100	100

[1]Excludes the MIA.

Although the averages for the war are rather impressive evidence of the significance of battle casualties in the over-all manpower position of the Army, the picture is incomplete unless account is taken of the situation for particular times and places. This is done most readily and adequately by means of noneffective rates for the major theaters. These appear in the several panels of Figures 3 and 4, and pertain to the living in hospital or confined to quarters because of disease, nonbattle injury, or wounds. During 1943 the wounded noneffectives exceeded the injured only at several points in the experience of MTO, SWPA, and SPA. Throughout 1944, however, in MTO the wounded ranged well above the injured and twice approached the noneffectives from disease. In ETO the curve for wounded crossed the nonbattle injury curve in June, the disease curve in July, and remained well above the disease curve until April 1945. In the Pacific the highest points on the wounded curve occurred in 1945, with values two to three times those on the nonbattle injury curve, but always well below the disease curve. For all theaters combined the curve for wounded lay close to that for disease from August 1944 until February 1945.

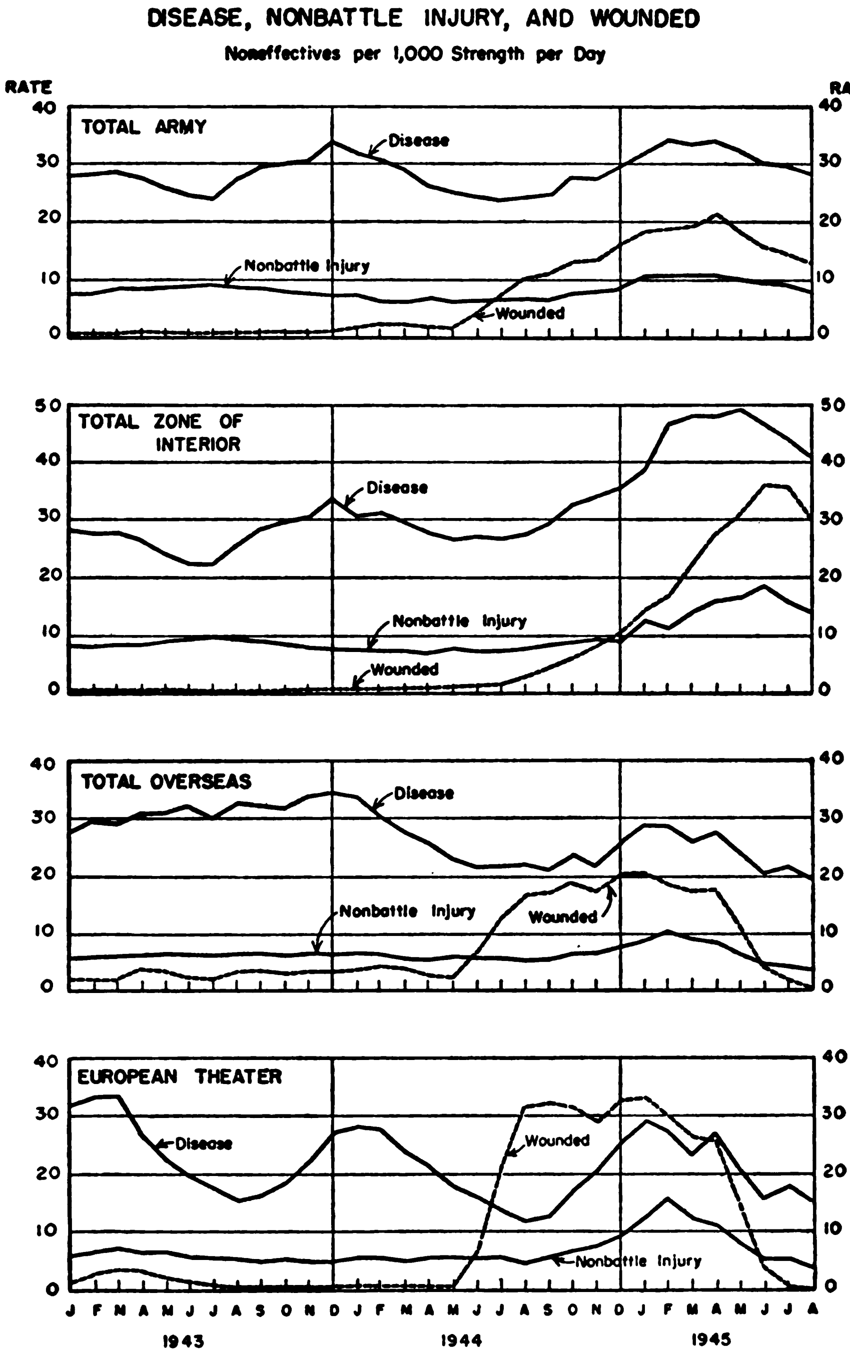

DISEASE, NONBATTLE INJURY, AND WOUNDED
Noneffectives per 1,000 Strength per Day
RATE
TOTAL ARMY
Disease
Nonbattle Injury
Wounded
TOTAL ZONE OF INTERIOR
Disease
Nonbattle Injury
Wounded
TOTAL OVERSEAS
Disease
Nonbattle Injury
Wounded
EUROPEAN THEATER
Disease
Wounded
Nonbattle Injury
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A
1943
1944
1945

Fig. 3.

DISEASE, NONBATTLE INJURY, AND WOUNDED

Noneffectives per 1,000 Strength per Day

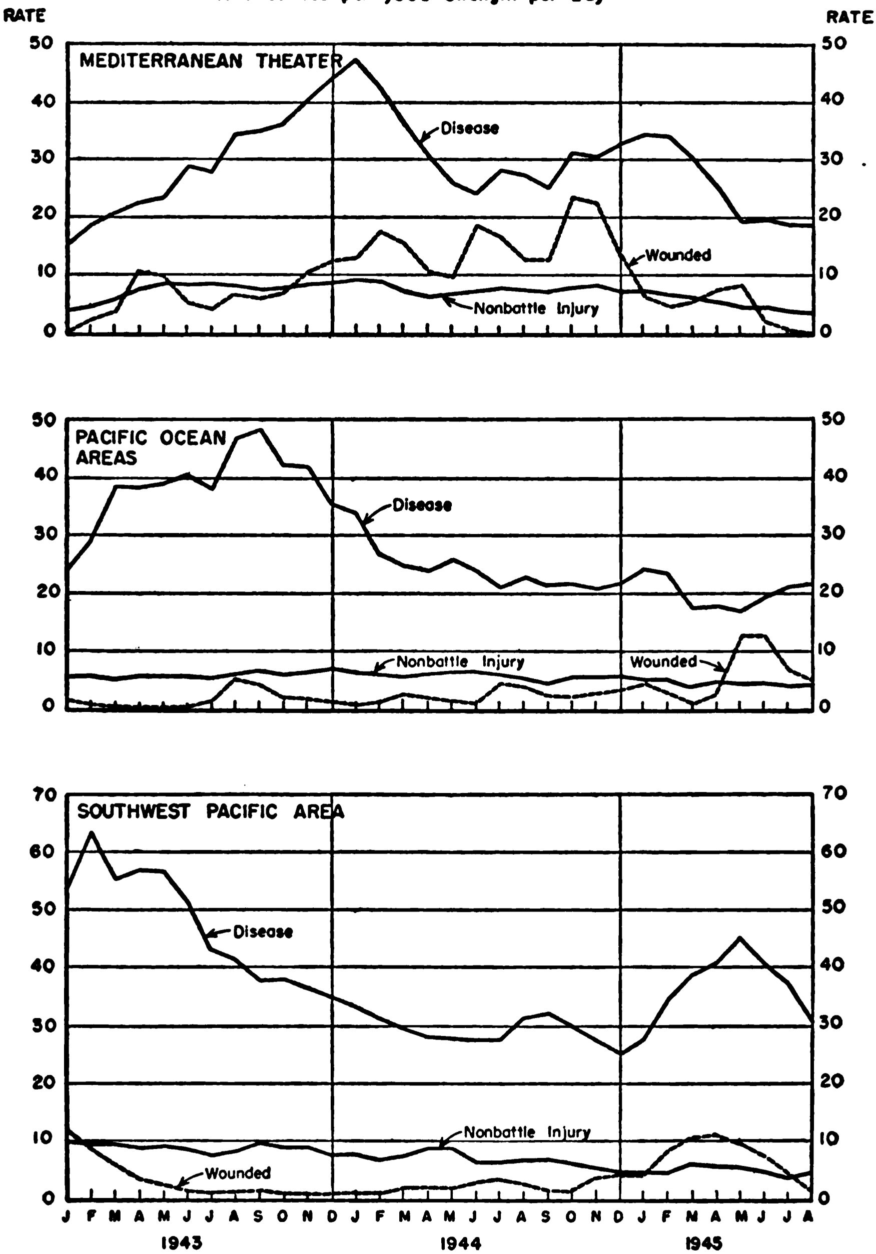


Fig. 4.

For the Army as a whole the relative importance of the wounded as a cause of noneffectiveness increased from about 6 percent during the first five months of 1944 to 12 percent in June, 20 percent in July, and 25 percent in August. Thereafter it rose slowly to 30 per cent in December 1944 and ranged between 29 and 32 percent for the rest of the war period. By December 1945 it was down to 20 percent, and by December 1946 to 13 percent, of the total. Another aspect of the question may be illustrated with reference to the number of beds occupied. At the end of January 1945 fixed hospitals in the European Theater reported an average of 102 patients for each 100 beds in their tables of organization (80 percent being normal utilization, but such hospitals generally being provided with equipment for temporary expansion beyond their T/O capacity). During January the U.S. patients in all ETO hospitals amounted to 6.7 percent of theater strength. This total had the following components: wounded 3.0; disease 2.5; and injured 1.2.

CORRELATION BETWEEN BATTLE AND NONBATTLE ADMISSIONS

It is of the nature of man to react with his entire being to strong stimuli. If men are placed in a combat situation their attrition is not well estimated by adding a casualty rate to their previous rates for nonbattle causes. Life under combat conditions will interfere with preventive measures otherwise considered routine and effective, will transform anxiety into somatic symptoms, particularly those referable to the gastro-intestinal and cardiovascular systems, and may bring new risks of disease and nonbattle injury.

That nonbattle attrition depends upon combat is well established, but the numerical relationship is not one which can be specified for all places and for all times. Environmental circumstances and the previous experience of the troops shape the relationship in myriad ways. The most uniform and strongest of these relationships is the correlation between wounding and psychiatric breakdown in combat troops. Correlation coefficients* computed

*The linear correlation coefficient is a statistical measure of the strength of the linear relationship between two variables. Its square states the proportion of the variance in the dependent variable which may be accounted for by the relationship between the two variables. The sign of the coefficient is the sign of the slope of the regression line.

for echelons ranging from an infantry battalion to a combat theater, and (at the divisional level) for the greater part of the combat in World War II, average about +.70 to +.80. The coverage is poorest for the Pacific, where adequate data were not gathered routinely during the war and where, as in the Sixth Army, there was long a tendency to deny the existence of the problem except as it could be understood in terms of such concepts as "straggler," which were current in the Civil War. At the theater level, as illustrated in the top panels of Figure 5, the experience of the Southwest Pacific Area was atypical, for the dynamic factors behind the *reported* incidence were evidently operative in the base areas. On the whole, however, once the reporting was rationalized the infantry divisions in World War II recorded data like those plotted in the bottom panels of Figure 5.

RELATION BETWEEN RATES FOR NEUROPSYCHIATRIC AND WOUNDED ADMISSIONS

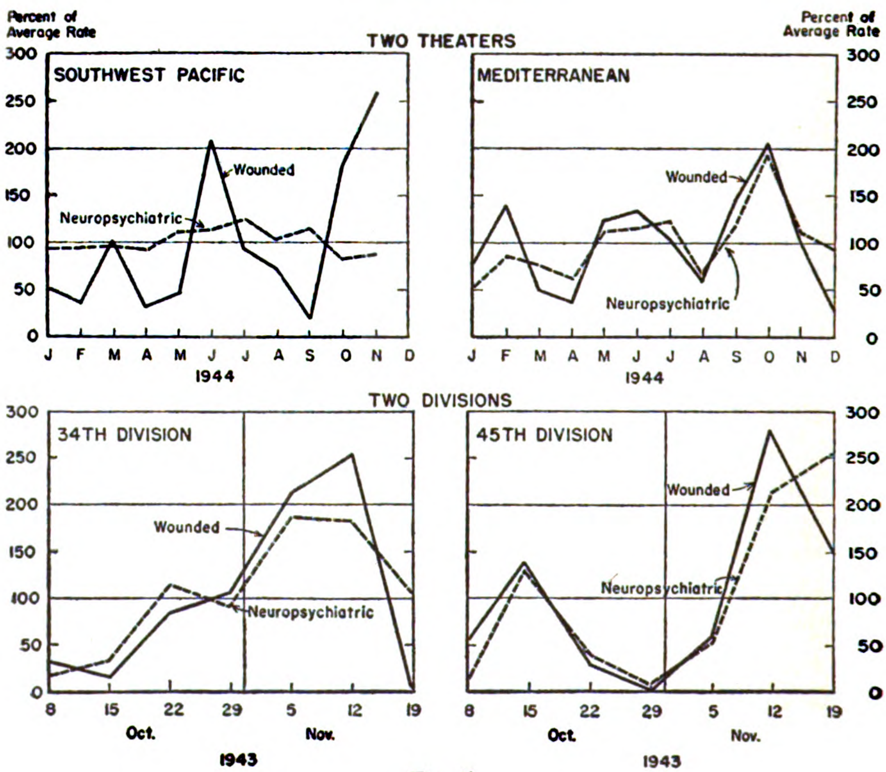


Fig. 5.

Data for large aggregates, such as field armies, show that the gross correlation between disease and wounding depends largely upon the psychiatric factor and that the net average relationship between non-psychiatric disease and wounding is weaker than the relationship between all disease and wounding. In part, the relationship is weak because of such seasonal shifts as may occur in the disease rate from factors entirely unrelated to combat. In order to estimate the relationship free from the interference of seasonal shifts in the disease rate, weekly divisional rates have been transformed to percentages of the average for all units for that week. This has not been done systematically for any large body of experience, but has been done for: (1) all divisions in combat in ETO on or before 1 August, for five weeks selected at random from the interval June 1944 to May 1945; (2) for all MTO infantry divisions for ten weeks selected at random from September 1943 to October 1944; and (3) for all Sixth Army divisions on Luzon for all the weeks from 10 March 1945 to 29 June 1945, inclusive. These three samples should represent the war period adequately, as far as ground troops are concerned, and their yield is shown in Table 7. In the European Theater, where seventeen divisions were studied, the coefficients for each week were on the order of +.6 to +.7 except for the week ending 25 August when a value of −.1 was obtained. At this time disease rates in ETO were still phenomenally low. Average coefficients of +.3 to +.6 explain about 10 to 35 percent of the variation found in the nonbattle admission rates. Differences of this order are often important in planning for the medical aspects of combat operations but they are small in comparison with other influences upon the disease admission rate.

The dependence of nonbattle injury upon combat is also illustrated by the correlation coefficients in Table 7. The most outstanding element in this relationship is one of considerable surgical interest, namely the correlation between cold injury and wounding. The gross relationship is clearly evident in Figure 6, taken from *Health*[2] for 31 March 1945, at the conclusion of the disastrous experience in the European Theater. It is interesting to note that failure to appreciate this relationship caused the theater to report, early in December, that the problem of cold injury was coming

[2]*ASF Monthly Progress Report, Sec. 7,* prepared by the Surgeon General.

Table 7

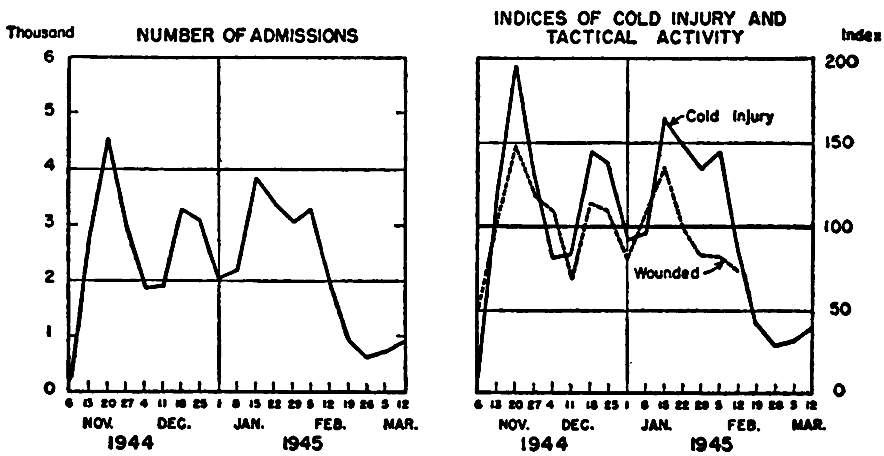
CORRELATION BETWEEN INCIDENCE OF WOUNDING AND INCIDENCE OF DISEASE AND NONBATTLE INJURY, INFANTRY DIVISIONS

Sample	Number of Division-weeks	Correlation Coefficient*	
		Between Disease (Including N-P) and Wounding	Between Injury and Wounding
ETO Divisions	85	+.55	+.52
MTO Divisions	48	+.38	+.41
SWPA Divisions on Luzon	153	+.29	+.32

*All these coefficients are highly significant in the statistical sense. For disease and injury the divisional rates for each week were transformed to percentages of their respective means for that week to make additive the information from different time-periods.

under control, the trend for both battle casualties and cold injuries being downward at that time. Subsequent changes in the tactical situation, with intensification of combat, revealed the intimate relation between cold injury and tactical activity. At no time during the winter season in the European Theater was there any evidence that the relation between cold injury and combat activity

COLD INJURY ADMISSIONS [a] IN THE EUROPEAN THEATER AND THEIR RELATION TO TACTICAL ACTIVITY



[a] To hospital and quarters

Fig. 6.

was essentially changed. For the twelve-week period 10 November 1944 through 26 January 1945, weekly rates for cold injury were correlated with rates for the wounded for all ETO infantry divisions. For three weeks the linear correlation coefficients are insignificantly different from zero. For three additional weeks the coefficients range between +.30 and +.50, and for the remaining six weeks between +.50 and +.82. The over-all average is +.56; this suggests that about 31 percent of the variability observed in the cold injury rates among divisions in the line derived from the same factors which caused variation in casualty rates.

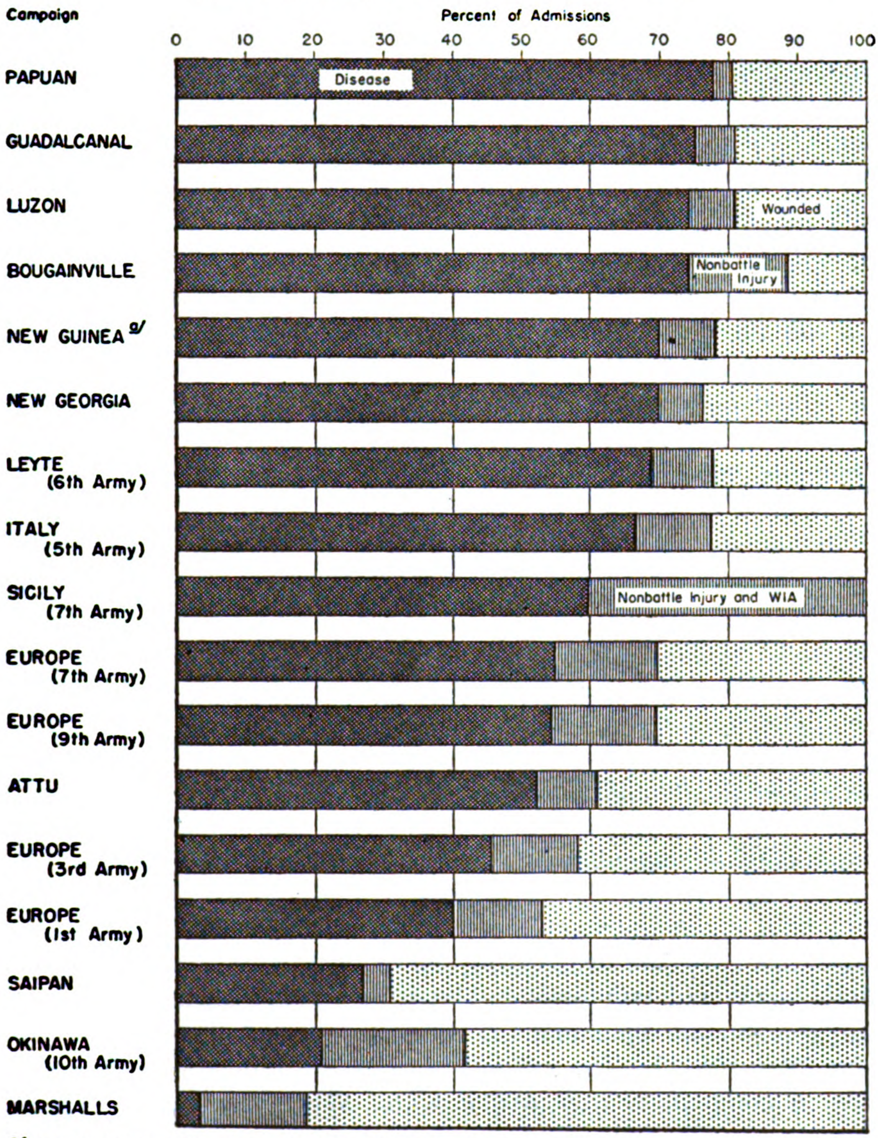
VARIATION IN PROPORTION OF WOUNDED AMONG ALL ADMISSIONS

Regardless of the index which is taken to measure the burden of the wounded, variations among and within theaters were outstanding in World War II. For example, on the basis of the admission data of Table 2 it is plain that the theaters as a whole suffered about 100 wounded for each 1,000 disease admissions, yet this ratio is 200 for ETO, 95 for MTO, 50 for the Pacific, eight for China-Burma-India and Africa-Middle East, and two for the American Theater. Within theaters there were often extreme variations, most notably in the Pacific, among different base areas, and between base areas and combat areas. Seasonal variation in disease incidence was also a factor making for change in the relative numerical importance of the wounded. Extremes of seasonal variation are exhibited by the ETO panel in Figure 2, fortunately before D-Day in Normandy, but this could be matched by curves for parts of the Pacific, for China-Burma-India, and for Africa-Middle East. Some of the early seasonal variation came under control as the war progressed. Perhaps nowhere was this more evident than in China-Burma-India where atabrine suppression and better environmental control of malaria, changes of duty tending to lessen exposure to malaria, and probably other factors as well, reduced the amplitude (from peak to trough) of the seasonal swing in the rate for all diseases from about 800 admissions per thousand strength per year during the 1942-1944 period to about 200 to 500 in 1945. The effects of improved preventive medicine were everywhere evident in reducing the number of admissions for disease so that the wounded received far better care than they otherwise might, but nevertheless there was always great uncertainty whether some new problem might not arise, or an old one defy solution within the framework of a particular combat operation. The worst period in this respect was with malaria in the 1942-1943 effort to turn the enemy away from Australia and the islands to the north and east. In certain small operations, notably against Biak, scrub typhus took a relatively heavy toll, but operations had generally ceased before the admissions reached full force. This was also true of dengue, which might have threatened the success of the Marianas Campaign had it swept through the force earlier. Again, although malaria came under satisfactory control in the Mediterranean Theater after the unfortunate Sicilian experience in the summer of 1943, infectious hepatitis remained outside control there is elsewhere, causing approximately 38,000 admissions in MTO and 37,000 in the Philippines during and after the Luzon Campaign. Thus, for any combat operation an extremely dynamic, uncertain situation exists, and one needs to view the whole picture from the standpoint of the forces tending to reduce admissions as well as those operating to increase them. The effectiveness and limitations of preventive measures must always have a major place in these calculations.

All the factors discussed in the foregoing paragraphs and in the preceding section operate to produce the variation found among the campaigns of the war. Figure 7 presents a percentage distribution of admissions for most of the campaigns of the war. Most of the Southwest Pacific campaigns are found in the top section of the panel, but the Central Pacific campaigns are at or near the bottom.

Despite its size and late date Luzon is very near the top of the chart with 74 percent of its admissions for disease and 81 percent for disease and nonbattle injury. The purpose of the chart is to show variation among campaigns, but the index chosen, percent of admissions, has the deficiency described earlier. In theory it would be better to use noneffective rates as an index, but computation of noneffective rates would require arbitrary assumptions as to average days lost per admission, by type, and there is ample reason to believe that such weights would fail to apply with any uniformity to the wide variety of campaigns and operations shown in Figure 7. It is easy to visualize the effects of any such weights,

PERCENT OF ADMISSIONS CLASSIFIED AS DISEASE, NONBATTLE INJURY AND WOUNDED, WORLD WAR II CAMPAIGNS



a/ Hollandia, Aitape, Wakde, Biak, and Admiralty Islands Operations.

Fig. 7.

however: the bars for disease would all be greatly shortened, and those for wounded lengthened.

INCIDENCE OF BATTLE CASUALTIES

Relation between Killed and Wounded

For the entire war, for U. S. troops the chance of being wounded was 3.4 times that of being killed. Although all such figures are imperfect, and doubtless increasingly so as one lengthens his historical view, Figure 8 has been prepared to show what happened to the ratio of WIA/KIA during World War II. The distribution used in obtaining the median value shown there for the period 1704-1871 is a simple tally of ratios given by Longmore[8] with no

RATIO OF WOUNDED TO KILLED, VARIOUS WARS FROM 1704 TO 1871, AND U.S. ARMY IN CIVIL WAR, WORLD WAR I, AND WORLD WAR II

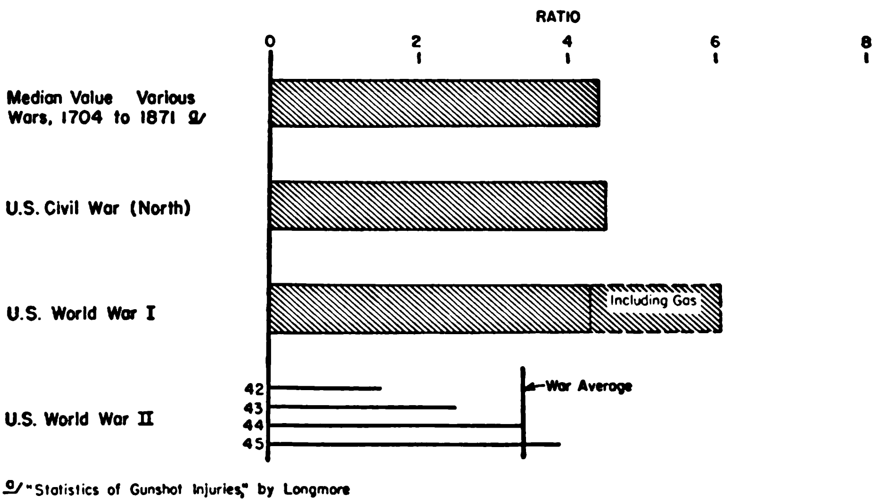


Fig. 8.

adjustment for the overlapping consequent upon his inclusion of both battle and war-totals in the table. Longmore's table covers the period from Blenheim (1704) to the end of the Franco-Prussian War (1871). The ratio WIA/KIA for World War II seems low in comparison with earlier wars. When the World War II value of 3.4 WIA per KIA is examined, however, certain important qualifications may be added. For the individual years 1942-1945 the ratios are: 1.5, 2.5, 3.4, and 3.9, which may be explained

[8] LONGMORE, T.: *Gunshot Injuries*, London, Longmans Green and Co., 1877, pp. 588-590.

by the relative importance of Air Corps casualties at various times during the war; the lower World War II value is probably attributable entirely to the importance of air combat during World War II. For example, the ratio for ETO casualties progressed as follows: 0.7 in December 1943; 0.6 in May 1944; 3.7 in July 1944; 3.5 in December 1944; and 3.7 in March 1945. Again, for Air Corps officers one finds the following ratios for the entire war period: 0.46 for ETO, 0.62 for MTO, 0.54 for AFPAC, 0.41 for CBI, and 0.32 for the Strategic Air Forces, while the over-all average was 0.50. For Infantry officers the parallel theater values are 3.63, 3.67, 3.13, 2.41, and 3.53. Similar differentials exist for the enlisted men, although it may be observed that the ratios are uniformly higher for enlisted men. Among the ground arms there is relatively little variation, the figures for enlisted men being: 4.1 for Cavalry, 4.3 for Coast Artillery, 4.5 for Field Artillery, 4.2 for Infantry, 4.4 for medical enlisted men, and 3.6 for the Engineers. When the Infantry (officers plus enlisted men) is taken as representative of the ground arms, the World War II average may be estimated as 4.1, essentially the same as has been reported for two hundred years or more.

That the ratio WIA/KIA is by no means invariant is immediately appreciated if one contemplates the situation of the losing side bereft of secure space into which to retire or evacuate its wounded. The Japanese ratios of WIA/KIA must have been very small in operations like Iwo Jima, Saipan, and Okinawa. Depending upon the outcome of the battle or campaign, not all individuals who are wounded are able, or choose, to retire in this fashion, and thus run the further risk of being killed. For any force of such a size that the enemy might interrupt communications with rear echelons and base areas the ratio WIA/KIA is likely to fall as the killed increase in number. Beachhead assaults and certain other tactical operations probably also tend to decrease the ratio.

Tactical factors may be partly responsible for the variation observed in the ratio for various campaigns, although reporting errors can hardly be ruled out. A summary of Pacific campaigns published in *Battle Casualties of the Army* for 1 July 1946, gives 2.2 for infantry divisions in the Papuan and Guadalcanal Campaigns, although none of the other Pacific campaigns of consequence has a ratio below 3.7 WIA per KIA.

The chief uncertainty in obtaining a reliable ratio of WIA/KIA lies in the delay which attends knowledge of the fate of the missing. Eventually one knows which were killed and which captured, but within a short period after a major combat an erroneous picture may be obtained because the count of killed is too small. Unless a great deal of ground is lost the WIA count is generally adequate because the wounded receive medical care.

Incidence of Wounds

The gross numbers of wounded in World War II have already been given in Table 2 and the rates in Figures 2 and 3. To this summary need be added only the few simple facts given in Table 8 for the Civil War and World War I. Both absolute numbers and

Table 8

U. S. Army Wounded in Various Wars

War	Number Wounded, in Thousands		Wounded per 1,000 Strength per Year	
	Total	Excluding Gas	Total	Excluding Gas
Civil War (April 1861-April 1865)				
North	318	318	97	97
World War I (April 1917-November1918)*				
Total Army	224	154	*81*	*56*
A.E.F.	224	154	238	*163*
World War II (December 1941-August 1945)				
Total Army	599	599	27	27
Overseas	599	599	*68*	*68*
ETO	386	386	*108*	*108*

*Many published figures are for the period April 1917-December 1918 or 1919 inclusive, or the year 1918. The April 1917-November 1918 interval is considered to be more comparable with the other dates in this table.

rates are given there because of the great differences among the wars as to length and size of force. Thus, with more than twice the number of casualties reported for World War I, World War II has an average rate less than half that for World War I. This is because World War II was more than twice as long as World War I and the Army more than twice as large. About 70,000 of the "wounded" of World War I were gas casualties, and for this reason a distinction is made in the table so that comparisons may be made after these have been excluded.

A more specific comparison of the ETO-A.E.F. experience is made in Figure 9; the ETO series shown there is based on TAG counts. It may surprise some to know how much more intense was the shorter combat activity of the A.E.F., the peak rate of

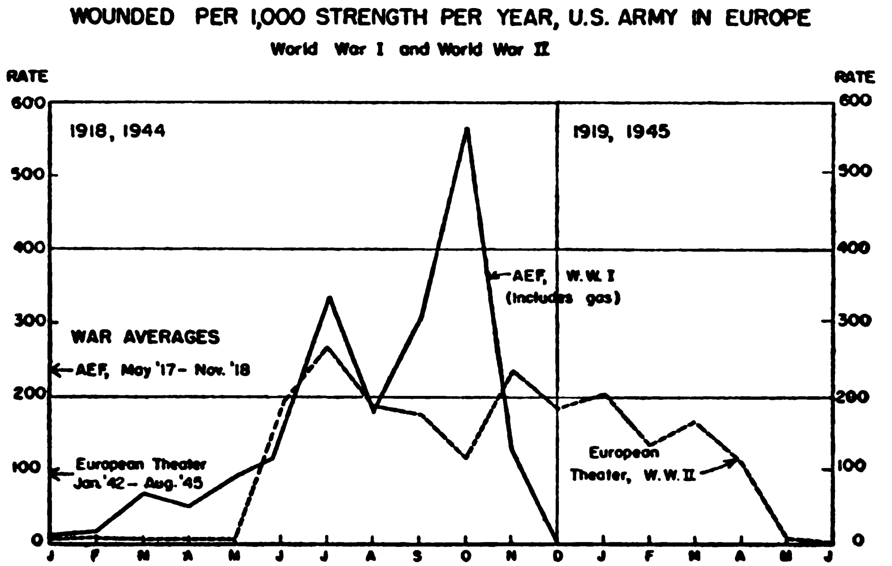


Fig. 9.

546 being just twice the ETO peak of 269. The strategic implications of these curves are rendered elusive by their being only partial measures of combat activity, excluding as they do the far greater numbers of casualties among the troops of allied nations.

Arm or Service. Some of the greatest differences in casualty incidence occur among the arms and services. In May 1945, there was published in *Health* an analysis of the war experience for the period December 1941-March 1945, inclusive, as given in the report *Battle Casualties of the Army* dated 1 April 1945. The latter report covered 75 percent of the killed and 85 percent of the wounded in the entire war. Only the wounded are discussed here. For the Pacific, where the Luzon Campaign was still in progress and the Ryukyus Campaign not yet begun, the coverage is necessarily incomplete. About 50 percent of the wounded in POA and

65 percent in SWPA are included in the report, while for ETO and MTO the respective theater percentages are 89 and 94. Expressed as wounded per 1,000 strength per year the rates are given in Table 9, separately for officers and enlisted men. Rates are presented both for all theaters combined and for ETO separately

Table 9

WOUNDED PER THOUSAND STRENGTH OVERSEAS PER YEAR BY ARM OR SERVICE, DECEMBER 1941 THROUGH MARCH 1945, ALL THEATERS AND ETO

Arm or Service	All Theaters		ETO	
	Officers	Enlisted Men	Officers	Enlisted Men
All Arms and Services	56.4	71.8	87.3	123.6
Infantry	251.0	264.9	422.2	454.4
Armored	—*	228.5	—*	327.7
Cavalry	165.1	163.1	235.7	191.6
Field Artillery	88.1	50.7	124.3	66.8
Air Corps	35.9	9.9	44.3	12.0
Chemical Warfare	31.0	29.6	35.5	34.2
Medical Department	9.2	26.7	13.2	41.2
Engineers	28.0	21.8	43.6	33.7
Coast Artillery	10.6	9.7	24.1	24.8
Other	4.8	3.8	6.4	4.5

*During World War II officers assigned to armored units were carried under such arms as Infantry and Cavalry, and the designation "Armored" was used only for enlisted personnel.

because the ETO rates were so much higher than the rates for other theaters. If the rate of 71.8 for enlisted men, all theaters, be taken as 100 percent, then the rates of Table 9 for enlisted men in all theaters may be expressed in percentage form, as follows:

Infantry	369
Armored	318
Cavalry	227
Field Artillery	71
Air Corps	14
Chemical Warfare	41
Medical Department	37
Engineers	30
Coast Artillery	14
Other	5

For ETO alone the series differs only in a minor way. The chief differences consist in somewhat lower percentages for Armored, Cavalry, and Field Artillery. The use of rates for enlisted strength distorts any comparison in which the Air Corps is involved because its officer casualties are so much higher. On the basis of the rates for officers the percentages are about 445 for Infantry, 290 for Cavalry, 155 for Field Artillery, and 65 for Air Corps. Even on this basis, however, the Air Corps rates are far below average. In part this is because the Air Corps, perhaps more than any other arm or service in World War II, actually had characteristics of both, being at once an *arm* in which men (largely officers) were exposed to the chance of wounding to a high degree, and a *service* in which men served with minimal exposure to enemy action. The chances of being killed were also very much higher for Air Corps officers, so that any comparison involving the Air Corps which is based on the wounded cannot validly be extended to all battle casualties. Here concern is with the wounded.

Although the Pacific returns are incomplete, it is instructive to make certain theater comparisons on the basis of the rates given in Table 10.

Table 10

WOUNDED PER THOUSAND OVERSEAS STRENGTH PER YEAR, DECEMBER 1941 THROUGH MARCH 1945, FOR SELECTED ARMS, BY THEATER, ENLISTED MEN ONLY

Theater	All Arms and Services	Infantry	Armored	Field Artillery	Air Corps	Other
All Theaters	71.8	264.9	228.5	50.7	9.9	*
European	123.6	454.4	327.7	66.8	12.0	*
Mediterranean	82.0	274.8	69.2	72.0	15.0	17.9
Southwest Pacific†	42.2	145.9	48.5	24.1	10.8	15.4
Pacific Ocean Areas	17.9	47.6	1.6	6.8	10.9	4.3

*Rate not computed.
†Excludes 20th Air Force.

One excellent report on the late Pacific phase of the war, excluded from the data summarized in Table 10, is the *Middle Pacific Casualty Report Number III on the Okinawa Campaign.* For a T/O strength of 100,000 Army combat troops this report gives

16,300 wounded,† or 16.3 percent. If the percentage of wounded, for men of each arm or service, is itself expressed as a percentage of the average of 16.3 percent, the following series of relative casualty rates is obtained for enlisted men during the Ryukyus Campaign:

Infantry	229
Cavalry*	64
Medical Department	58
Chemical Warfare*	53
Armored	31
Field Artillery	21
Engineers	19
Military Police*	9
Signal	8
Ordnance*	7
Coast Artillery*	5
Quartermaster*	3
Transportation	1

These percentages differ appreciably from those given earlier for two main reasons: (1) they apply to a field army; and (2) they pertain to a particular tactical situation. The effect of the first point is to reduce the variation among arms and services. The effect of the second, by virtue of the way in which the various arms were used, is primarily to reduce the casualty rates of Armored and Cavalry troops. However, the percentage for Field Artillery troops seems low in the light of the ETO experience because of the comparative weakness of Japanese artillery, especially in regard to counter-battery fire, even on Okinawa.

Military Occupational Specialty (MOS). Of all the factors making for variation in casualty rates, military occupation is the most important, except under circumstances in which a force may be decimated. It is the tactical situation, however, which largely determines what the average casualty rate of a field unit will be.

†A more complete count is given below in the summary by campaign, amounting to 17,800 WIA during 91 days of combat for an *average* daily Army strength of 69,200, or about 1,030 per 1,000 men per year. Most of the difference between the WIA counts derives from the exclusion of certain non-combat troops from the Middle Pacific report.

*T/O Strength was under 1,000 enlisted men.

The rates for the various arms and echelons vary primarily because of the occupations they embrace, and his occupation determines, in general, where a man falls on the scale of danger. Although it is the most important factor and although its general significance is well recognized and well understood even by those without military experience, statistical information on casualty rates by military occupation is only fragmentary. One great difficulty in obtaining reliable information is the fact that a man assigned to one MOS may perform duty in another. At a time when replacements are short, almost any MOS may be drawn upon for riflemen, for example. Moreover, although there are important, large-scale tabulations of casualties by MOS, there are only a few studies which give information on strength by MOS. These cover four infantry divisions of the Fifth Army from September 1943 to April 1944, the 27th Infantry Division (reinforced) on Saipan in June and July 1944, and Tenth Army combat troops in the Ryukyus Campaign of April through June 1945.

It is plain that even an MOS casualty rate is a variable quantity, depending upon the combat situation in all its complexity, and it is for this reason that the three series of rates shown in Table 11 differ considerably. However, the indications are unmistakable that certain occupations tend to be much more dangerous, and thus more productive of casualties, than others. The several series intercorrelate to a very high degree, the correlation coefficient being +.92 for the MTO and Ryukyus MOS casualty rates per 1,000 men per day, for example. Also included in the table are figures showing what percentage of the wounded fell within certain MOS groupings. In this portion of the table an AGF tabulation of 100,700 Infantry men killed, wounded, and missing between 1 June and 29 August, 1944, has been used, although it has no rate counterpart. The percentage distributions are also very highly correlated. The casualties among riflemen, gunners, squad leaders, and ammunition handlers constitute about two-thirds of all the divisional casualties.

As a means of summarization a relative casualty rate has been computed in the form of a summary index with a base of 100 for all occupations. This gives riflemen an index of 432 percent of the average, and auto mechanic as 18 percent, for example. It is a rough means of arraying the occupations according to relative risk of wounding or death in combat. Differences of 10 to 1 and 20 to 1 are

Table 11

Battle Casualties (Killed, Wounded, and Missing) by Military Occupation

Military Occupational Specialty		Percent of Casualties					Casualties per 1,000 Men per Day			
SSN[9]	MOS	ETO[1] Infantry Divisions	MTO[2] Infantry Divisions	Saipan[3] Division and Attached Troops	Ryukyus[4] Tenth Army	Average	MTO[5] Divisions	Saipan[6] Division and Attached Troops	Ryukyus[7] Tenth Army	Summary[8] Index
745	Rifleman	34.1	38.1	23.8	44.4	35.1	12.2	15.5	22.9	432
746	Automatic Rifleman	4.8	3.9	6.4	5.8	5.2	4.8	19.4	10.7	280
653	Squad Leader	11.3	8.1	11.2	8.4	9.8	5.2	12.1	8.6	212
651	Platoon Sergeant	2.6	1.8	3.1	1.8	2.3	3.9	10.1	5.2	155
652	Section Leader	1.1	1.4	1.5	0.9	1.2	3.7	8.8	6.0	151
657	Litter Bearer	0.8	1.2	1.4	1.4	1.2	3.4	11.7	2.9	140
603-607	Gunner	6.4	8.0	5.0	5.4	6.2	6.2	4.6	4.9	134
504	Ammunition Handler	10.0	8.3	10.4	6.5	8.8	3.6	9.5	3.5	132
761	Scout	0.8	1.1	0.9	0.9	0.9	4.9	4.9	4.2	118
674-676	Messenger	3.3	2.7	3.3	2.0	2.8	2.8	7.9	2.9	108
225, 861	Surgical Technician	0.8	0.5	1.8	1.1	1.0	1.6	4.5	2.6	70
521	Basic	10.0	4.0	5.4	1.6	5.2	1.4	6.4	1.1	68
531	Cannoneer	0.8	1.2	1.4	1.7	1.3	1.4	1.2	2.9	48
238, 641	Lineman, Tel. & Tel.	0.5	1.5	0.7	0.8	0.9	2.5	1.5	0.8	41
177, 740, 766, 776	Radio Operator	0.7	0.8	0.9	0.6	0.8	1.3	1.9	1.0	34
405	Clerk-Typist	0.1	0.2	0.1	0.5	0.2	0.5	2.1	1.4	32
695	Orderly	0.1	0.3	0.1	0.3	0.2	0.9	0.9	1.9	32
060	Cook	0.4	0.7	0.6	0.7	0.6	1.2	1.0	1.2	29
245, 345	Truck Driver	1.2	2.6	2.1	1.8	1.9	1.0	1.2	1.1	28
821	Supply NCO	0.2	0.2	0.3	0.2	0.2	0.8	1.4	1.1	27
539	Section Chief	0.0	0.2	0.1	0.1	0.1	1.0	0.7	0.9	22
014	Auto Mechanic	0.1	0.4	0.2	0.3	0.2	1.0	0.5	0.6	18
	Other Enlisted Men	4.5	7.4	13.9	7.3	8.3	1.2	1.9	0.7	31
	TOTAL ENLISTED MEN	94.6	94.6	94.6	94.5	94.6	3.7	4.7	3.6	100
	OFFICERS	5.4	5.4	5.4	5.5	5.4	4.0	4.7	3.5	102
	ALL TROOPS	100.0	100.0	100.0	100.0	100.0	3.7	4.7	3.6	100

(See opposite page for references.)

common even in this curtailed list of occupations. One must place the rifleman in a class by himself, with the automatic rifleman and the squad leader next, when this list of occupations is used. The litter-bearer places sixth, slightly above the various types of gunner and the ammunition handler.

No customary unit of risk is satisfactory for comparing casualty rates of ground and air combat personnel, and no purpose is served here by adding further to an apparently fruitless controversy. It is plain, however, that combat air crews sustained casualties at a rate which unquestionably places combat flying high among the dangerous occupations, and that this was particularly true early in the war in Europe when command of the air was being won from the enemy. This is well illustrated by Table 12, which gives data on casualties among air crew personnel in ETO, MTO, and the Middle East. The rates are averages covering calendar periods of considerable length and thus it is difficult to compare them with any ground rates except possibly those for the entire ETO and Italian Campaigns. When this is done, it seems evident that combat air crews were heavily exposed and that it is useless to contend that this ground or that air occupation was the most dangerous of the war.

DeVinney's data[4] by MOS include an excellent illustration of the association between nonbattle casualties and battle casualties (WIA, KIA, and MIA) during combat. For the 3rd, 34th, 36th, and

[4]DeVinney, L. C.: *Consolidated Report on the Casualty Experience of Four Infantry Divisions in the Italian Campaign from 9 September 1943 to 4 April 1944.* Unpublished report dated 28 August 1944, on file in SGO Medical Statistics Division.

←

[1]Based on AGF tabulation for all infantry in ETO, 1 June to 29 August 1944, and covering 100,700 casualties.

[2]Based on experience of 3rd, 34th, 36th, and 45th Infantry Divisions, 9 September 1943 to 4 April 1944.

[3]Based on report for 27th Infantry Division and attached troops, a total strength of 20,000 present for duty.

[4]Based on POA Campaign Report No. III covering casualties in a T/O strength of 100,000 divisional and army troops.

[5]Rates are based on divisional combat time, not calendar time.

[6]An average rate of 4.69 for all divisional troops per divisional combat day in this period was used to convert percentage casualties by MOS into rates.

[7]An average rate of 3.6 for all Tenth Army troops was used to convert percentage casualties by MOS into rates.

[8]Average casualty rate for three campaigns expressed as percentage of rate for all troops.

[9]SSN's appear here as in source reports. During the war the SSN's for some MOS's were changed. In preparing the table data were grouped by MOS so that different SSN's are combined here if they pertain to the same MOS.

45th Infantry Divisions during their time in the line from 9 September 1943 to 4 April 1944, which was about 66 percent of the calendar time embraced by these dates, DeVinney calculated average admission rates of 3.7 for battle casualties, and 4.7 for nonbattle casualties, per 1,000 men per divisional combat day. For a slightly different grouping of units and for a period six months in length he calculated nonbattle rates of 3.7 when divisions were out of action and 4.4 when they were in action. The spread between these rates would have been much wider had the non-combat periods been longer. As it was, they were generally so short that the nonbattle admission experience out of action must have been largely influenced by the character of the recent combat. Also, the spread was largest for Infantry, the rates being 4.1 and 5.2 for that arm, whereas they remained almost the same for Artillery and all others.

Table 12

CASUALTY RATES OF COMBAT AIR CREWS AND GROUND DIVISIONS OPERATING AGAINST GERMANY, 1941-1945

Calendar Period	Average Strength	Casualties per 1,000 Men per Day			
		Dead	Wounded	Missing	Total
		A: Combat Air Crews			
Dec. 41-Dec. 42	1,900	0.8	0.3	1.0	2.11
1943	20,000	0.9	0.3	1.0	2.19
1944	72,200	0.4	0.3	1.5	2.18
Jan.-Mar. 45	97,600	0.1	0.2	0.8	1.05
Dec. 41-Mar. 45	35,600	0.46	0.26	1.22	1.94
		B: Ground Divisions			
ETO, Jun. 44-May 45	468,000	0.50	2.07	0.35	2.92
Italy, Sep. 43-May 45	92,200	0.26	1.15	0.15	1.56

The relation between battle and nonbattle casualty rates in DeVinney's report may be best appreciated from the scatter-diagram given in Figure 10. The values range from 0.5 for battle and 2.0 for nonbattle admissions among clerk-typists (SSN 405) to 12.2 and 10.7 for riflemen (SSN 745) and the correlation coefficient is +.91. The intercept value in the regression equation suggests that the nonbattle rate would be about 2.2 without the influence of combat, whereas it averaged 4.7 during this period and ranged up to 10.7. It may be relevant to note that the major diagnoses included in the

RELATION BETWEEN BATTLE AND NONBATTLE CASUALTIES FOR CHIEF MILITARY OCCUPATIONS DURING COMBAT

Rates per 1,000 Strength per Day

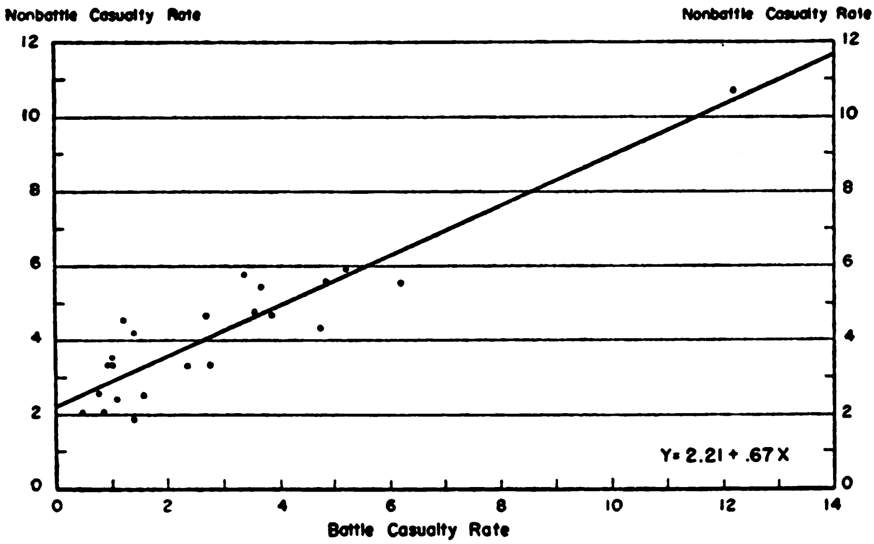


Fig. 10.

nonbattle rates were: respiratory disease, 12 percent; malaria, 11 percent; injury, 10 percent; neuropsychiatric disorder, 9 percent; trench foot, 8 percent; jaundice, 8 percent; neuromuscular disease, 6 percent; gastro-intestinal disease, 6 percent; and all others, 30 percent. It is also of interest that the relationship seems not to be confined to enlisted men, for DeVinney gives the following figures for officers:

Table 13

Battle and Nonbattle Admission Rates for Officers, Four MTO Divisions

Officers, by Rank	Admissions per 1,000 Men per Divisional Combat Day	
	Battle	Nonbattle
General and Field	1.4	2.2
Captain	2.1	3.0
First Lieutenant	3.1	3.6
Second Lieutenant	9.3	8.1
Warrant Officers	0.2	1.1
All Officers	4.0	4.2

These points fall well within the swarm shown in the scatter-diagram of Figure 10, although the nonbattle rate for warrant officers seems atypically low.

The variation in casualty rates by rank for officers is entirely analogous to the variation by MOS among enlisted men. The data of Table 13 are combined with those for the Ryukyus Campaign[5] in Table 14. It will be noted that the parallel is exceedingly close except for first and second lieutenants. However, if these are grouped together their relative rates are also similar, 139 percent for Fifth Army and 147 percent for Tenth. The differences in the table probably stem from variations in the employment of these ranks in the two armies. It would appear that first and second lieutenants were used almost interchangeably on Okinawa but not in Italy.

Table 14

RELATIVE BATTLE CASUALTY RATES FOR OFFICERS, BY RANK

Rank	Percentage of Rate for All Officers	
	Fifth Army Divisions	Tenth Army Combat Troops
General or Field	35	35
Captain	52	53
First Lieutenant	78	131
Second Lieutenant	232	176
Warrant Officer	5	12
Total	100	100
Rate for all officers*	4.0	3.5

*Casualties (WIA, KIA, and MIA) per 1,000 strength per day.

Campaigns. During the war several summaries of campaign casualties were published in *Health*, the latest in May 1945. They were based upon unit and special reports received by The Surgeon General, upon tactical summaries submitted by the various theaters by radio to the War Department, upon operational reports transmitted at the conclusion of or during operations by the Army or Navy units involved, as well as upon special casualty summaries prepared by the theaters. These sources were combed with care, but proved far from satisfactory for the purpose in that they were at times fragmentary or inconsistent, and occasionally failed to give both strengths and casualties on a basis suitable for matching.

[5] *USAF MIDPAC, Casualty Report Number III*, including Okinawa Campaign, Prepared by Hq. Replacement Training Command, 17 September 1945.

Hence, the resulting extracts were regarded as provisional in nature in the expectation that subsequent and more critical historical study would establish more correct values. At this writing no great progress appears yet to have been made in this direction, and it seems doubtful if the Department of Defense will establish definitive counts within the proximate future. Accordingly, the May 1945 table has been reviewed in the light of a limited amount of newly accessible source-material, and made comparable with the figures in the report *Battle Casualties of the Army* for 1 July 1946, which gives no strengths. The revised table (Table 15) must still be regarded as provisional.

As has already been mentioned in Chapter I, one of the most difficult tasks in assembling the material on each campaign was that of establishing the time period over which the casualties were sustained and of ascertaining whether one count, larger than another, was so by virtue of its being based on a longer period of combat, a larger strength, or a more complete casualty count. Wherever possible, for those campaigns or lesser actions for which the recorded casualties were not tied to specific dates, the terminal date has been selected so as to include some part of the mopping-up period. However, even in the areas in which official closing dates were set, e.g., Hollandia, Aitape, and Sansapor, numbers of Japanese were at large beyond the perimeters of U. S. bases long afterwards.

In the computation of each casualty rate the estimated mean strength of the effective force has been used. Where casualties were heavy and replacements few the resulting rates are thus much higher than rates based upon assault strengths.

In the interest of completeness Marine Corps casualties have been included in joint amphibious operations, but it should be remembered that Marine Corps and Army rates, like those for different operations, cannot be compared for purposes of evaluating tactical efficiency unless many other factors are taken into account.

With few exceptions the data in Table 15 pertain to the experience of ground and service troops only. Theater rates for the European and Mediterranean campaigns include casualties sustained by the Air Forces, as do the rates for Leyte and Luzon during the Philippine Campaign.

The absolute numbers of casualties given in Table 15 should not be quoted in competition with official TAG counts should these

Table 15

U.S. Army Casualties in Major Ground Campaigns and Operations, World War II, by Theater of Operation

Theater and Campaign	Calendar Period	Days	Estimated Average Strength
NORTH AMERICAN			
Attu[1]	11 May 1943- 1 Jun. 1943	22	15,200
PACIFIC OCEAN AREAS			
Guadalcanal			
Marines	7 Aug. 1942-17 Nov. 1942	103	32,650
Army[2]	12 Nov. 1942- 9 Feb. 1943	90	21,000
Total		187	28,100
New Georgia			
Navy and Marines	30 Jun. 1943-22 Sep. 1943	85	6,000
Army	30 Jun. 1943-22 Sep. 1943	85	20,100
Total		85	26,100
Bougainville			
Marines	1 Nov. 1943-30 Apr. 1944	182	18,000
Army	19 Nov. 1943-30 Apr. 1944	164	38,200
Total		182	52,400
Gilbert Islands			
Makin[4]	21 Nov. 1943-23 Nov. 1943	3	7,900
Tarawa[3]	20 Nov. 1943-23 Nov. 1943	4	17,000
Total		4	22,900
Marshall Islands			
Kwajalein, So.[4]	31 Jan. 1944- 5 Feb. 1944	6	21,300
Kwajalein, No.[3]	31 Jan. 1944- 2 Feb. 1944	3	20,100
Eniwetok[5]	31 Jan. 1944- 5 Feb. 1944	6	10,000
Total		6	41,400
Marianas Islands			
Saipan[6]			
Marine	15 Jun. 1944-23 Jul. 1944	39	40,000
Army	16 Jun. 1944-23 Jul. 1944	38	21,500
Total		39	60,900
Guam			
Marine	21 Jul. 1944-10 Aug. 1944	21	27,300
Army	21 Jul. 1944-10 Aug. 1944	21	18,000
Total		21	45,300

†Not available.
[1]From Statistical Health Report. [2]Two divisions only. [3]Marine operation. [4]Army operation. [5]Joint operation. [6]Includes 14 days of mopping-up.

Table 15 (Continued)

U.S. Army Casualties in Major Ground Campaigns and Operations, World War II, by Theater of Operation

Theater and Campaign	Number of Men Reported			Casualties Per 1,000 Men Per Day		
	Killed	Wounded	Missing, Captured	Killed	Wounded	Missing, Captured
NORTH AMERICAN						
Attu[1]	549	1,148	†	1.64	3.43	†
PACIFIC OCEAN AREAS						
Guadalcanal						
Marines	1,190	2,753	28	0.35	0.82	0.01
Army[2]	820	1,640	5	0.43	0.87	0.00
Total	2,010	4,393	33	0.38	0.84	0.01
New Georgia						
Navy and Marines	189	494	†	0.37	0.97	†
Army	803	3,790	23	0.47	2.22	0.01
Total	992	4,284	†	0.45	1.93	†
Bougainville						
Marines	440	1,376	18	0.13	0.42	0.01
Army	511	2,569	62	0.08	0.41	0.01
Total	951	3,945	80	0.10	0.41	0.01
Gilbert Islands						
Makin[4]	66	187	0	2.78	7.89	0.00
Tarawa[3]	985	2,193	3	14.49	32.25	0.04
Total	1,051	2,380	3	11.47	25.98	0.03
Marshall Islands						
Kwajalein, So.[4]	177	1,037	0	1.38	8.11	0.00
Kwajalein, No.[3]	195	545	65	3.23	9.04	1.08
Eniwetok[5]	299	786	0	4.98	13.10	0.00
Total	671	2,368	65	2.70	9.53	0.26
Marianas Islands						
Saipan[6]						
Marine	2,116	10,419	247	1.36	6.68	0.16
Army	1,010	2,741	79	1.24	3.35	0.10
Total	3,126	13,160	326	1.32	5.54	0.14
Guam						
Marine	1,098	4,944	128	1.92	8.62	0.22
Army	191	704	20	0.51	1.86	0.05
Total	1,289	5,648	148	1.35	5.94	0.16

†Not available.

[1]From Statistical Health Report. [2]Two divisions only. [3]Marine operation. [4]Army operation. [5]Joint operation. [6]Includes 14 days of mopping-up.

Table 15 (Continued)

U.S. Army Casualties in Major Ground Campaigns and Operations, World War II, by Theater of Operation

Theater and Campaign	Calendar Period	Days	Estimated Average Strength
PACIFIC OCEAN AREAS (Continued)			
Tinian[3, 7]	24 Jul. 1944- 9 Aug. 1944	17	40,200
Total Marianas			
Marine	15 Jun. 1944-10 Aug. 1944	57	49,400
Army	16 Jun. 1944-10 Aug. 1944	56	21,400
Total		57	70,400
Caroline Islands			
Marine[8]	15 Sep. 1944-11 Oct. 1944	27	23,000
Army[9]	17 Sep. 1944-22 Nov. 1944	69	19,600
Total		69	28,600
Iwo Jima[3]	19 Feb. 1945-26 Mar. 1945	36	40,000
Ryukyus[10]			
Marine	1 Apr. 1945-30 Jun. 1945	91	51,200
Army	1 Apr. 1945-30 Jun. 1945	91	69,200
Total[11]		91	120,400
Corps[12]		91	99,500
Division[12]		91	69,100
SOUTHWEST PACIFIC AREA			
Philippine Islands	7 Dec. 1941-10 May 1942	137	33,000
Papuan	26 Sep. 1942-23 Jan. 1943	120	10,200
Dexterity Operation			
Arawe[4]	15 Dec. 1943-10 Feb. 1944	58	4,400
Cape Gloucester[3]	26 Dec. 1943-28 Apr. 1944	125	15,000
Saidor[4]	2 Jan. 1944-10 Feb. 1944	40	11,500
Total		125	20,600
Admiralty Islands	1 Mar. 1944-30 Apr. 1944	61	19,000
Reckless Operation			
Hollandia	22 Apr. 1944- 6 Jun. 1944	46	28,700
Aitape	22 Apr. 1944-25 Aug. 1944	126	24,700
Total		126	35,200
Straitline Operation[13]			
Wakde-Toem	17 May 1944-12 Jul. 1944	56	19,500
Biak-Soepiori	27 May 1944-22 Jul. 1944	56	29,700
Total		66	41,700

†Not available.
[3]Marine operation. [4]Army operation. [5]Joint operation. [6]Includes 14 days of mopping-up. [7]Includes 8 days of mopping-up. [8]Peleliu. [9]Peleliu and Angaur. [10]Includes 9 days of mopping-up. [11]Tenth U.S. Army; includes Army and Marine Corps troops. [12]Both Army and Marine Corps Units. [13]Includes air and ground troops.

Table 15 (Continued)
U.S. Army Casualties in Major Ground Campaigns and Operations, World War II, by Theater of Operation

Theater and Campaign	Number of Men Reported			Casualties Per 1.000 Men Per Day		
	Killed	Wounded	Missing, Captured	Killed	Wounded	Missing, Captured
PACIFIC OCEAN AREAS (Continued)						
Tinian[3, 7]	295	1,554	0	0.43	2.27	0.00
Total Marianas						
Marine	3,509	16,917	375	1.25	6.01	0.13
Army	1,201	3,445	99	1.00	2.87	0.08
Total	4,710	20,362	474	1.17	5.07	0.12
Caroline Islands						
Marine[8]	858	4,933	228	1.38	7.94	0.37
Army[9]	424	2,492	9	0.31	1.84	0.01
Total	1,282	7,425	237	0.65	3.76	0.12
Iwo Jima[3]	5,435	14,893	53	3.77	10.34	0.04
Ryukyus[10]						
Marine	2,779	13,609	119	0.60	2.92	0.03
Army	4,468	17,821	81	0.71	2.83	0.01
Total[11]	7,247	31,430	200	0.66	2.87	0.02
Corps[12]	7,191	31,298	200	0.79	3.46	0.02
Division[12]	7,101	30,803	196	1.13	4.90	0.03
SOUTHWEST PACIFIC AREA						
Philippine Islands	1,638	1,813	31,156	0.36	0.40	6.89
Papuan	696	2,035	62	0.57	1.66	0.05
Dexterity Operation						
Arawe[4]	118	352	4	0.46	1.38	0.02
Cape Gloucester[3]	311	1,114	77	0.17	0.59	0.04
Saidor[4]	40	111	10	0.09	0.24	0.02
Total	469	1,577	91	0.18	0.61	0.04
Admiralty Islands	230	1,109	11	0.20	0.96	0.01
Reckless Operation						
Hollandia	90	493	13	0.07	0.37	0.01
Aitape	316	1,989	24	0.10	0.64	0.01
Total	406	2,482	37	0.09	0.53	0.01
Straitline Operation[13]						
Wakde-Toem	437	1,850	12	0.40	1.69	0.01
Biak-Soepiori	432	2,361	6	0.26	1.42	0.00
Total	869	4,211	18	0.32	1.53	0.01

†Not available.

[3]Marine operation. [4]Army operation. [5]Joint operation. [6]Includes 14 days of mopping-up. [7]Includes 8 days of mopping-up. [8]Peleliu. [9]Peleliu and Angaur. [10]Includes 9 days of mopping-up. [11]Tenth U.S. Army; includes Army and Marine Corps troops. [12]Both Army and Marine Corps Units. [13]Includes air and ground troops.

Table 15 (Continued)
U.S. Army Casualties in Major Ground Campaigns and Operations, World War II, by Theater of Operation

Theater and Campaign	Calendar Period	Days	Estimated Average Strength
SOUTHWEST PACIFIC AREA (Continued)			
Noemfoor	2 Jul. 1944-31 Aug. 1944	61	18,000
Sansapor-Mar	30 Jul. 1944-31 Aug. 1944	33	20,500
Morotai	15 Sep. 1944- 4 Oct. 1944	20	31,200
Philippines			
Leyte-Samar and Central Visayan Islands			
Sixth Army	19 Oct. 1944-25 Dec. 1944	68	140,400
Island	19 Oct. 1944-30 Jun. 1945	255	145,700
Mindoro	15 Dec. 1944-30 Jun. 1945	198	18,900
Luzon			
Sixth Army	9 Jan. 1945-30 Jun. 1945	173	180,200
Island	9 Jan. 1945-30 Jun. 1945	173	265,400
Palawan	28 Feb. 1945-30 Jun. 1945	123	2,600
Panay[14]	18 Mar. 1945-30 Jun. 1945	105	15,100
Cebu[15]	26 Mar. 1945-30 Jun. 1945	97	19,500
Mindanao[16]	10 Mar. 1945-30 Jun. 1945	113	41,700
All Islands	19 Oct. 1944-30 Jun. 1945	255	351,000
MEDITERRANEAN			
North Africa[17]	8 Nov. 1942-13 May 1943	187	277,300
Sicily, by Echelon	10 Jul. 1943-17 Aug. 1943	39	
Division			100,300
Corps			124,700
Army			183,500
Theater			525,800
Italy, by Echelon	9 Sep. 1943- 8 May 1945	608	
Division			90,500
Army			182,800
Theater[18]			615,600
Italy, by Phase (5th Army)			
Salerno[19]	9 Sep. 1943-20 Sep. 1943	12	94,900
Naples-Foggia	21 Sep. 1943- 6 Oct. 1943	16	180,300
Volturno	7 Oct. 1943-15 Nov. 1943	40	201,500
Winterline	16 Nov 1943-15 Jan. 1944	61	200,600

†Not available.

[14]Includes Negroes Occidental. [15]Includes Negroes Oriental. [16]Includes Sulu Archipelago. [17]Entire theater experience. [18]Includes So. France to 31 Oct. 1944. [19]KIA and WIA may be low.

Table 15 (Continued)
U.S. Army Casualties in Major Ground Campaigns and Operations, World War II, by Theater of Operation

Theater and Campaign	Number of Men Reported			Casualties Per 1,000 Men Per Day		
	Killed	Wounded	Missing, Captured	Killed	Wounded	Missing, Captured
SOUTHWEST PACIFIC (Continued)						
Noemfoor	65	343	3	0.06	0.31	0.00
Sansapor-Mar	34	85	0	0.05	0.13	0.00
Morotai	30	80	1	0.05	0.13	0.00
Philippines						
Leyte-Samar and Central Visayan						
Sixth Army	2,381	9,128	†	0.25	0.96	†
Island	2,968	10,235	†	0.08	0.28	†
Mindoro	16	153	†	0.00	0.04	†
Luzon						
Sixth Army	7,142	27,708	†	0.23	0.89	†
Island	7,375	29,008	†	0.16	0.63	†
Palawan	11	51	†	0.03	0.16	†
Panay[14]	283	1,264	†	0.18	0.80	†
Cebu[15]	489	1,762	†	0.26	0.93	†
Mindanao[16]	682	3,523	†	0.14	0.75	†
All Islands	11,824	45,996	†	0.13	0.51	†
MEDITERRANEAN						
North Africa[17]	2,767	10,469	5,796	0.05	0.20	0.11
Sicily, by Echelon						
Division	1,304	4,793	1,063	0.33	1.23	0.27
Corps	1,397	5,084	1,081	0.29	1.05	0.22
Army	1,439	5,236	1,116	0.20	0.73	0.16
Theater	1,886	5,546	2,334	0.09	0.27	0.11
Italy, by Echelon						
Division	14,375	63,360	8,370	0.26	1.15	0.15
Army	19,488	80,576	9,637	0.18	0.72	0.09
Theater[18]	29,665	95,612	25,769	0.08	0.26	0.07
Italy, by Phase (5th Army						
Salerno[19]	509	1,847	1,112	0.45	1.62	0.98
Naples-Foggia	293	996	116	0.10	0.35	0.04
Volturno	1,399	5,186	267	0.17	0.64	0.03
Winterline	1,642	6,962	253	0.13	0.57	0.02

†Not available.

[14]Includes Negroes Occidental. [15]Includes Negroes Oriental. [16]Includes Sulu Archipelago. [17]Entire theater experience. [18]Includes So. France to 31 Oct. 1944. [19]KIA and WIA may be low.

Table 15 (Continued)

U.S. ARMY CASUALTIES IN MAJOR GROUND CAMPAIGNS AND OPERATIONS, WORLD WAR II, BY THEATER OF OPERATION

Theater and Campaign	Calendar Period	Days	Estimated Average Strength
MEDITERRANEAN (Cont.)			
Gustav Line	16 Jan. 1944-10 May 1944	116	227,200
May Offensive	11 May 1944- 4 Jun. 1944	25	240,500
Pursuit Northward	5 Jun. 1944-13 Jul. 1944	39	208,700
Arno Valley	14 Jul. 1944-15 Aug. 1944	33	152,900
Gothic Line	16 Aug 1944-20 Dec. 1944	127	142,400
Northern Appenines	21 Dec. 1944-13 Apr. 1945	114	165,100
Spring Offensive	14 Apr. 1945- 8 May 1945	25	174,900
Southern France	15 Aug. 1944-31 Oct. 1944	78	122,700
EUROPEAN			
Air Phase[17]	1 Jan. 1942-31 May 1944	882	358,000
Ground Invasion, by Echelon			
Division	6 Jun. 1944- 8 May 1945	337	
All Types			468,000
Infantry			346,300
Armored			96,500
Airborne			25,200
Corps[20]			686,100
Army			904,300
Theater[18]	1 Jun. 1944- 8 May 1945	342	2,355,000
Air and Ground Phases[17]	1 Jan. 1942- 8 May 1945	1,224	914,000
Campaigns of First Army[21]			
Opening Phases	6 Jun. 1944-31 Jul. 1944	56	
Exploitation of St. Lo	1 Aug. 1944-12 Sep. 1944	43	
Battle of Germany	13 Sep. 1944-15 Dec. 1944	94	
German Counter Offensive	16 Dec. 1944- 2 Jan. 1945	18	
Roer River Offensive	3 Jan. 1945-22 Feb. 1945	51	
Closing Phases	23 Feb. 1945- 8 May 1945	75	
Total[24]	6 Jun. 1944- 8 May 1945	337	312,000
Campaigns of Third Army[22]			
France, Avranches, Brest to the Moselle	1 Aug. 1944-24 Sep. 1944	55	
Forcing the Moselle	25 Sept. 1944- 7 Nov. 1944	44	

†Not available.

[13]Includes air and ground troops. [17]Entire theater experience. [18]Includes So. France to 31 Oct. 1944. [19]KIA and WIA may be low. [20]See text for estimation. [21]Data from Statistical Health Report supplemented by ETO Combat Medical Statistical Report. [22]Rates are arithmetic averages of daily rates for indicated periods, based on ETO Combat Medical Statistical Report. [23]Excludes So. France period. [24]Individual Army totals are from Statistical Health Report and generally exceed AG counts by about 2 percent. Because its tactical use was so slight, and its casualty counts quite small, the Fifteenth Army is omitted. The First Airborne Army is also excluded because its strength and casualties are included in the counts for the armies already listed, with the possible exception of a brief period in the fall of 1944.

Table 15 (Continued)

U.S. Army Casualties in Major Ground Campaigns and Operations, World War II, by Theater of Operation

Theater and Campaign	Number of Men Reported			Casualties Per 1,000 Men Per Day		
	Killed	Wounded	Missing, Captured	Killed	Wounded	Missing, Captured
MEDITERRANEAN (Cont.)						
Gustav Line	4,415	16,281	4,199	0.17	0.62	0.16
May Offensive	3,205	13,876	1,045	0.53	2.31	0.17
Pursuit Northward	1,424	6,324	306	0.17	0.78	0.04
Arno Valley	537	2,469	270	0.11	0.49	0.05
Gothic Line	3,663	16,254	1,628	0.20	0.90	0.09
Northern Appenines	1,142	5,226	372	0.06	0.28	0.02
Spring Offensive	1,259	5,155	69	0.29	1.18	0.02
Southern France	†	14,000	†	†	1.46	†
EUROPEAN						
Air Phase[17]	8,186	4,897	21,395	0.03	0.02	0.07
Ground Invasion, by Echelon						
Division						
All Types	78,251	327,145	54,928	0.50	2.07	0.35
Infantry	64,787	270,856	45,477	0.56	2.32	0.39
Armored	9,748	40,753	6,842	0.30	1.25	0.21
Airborne	3,716	15,536	2,609	0.44	1.83	0.31
Corps[20]	83,759	350,173	58,794	0.36	1.51	0.25
Army	89,268	373,202	62,661	0.29	1.22	0.21
Theater[18]	99,128	381,135	77,061	0.12	0.47	0.10
Air and Ground Phases[17]	107,314	386,032	98,456	0.10	0.35	0.09
Campaigns of First Army[21]						
Opening Phases	†	†	†	†	3.30	†
Exploitation of St. Lo	†	†	†	†	1.97	†
Battle of Germany	†	†	†	†	1.45	†
German Counter Offensive	†	†	†	†	1.88	†
Roer River Offensive	†	†	†	†	1.12	†
Closing Phases	†	†	†	†	1.06	†
Total[24]	†	183,000	†	†	1.74	†
Campaigns of Third Army[22]						
France, Avranches, Brest to the Moselle	†	†	†	†	1.53	†
Forcing the Moselle	†	†	†	†	0.61	†

†Not available.

[13]Includes air and ground troops. [17]Entire theater experience. [18]Includes So. France to 31 Oct. 1944. [19]KIA and WIA may be low. [20]See text for estimation. [21]Data from Statistical Health Report supplemented by ETO Combat Medical Statistical Report. [22]Rates are arithmetic averages of daily rates for indicated periods, based on ETO Combat Medical Statistical Report. [23]Excludes So. France period. [24]Individual Army totals are from Statistical Health Report and generally exceed AG counts by about 2 percent. Because its tactical use was so slight, and its casualty counts quite small, the Fifteenth Army is omitted. The First Airborne Army is also excluded because its strength and casualties are included in the counts for the armies already listed, with the possible exception of a brief period in the fall of 1944.

Table 15 (Continued)

U.S. Army Casualties in Major Ground Campaigns and Operations, World War II, by Theater of Operation

Theater and Campaign	Calendar Period	Days	Estimated Average Strength
EUROPEAN (Continued)			
Metz and Saar	8 Nov. 1944-18 Dec. 1944	41	
Bastogne-St. Vith	19 Dec. 1944-28 Jan. 1945	41	
Eifel to the Rhine, Capture of Trier	29 Jan. 1945-12 Mar. 1945	43	
Koblenz and Palatinate	13 Mar. 1945-21 Mar. 1945	9	
Forcing the Rhine and Mulde	22 Mar. 1945-21 Apr. 1945	31	
Crossing Danube, Czechoslovakia, and Austria	22 Apr. 1945- 8 May 1945	17	
Total[24]	1 Aug. 1945- 8 May 1945	281	286,000
Seventh Army[23, 24]	1 Nov. 1944- 8 May 1945	189	252,300
Ninth Army[24]	5 Sep. 1944- 8 May 1945	246	229,700

†Not available.

[22]Rates are arithmetic averages of daily rates for indicated periods, based on ETO Combat Medical Statistical Report. [23]Excludes So. France period. [24]Individual Army totals are from Statistical Health Report and generally exceed AG counts by about 2 percent. Because its tactical use was so slight, and its casualty counts quite small, the Fifteenth Army is omitted. The First Airborne Army is also excluded because its strength and casualties are included in the counts for the armies already listed, with the possible exception of a brief period in the fall of 1944.

become available in comparable form, but every effort has been made to use or to adjust to TAG counts released in the 1 July 1946 issue of *Battle Casualties of the Army*. The emphasis here is placed upon the casualty *rates*, especially those for WIA, and thus places a premium upon having strength and casualty data which match. Certain arbitrary features of the comparisons which may be made from the table are worth noting:

1. Rates for small forces are bound to vary more than rates for large forces;
2. In consequence of 1 it is virtually inevitable that the highest rates will appear in the campaigns involving the smaller forces; and

Table 15 (Continued)
U.S. Army Casualties in Major Ground Campaigns and Operations, World War II, by Theater of Operation

Theater and Campaign	Number of Men Reported			Casualties Per 1,000 Men Per Day		
	Killed	Wounded	Missing, Captured	Killed	Wounded	Missing, Captured
EUROPEAN (Continued)						
Metz and Saar	†	†	†	†	2.04	†
Bostogne-St. Vith	†	†	†	†	1.69	†
Eifel to the Rhine, Capture of Trier	†	†	†	†	1.26	†
Koblenz and Palatinate	†	†	†	†	1.39	†
Forcing the Rhine and Mulde	†	†	†	†	0.74	†
Crossing Danube, Czechoslovakia, and Austria	†	†	†	†	0.35	†
Total[24]	†	106,600	†	†	1.33	†
Seventh Army[23, 24]	†	51,000	†	†	1.07	†
Ninth Army[24]	†	34,500	†	†	0.61	†

†Not available.

[22]Rates are arithmetic averages of daily rates for indicated periods, based on ETO Combat Medical Statistical Report. [23]Excludes So. France period. [24]Individual Army totals are from Statistical Health Report and generally exceed AG counts by about 2 percent. Because its tactical use was so slight, and its casualty counts quite small, the Fifteenth Army is omitted. The First Airborne Army is also excluded because its strength and casualties are included in the counts for the armies already listed, with the possible exception of a brief period in the fall of 1944.

3. Direct comparison of Pacific and European rates is confused by variations in size of force, length of operation, and the relative discreteness of individual actions.

The greatest usefulness of the listing derives from its character as a record of individual operations rather than as a basis for statistical generalization designed to serve the ends of prediction. This is because the recorded attributes (geographical location, length, size of force) have only moderate value as determinants of casualty incidence. The most significant determinants are poorly recorded and difficult of access, e.g., relative superiority (or inferiority) over the enemy in point of such factors as: (1) air or naval support; (2) land artillery; (3) size of force; (4) quality of weapons; (5) position for offensive or defensive action, including natural features of terrain and prepared positions; (6) experience and condition of troops; (7) adequacy of logistic support; and (8) leadership. Some allowance for these factors, varying with the background of the reader, can be made in studying the campaign table, which is another way of saying that it serves chiefly as a collection of individual models for planning purposes. Better information would come out of application of the methods of "operations analysis" which were so useful in rationalizing selected aspects of air and naval action in World War II, but for which very little has been done for ground action.*

For the most part the Pacific combat falls neatly into distinct entities, whereas in Europe the boundaries are set for phases which seem arbitrary by comparison. The latter also involve much larger forces, for in preparing the table it proved practical to subdivide no farther down, echelon-wise, than the experience of an army. One may well ask, then: What is a campaign? without finding a satisfactory answer. The phases and subgroupings employed here are, however, those which appear in the operational reports of the units concerned, where they serve to organize the entire tactical discussion in a way which reflects the realities of operational planning as well as the synthesis of hindsight.

Echelon. Because of the comparative stability in the organization of ground troops in World War II, and because of the orderly and consistent fashion in which units of various sizes were used tactically, the variation in casualty rates by echelon presents one of the most constant patterns recurring in casualty statistics. In general, if a divisional casualty rate is given a base value of 100, the corresponding corps rate is on the order of 70 to 80, the army rate 55 to 65, and the theater rate 20 to 25 percent, in World War II operations. In other words, given operations of sufficient size to involve field armies, despite differences as to average level of incidence of wounding, the internal pattern of rates by echelon will be relatively constant. Figure 11 gives the echelon rates and percentages as observed in the entire ETO experience. Echelon rates, it

*The British maintained operational research groups which investigated such problems as damage by gunfire and bombing on land targets, wounding-power of rifle bullets, effect of flame-throwers on military personnel, casualties and effect of fire support in the Normandy invasion, and mine-field clearance and casualties.

VARIATION IN EUROPEAN THEATER ADMISSION RATES FOR WOUNDED, BY ECHELON

Ground Troops

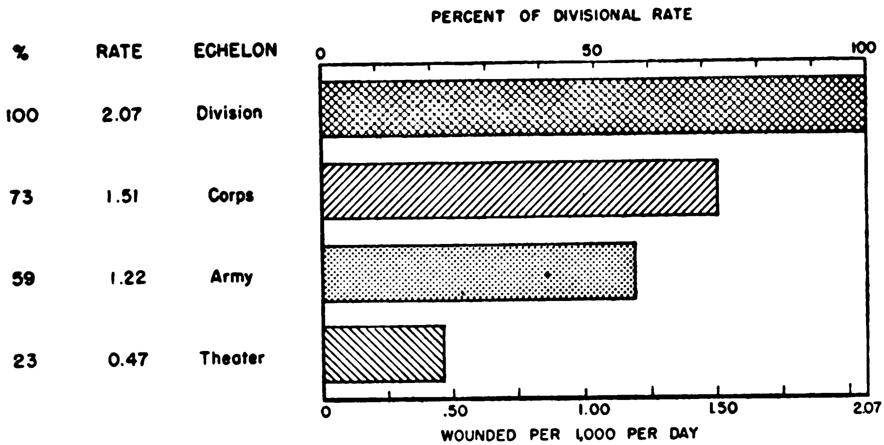


Fig. 11.

should be noted, are cumulative in the sense that the rate for any echelon includes the experience of all component units and, by that token, of lower echelons of military organization. Thus a corps rate includes the experience of component divisions, and these in turn of regiments, etc. As rates are calculated for echelons of increasing size the high risk of front-line troops is thus progressively diluted by the experience of troops less immediately exposed. Hence echelon rates do not measure the danger which inheres in a given physical distance from the front line. As an approximation, Figure 12 has been prepared by decumulating echelon rates. At one extreme are the rates for specific occupations characteristic of infantry companies, and at the other the rate for theater troops, i.e., those to the rear of field armies.

Frequency Distributions of Rates. The World War II averages conceal tremendous variation in the incidence of wounding, even for particular armies and for individual campaigns, as suggested by Table 15. Fortunately, there are also rather reliable distributions of casualty rates for various echelons and intervals of time, and in subsequent pages these are shown graphically to facilitate estimation. The distributions have been smoothed by hand in plotting, but since they are generally based on more than 150 unit-periods

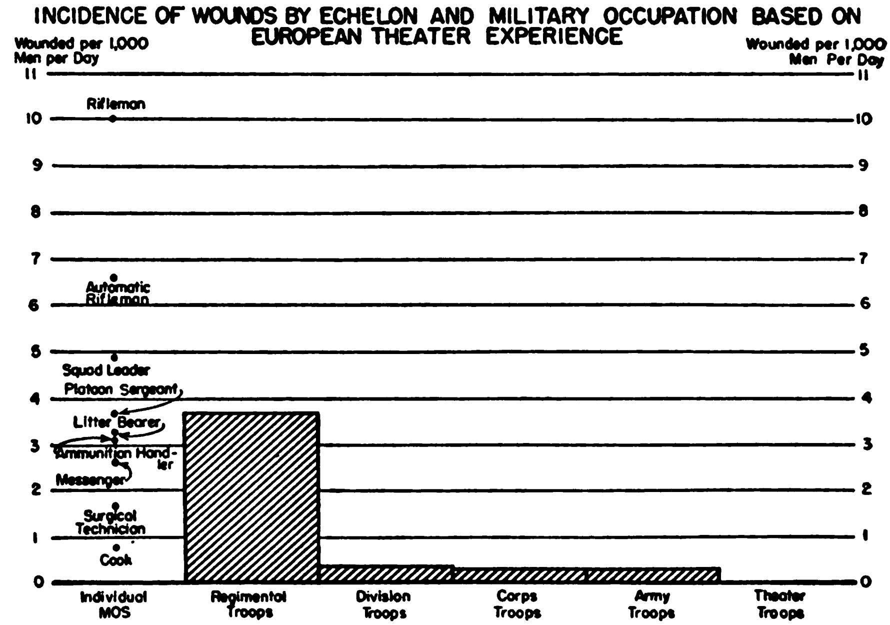


Fig. 12.

their contour is very little affected by the smoothing process. In Figures 17 and 19, however, where they are often based on fewer than 50 unit-periods, smoothing does have an appreciable effect. Rates are available for divisions and for armies, on both a daily and a weekly basis.

There are four distributions of rates for wounded based on the *division-day*. These are:

1. SWPA, Leyte Campaign from 20 October 1944 to 25 December 1944 (the assault period), Sixth Army, XXIV Corps, consisting of the 286 reported days experienced by the 7th, 77th, and 96th Infantry Divisions;
2. MTO, Italian Campaign from 9 September 1943 to 8 May 1945, Fifth Army divisions (eight infantry, one mountain, and one armored) with 3,533 days;
3. SWPA, Luzon Campaign from 9 January 1945 to 31 March 1945, Sixth Army, I Corps, consisting of 264 days experienced by 6th, 25th, 32nd, 33rd, and 43rd Infantry Divisions; and

4. POA, Okinawa Campaign from 1 April 1945 to 30 June 1945, Tenth Army, consisting of 436 days experienced by four U. S. Army Infantry and two Marine Corps divisions.

These four distributions have been plotted in cumulative form in Figure 13. Unfortunately, the ETO experience is not available in daily form, but its curve would lie somewhat to the right of the Luzon curve, but still rather far from that for Okinawa which, for a field army, is the most variable of the war. These curves are drawn in cumulative fashion to facilitate interpolation for practical purposes. The farther to the right a curve extends the more variable are the rates, and the more vertical the curve the less variable are the rates. The curve for divisions of the Fifth Army, for example, indicates that 50 percent of the division-days carried rates less than, and 50 percent more than, 0.2 per 1,000 per day, or about 3 wounded per division of 15,000 men. However, 25 percent of the division-days were above 1.0 per 1,000 men per day, or 15 wounded per division of 15,000 men. For the Tenth Army divisions the parallel rates are 3.5 and 8.1. It may be pertinent to note that inclusion of the two Marine Corps divisions does not appreciably affect the shape of the distribution for the Tenth Army divisions.

Since the Tenth Army experience differs so greatly from the rest, and is not available in the form of division weeks, the band of variation in Figure 14, which summarizes data on *division-weeks*, is too narrow. Were it available the Tenth Army curve would again extend far to the right. Those plotted in Figure 14 are:

1. ETO, entire campaign from 6 June 1944 to 8 May 1945, all field armies, and all types of divisions (infantry, armored, and airborne), covering 1,741 division-weeks;
2. MTO, Italian Campaign, 10 Fifth Army divisions, from 9 September 1943 to 8 May 1945, covering 521 division-weeks; and
3. SWPA, Luzon Campaign, 10 Sixth Army divisions, from 9 January 1945 to 30 June 1945, covering 205 division-weeks.

The curves are of the same cumulative type as those of Figure 13 and are read in the same way. Thus, the rates exceeded by 25 percent of the division-weeks are about 10 per 1,000 men per week for the Fifth Army, 14 for the Sixth Army, and 19 for the ETO, divisions. These curves exclude the maximum rates which lie between

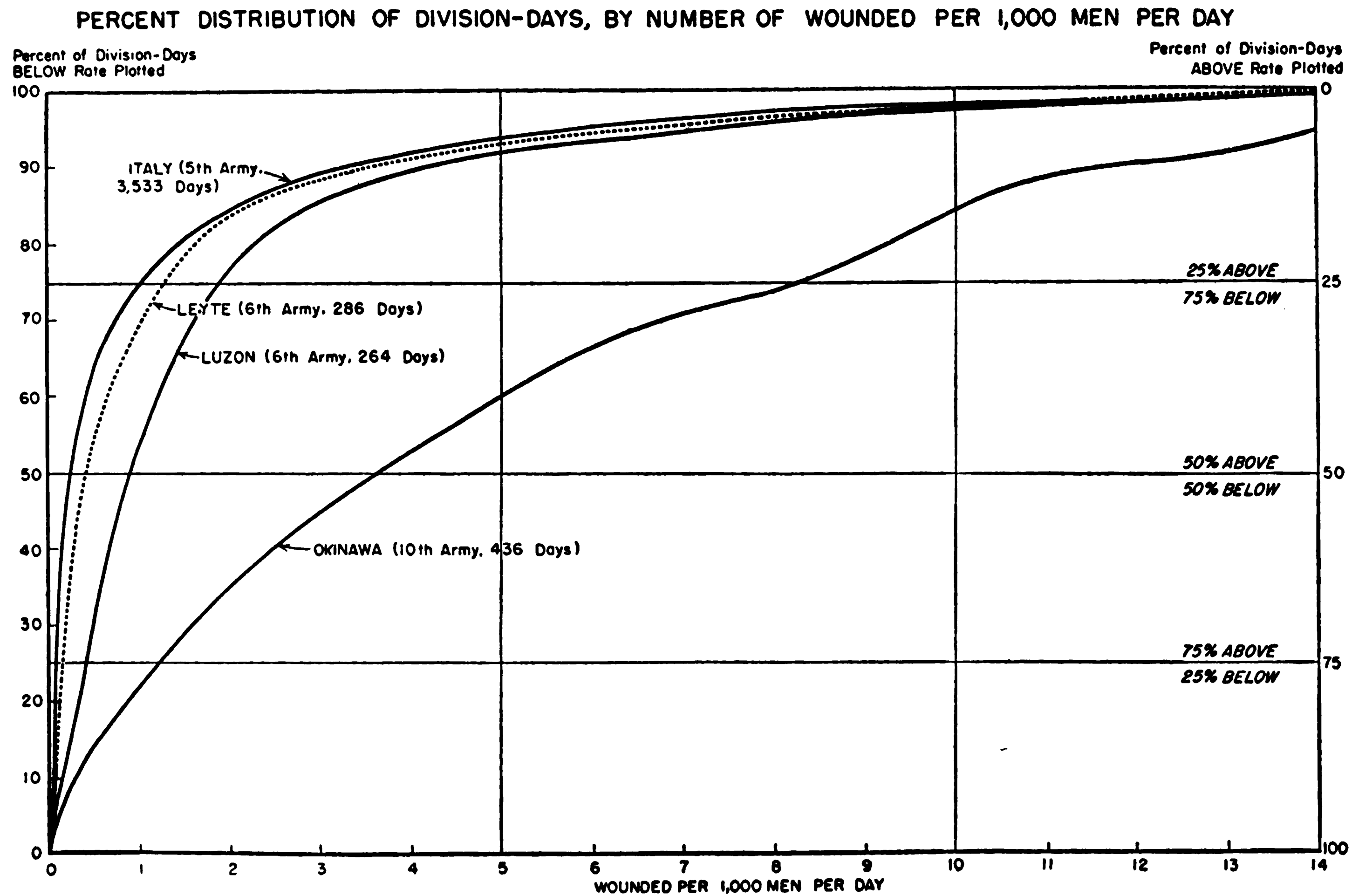

PERCENT DISTRIBUTION OF DIVISION-DAYS, BY NUMBER OF WOUNDED PER 1,000 MEN PER DAY
Percent of Division-Days BELOW Rate Plotted
Percent of Division-Days ABOVE Rate Plotted
ITALY (5th Army, 3,533 Days)
LEYTE (6th Army, 286 Days)
LUZON (6th Army, 264 Days)
OKINAWA (10th Army, 436 Days)
25% ABOVE
75% BELOW
50% ABOVE
50% BELOW
75% ABOVE
25% BELOW
WOUNDED PER 1,000 MEN PER DAY

Fig. 13.

PERCENT DISTRIBUTION OF DIVISION-WEEKS, BY NUMBER OF WOUNDED PER 1,000 MEN PER WEEK

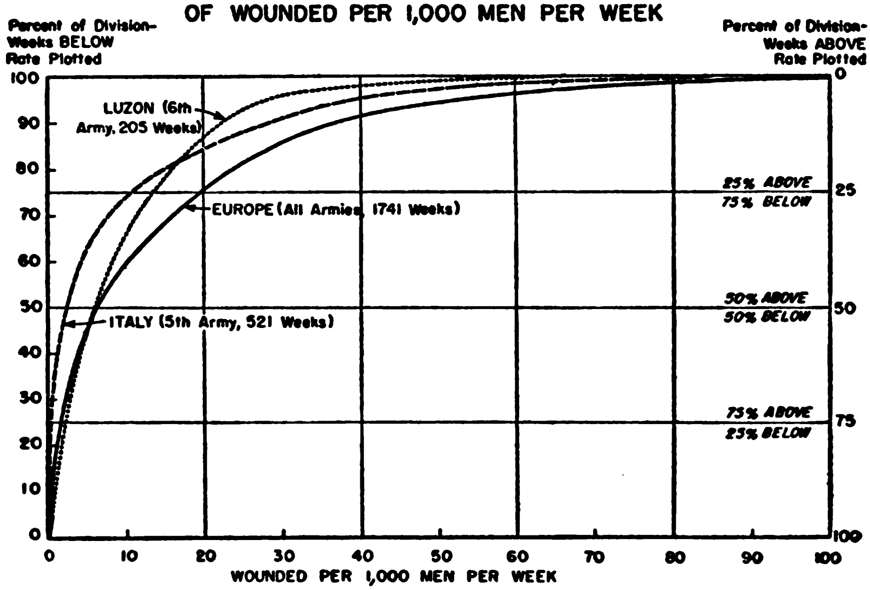


Fig. 14.

115.0 and 119.9 for the Fifth Army, and between 120.0 and 124.9 for the ETO, divisions. If one were to plan on a long-term basis, making other assumptions requiring no more than average figures, the average (median) rates of 2.5 to 6.5 shown in the chart should be supplemented with figures in the range of 15 to 20 if the Okinawa type of situation may be encountered.

One additional dimension is afforded by the considerable volume of data on the ETO divisions. This concerns the type of division, whether infantry, armored, or airborne. The three separate curves are shown in Figure 15. There are two important conclusions to be drawn from Figure 15: (1) the rates for airborne divisions are the most variable, and include proportionately more high, and more low, values than either of the other two sets; and (2) the rates for infantry divisions are uniformly higher than those for armored, but by a fairly small margin.

Parallel to the divisional distributions are those for the *field armies*, both daily and weekly in form. The daily series are:

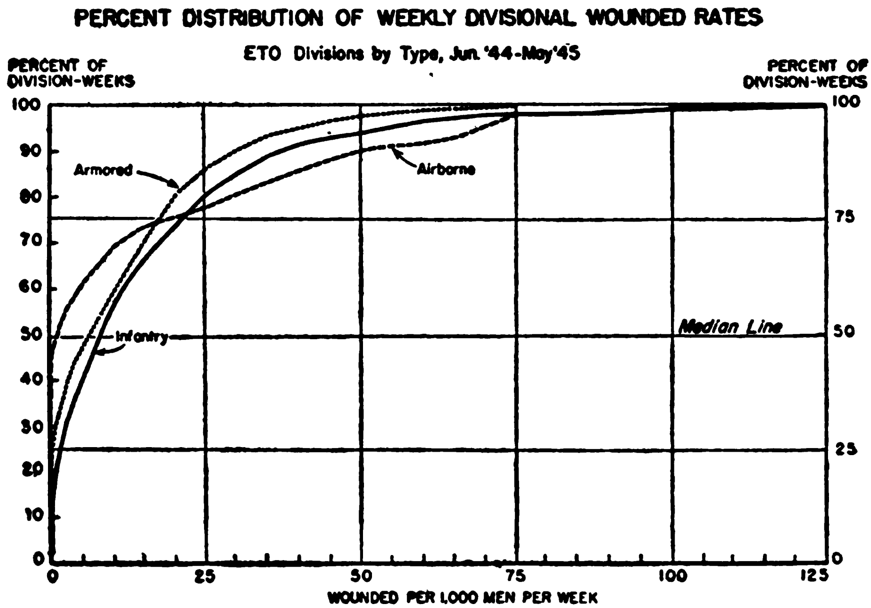


Fig. 15.

1. ETO, each of four field armies, for period 6 June 1944 to 8 May 1945, covering 1,029 army-days; and
2. MTO, Italy, Fifth Army, for 420 days in 1943 and 1944, about 70 percent of the calendar period of the Italian Campaign.

The several distributions are shown in Figure 16 in the same form as in the preceding charts. Again the variation is minimized by exclusion of the data for the Tenth Army, for which no daily series is available.

The distributions of *army-weeks* are more plentiful; Figure 17 gives four of the more important ones:

1. MTO, Italy, Fifth Army, comprising 86 weeks of an 87-week campaign;
2. SWPA, Leyte and Luzon, Sixth Army, from 28 October 1944 to 30 December 1944, and from 13 January 1945 to 29 June 1945, 35 weeks in all;

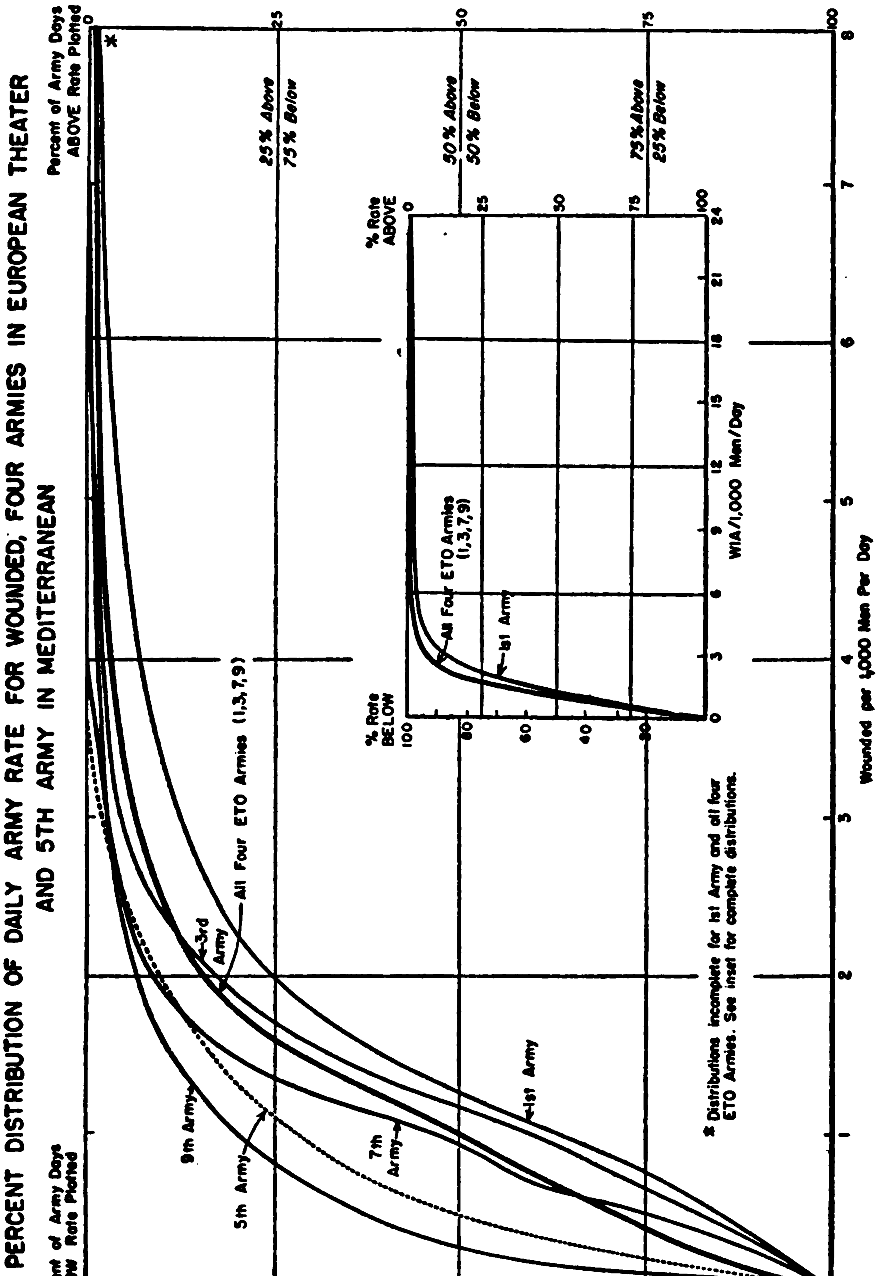

PERCENT DISTRIBUTION OF DAILY ARMY RATE FOR WOUNDED; FOUR ARMIES IN EUROPEAN THEATER
AND 5TH ARMY IN MEDITERRANEAN
Percent of Army Days BELOW Rate Plotted
Percent of Army Days ABOVE Rate Plotted
25% Above
75% Below
50% Above
50% Below
75% Above
25% Below
9th Army
5th Army
7th Army
3rd Army
All Four ETO Armies (1,3,7,9)
1st Army
% Rate ABOVE
% Rate BELOW
All Four ETO Armies (1,3,7,9)
1st Army
WIA/1,000 Men/Day
* Distributions incomplete for 1st Army and all four ETO Armies. See inset for complete distributions.
Wounded per 1,000 Men Per Day

Fig. 16.

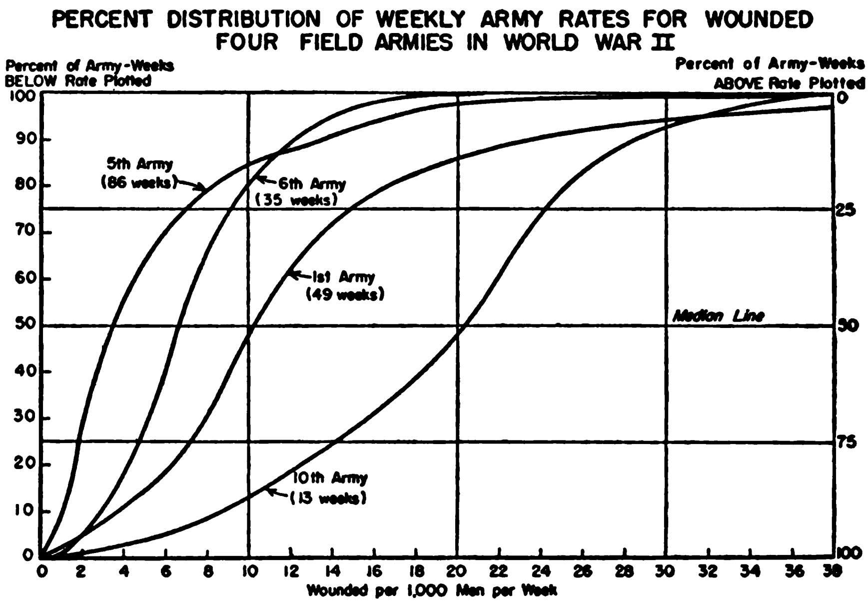


Fig. 17.

3. ETO, Normandy, France, and Germany, First Army, from 9 June 1944 to 11 May 1945, or 49 weeks in all; and
4. POA, Okinawa, Tenth Army, from 6 April 1945 to 29 June 1945, or 13 weeks in all.

These are among the most valuable data on casualties to come out of the war. The picture is, again, one of great variability, with the Tenth Army occupying the extreme position. The median rates are about 3.6, 6.4, 10.2, and 20.4 for the Fifth, Sixth, First, and Tenth Armies. Ten percent of the rates were above 12.1, 13.6, 23.2, and 28.4 for the Sixth, Fifth, First, and Tenth Armies respectively, where rates are expressed as wounded per 1,000 men per week.

Some perspective on the curves for wounded is afforded by comparing them with those for nonbattle casualties, both disease and nonbattle injury. This is done graphically in Figure 18 for the First, Fifth, Sixth, and Tenth Armies, representing the combat experience of all four major theaters. The relationship of battle to nonbattle casualties is an exceedingly complex one. No simple pat-

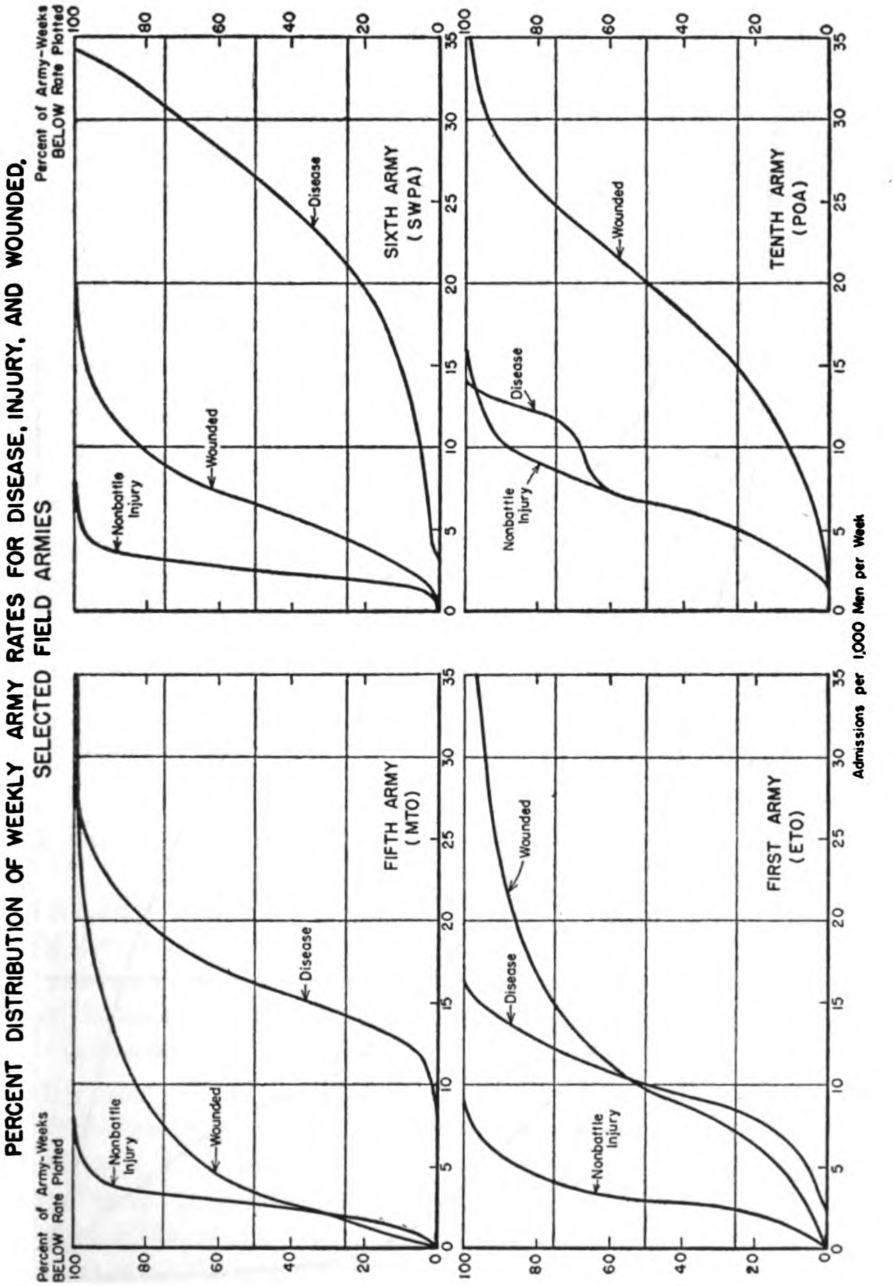

PERCENT DISTRIBUTION OF WEEKLY ARMY RATES FOR DISEASE, INJURY, AND WOUNDED, SELECTED FIELD ARMIES
Percent of Army-Weeks BELOW Rate Plotted
FIFTH ARMY (MTO)
SIXTH ARMY (SWPA)
FIRST ARMY (ETO)
TENTH ARMY (POA)
Nonbattle Injury
Wounded
Disease
Admissions per 1,000 Men per Week

Fig. 18.

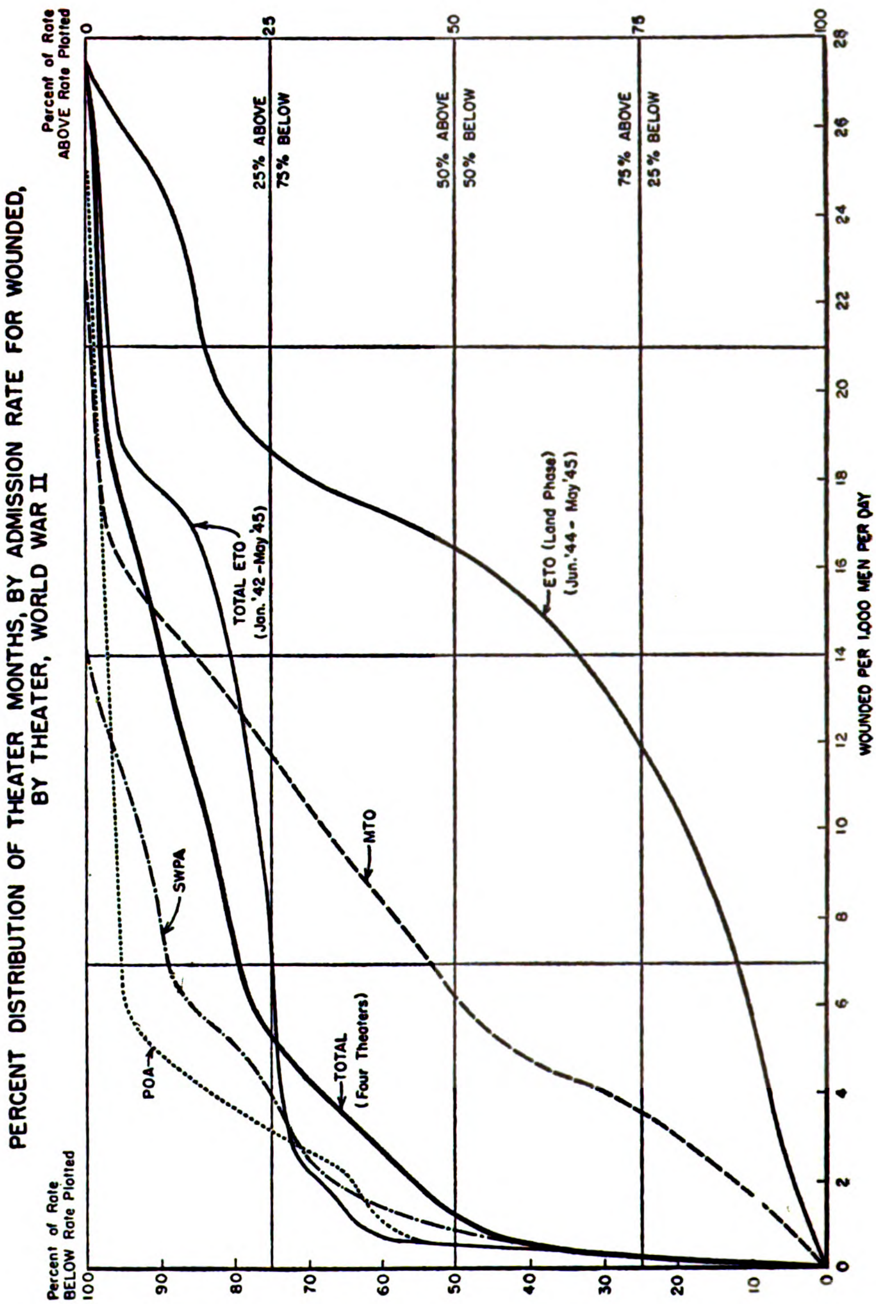

PERCENT DISTRIBUTION OF THEATER MONTHS, BY ADMISSION RATE FOR WOUNDED, BY THEATER, WORLD WAR II
Percent of Rate ABOVE Rate Plotted
Percent of Rate BELOW Rate Plotted
25% ABOVE 75% BELOW
50% ABOVE 50% BELOW
75% ABOVE 25% BELOW
TOTAL ETO (Jan.'42-May'45)
ETO (Land Phase) (Jun.'44-May'45)
MTO
SWPA
POA
TOTAL (Four Theaters)
WOUNDED PER 1,000 MEN PER DAY

Fig. 19.

Table 16

AVERAGE CASUALTY EXPERIENCE OF U. S. FIELD ARMIES IN COMBAT, ADMISSIONS PER 1,000 MEN PER WEEK

Theater and Army	Disease	Nonbattle Injury	Wounded	Total
EUROPEAN				
First	10.3	3.4	12.0	25.8
Third	10.0	2.7	9.1	21.8
Seventh*	14.0	3.7	7.8	25.5
Ninth	7.5	2.1	4.2	13.8
MEDITERRANEAN				
Seventh (Sicily)	28.4	2.7†	16.3†	47.4
Fifth	16.7	2.7	5.5	24.9
PACIFIC				
Sixth (Leyte)	22.1	2.9	7.0	32.0
Sixth (Luzon)	26.3	2.4	7.2	35.9
Tenth	7.7	7.3	20.8	35.8

*Including period in Southern France when army was assigned to MTO.
†Estimated. Reported rate of 19.0 includes both WIA and nonbattle injury.

tern will suffice for purposes of prediction. For the Fifth and Sixth Armies, admissions for disease dominate the picture, whereas this is not true of the First and notably of the Tenth Army. The underlying distributions are so skewed that mean rates generally exceed the median rates by a wide margin, and accordingly Table 16 presents the mean rates for all the major U. S. field armies throughout their entire periods of combat in World War II.

For surgical planning at the theater level it is useful to have for reference distributions of theater rates actually experienced in World War II. These also were extremely variable, as may be seen from Figure 19. Shown there are distributions for the four major theaters, ETO, MTO, SWPA, and POA, for the entire period of the war, the total of all these, and a distribution for the land phase of combat in ETO, namely the 12 months from June 1944 through May 1945.

The Tactical Situation. No factor is more important as a determinant of casualty rates, and none less well documented statistically, than the tactical situation. Only two kinds of observations are readily available from the reports of World War II. The first gives the casualty experience of a unit in relation to its type of contact with the enemy and the character of the enemy opposition, and may be classified as patrolling, holding, attack, defense, and counterattack, perhaps with qualitative distinctions as to severity of opposition, and the like. The second type, here called tactical activity, consists of a compilation of unit-rates for periods when units were in certain well-defined tactical situations of a more general nature, e.g., overwater assault and establishment of a beachhead, attack on a fortified line, reduction of an isolated port or town, breakthrough following a period of containment by the enemy, defensive operation, and river-crossing.

In the 1943 annual report of the Fifth Army surgeon there is a unique table of weekly divisional casualty rates coded as to type of contact. Only 66 division-weeks are involved, so most of the groups are small, and in Table 17 below it has been necessary to regroup them in even more summary form. Plainly, this type of

Table 17

WOUNDED PER 1,000 PER WEEK, FIFTH ARMY DIVISIONS, BY TYPE OF CONTACT WITH ENEMY, 1943

Type of Contact	Number of Division-weeks	Wounded per 1,000 Men per Week	
		Rate	Percentage of Average Rate
1. Enemy counter-attack, or attack against heavy opposition	21	21.0	202
2. Advance against resistance, attack against light opposition, advance slowed by mines and demolition, patrolling with contact, and enemy artillery attack	23	10.2	98
3. Patrolling without contact, reserve	22	0.5	5
Total	66	10.4	100

classification can be very effective in analyzing or in forecasting casualty rates, for the extreme rates in Table 17 are in the ratio of 40 to 1.

The second type of tactical information which shows the influence of the tactical situation on WIA rates, and reveals the probable range within which WIA rates will fall, is the classification by tactical activity. In an effort to provide a rough scale of rates corresponding to types of tactical activity in World War II, operations reports and other sources were reviewed and the following classes established:

Beachhead operations. Characterized by overwater assault on enemy-held territory, and establishment of a forward position secure enough to repel enemy counterattack and to permit expansion.

Reduction of ports and towns. Encirclement, and sustained assault on enemy-held ports and towns, usually heavily fortified and defended, or both.

Assault on fortified lines. Assault on an entire enemy line, consisting of at least some heavily fortified, mutually supported points.

Offensive breakthrough operations. Full-scale offensive effort concentrated at one or more points in order to penetrate the enemy line, of whatever nature.

Defensive operations. In which the enemy counterattacks in sufficient force to throw American forces on the defensive, or the American forces are being contained in an essentially defensive position from repeated enemy attempts to counterattack.

River crossings. Major crossings against enemy opposition, with intent to establish a secure bridgehead permitting further expansion.

These six groupings are not altogether mutually exclusive, classification as one type or the other sometimes being a matter of emphasis. They are, however, reasonably easy to apply to World War II experience, and in the present compilation it has been possible to include 169,000 WIA, or about 28 percent of all the WIA sustained by ground troops in World War II, in these categories of tactical activity.

Table 18 presents a summary of the findings for combat divisions. Attached corps and army troops are excluded, so that in point of echelon the data pertain to the division. Each line per-

Table 18

WOUNDED IN ACTION BY TACTICAL ACTIVITY, U. S. ARMY AND MARINE CORPS DIVISIONS, WORLD WAR II

Tactical Activity	Number of Operations	Number of Divisions	Wounded	
			Number	Rate*
Beachhead Operations	8	24	26,570	11.04
Offensive Breakthrough Operations	3	16	7,420	7.14
Reduction of Ports and Towns	9	23	25,139	5.88
Assault on Fortified Lines	7	47	46,910	5.10
River Crossings	7	43	18,339	5.02
Defensive Enemy Counterattack	8	63	45,049	3.73
Total	42	216	169,427	5.19

*WIA per 1,000 men per day.

tains to a defined type of action, e.g., river crossing, and includes the number of operations falling into that type as well as its average WIA rate. The highest rate is 11.04 per 1,000 per day for beachhead operations. This is about seven times the average rate for a division in combat in World War II, and more than twice the average for practically all the other types of action shown in the table. Offensive breakthrough operations rank next to beachhead operations with an average rate of 7.14 WIA per 1,000 per day. Third is the rate of 5.88 for the reduction of ports and towns. The rates for assault on fortified lines and for river crossings are about the same, 5.10 and 5.02, more than three times the average figure for a World War II division in combat. Lowest of six rates is that of 3.73 for defensive operations, but this rate is more than twice the World War II average for a division in combat.

In some instances, e.g., beachhead operations, the type is so well defined that there is little question as to the identity of the individual operations to be included. In other instances, e.g., defensive operations, such is not the case and the result obtained will vary with the operations chosen to represent the class. Figure 20 has been prepared to give a graphic summary of the entire classification and to exhibit the relative variation *within* each type of

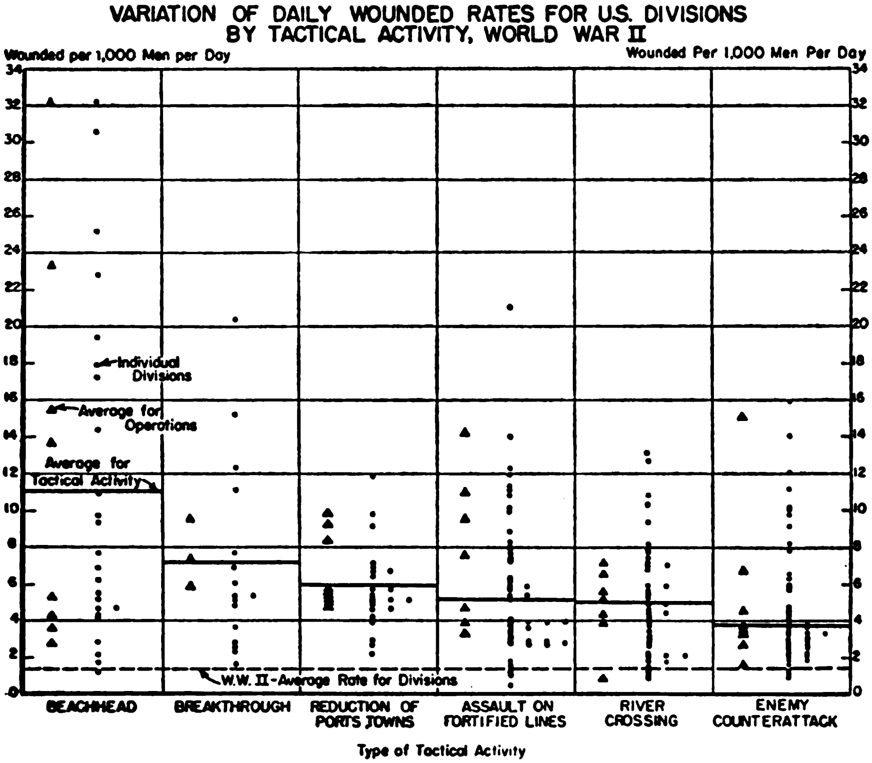


Fig. 20.

operation. The horizontal lines give the average rates for each type of tactical activity. Within each type are two sets of individual points. The triangles to the left give the average rates for each operation of the particular type. The dots to the right give the rates for the individual division-periods comprised by all the operations of the particular type. It must be borne in mind that even the average rates, for operations and for types, are divisional rates.

CHAPTER III

DEATH FROM WOUNDING

THE proportion of deaths among *all men hit* is fundamental knowledge for a variety of surgical problems, although perhaps greatest interest attaches to the proportion of the *wounded* (excluding those designated as killed) who die of their wounds. The accompanying table gives the summary facts as published by The Adjutant General.[1]

For ground troops about 23 men died among an average 100 hit, and for certain factors, e.g., military occupational specialty and echelon, there is apparently little variation in the ratio of deaths to all men hit. The only appreciable difference among the arms and services occurs between air and ground personnel. For example, expressed as a percentage of all who were hit the number who died is 69 percent for Air Corps officers and 26 percent for Infantry officers, whereas the parallel percentages for enlisted men are 62 and 23. These figures also illustrate the characteristic, if small, difference between enlisted men and officers of the same arm. Some variations are also noted among the different campaigns, partly, at least, because of differences in the reporting of the wounded and the missing but perhaps also because of tactical differences. The unequivocally important factors in the fatality of hits are the weapons used, the regions of the body which are struck, the delay between wounding and surgery, and the quality of the professional care available. The first three factors are discussed below; the fourth lies outside the scope of this volume.

In view of the speed with which the mortally wounded die, the way in which the distinction is made between the killed and the wounded will largely determine the proportion judged to have died of wounds. This is one reason why it is difficult to compare the fatality percentages of different wars or of armies not under the same administrative control. The two major sources of an overall estimate of the proportion of wounded who died are the TAG

[1] *Battle Casualties of the Army*, CFM-10, 1 July 1946.

Table 19

KILLED AND WOUNDED IN WORLD WAR II
7 DECEMBER 1941-31 DECEMBER 1945

Type of Casualty	All Arms and Services		Infantry	
	Number	Percent	Number	Percent
Killed	175,407	22.7	115,246	19.5
Wounded				
Died of wounds	26,706	3.4	19,919	3.4
Survived wounding	571,822	73.9	455,546	77.1
Total	773,935	100.0	590,711	100.0

series and the Statistical Health Report, exhibited below in Table 20. Neither source is as reliable as a third, which will become available when final tabulations have been made on the Individual Medical Records processed statistically by the Surgeon General. Differences in the reporting practices underlying these sources are discussed in Chapter I. Fortunately, there are available provisional tabulations of Individual Medical Records from three theaters during the first half of 1944, and these are utilized in subsequent sections.

Coding practice in the Office of the Surgeon General conforms to AR 40-1025, which specifies that deaths will be called DOW rather than KIA only if the man was admitted to a medical

Table 20

WOUNDED AND PERCENTAGE DYING OF WOUNDS, BY THEATER, WORLD WAR II

Theater or Area	TAG Counts		Statistical Health Report	
	Number Wounded	Percent Dying	Number Wounded	Percent Dying
European	386,000	4.2	396,000	2.9
Mediterranean	112,000	3.9	131,000	3.1
Southwest Pacific	60,000	6.3	66,000	5.5
Pacific Ocean	36,000	5.7	42,000	3.3
Asiatic	3,000	6.2	4,000	4.0
Other	2,000	4.1	2,000	2.1
Total	599,000	4.5	641,000	3.2

installation before he died. Training doctrine[2] specified that the Emergency Medical Tag, the first medical record form, be initiated at the aid station, and although some variation characterized field practice, it seems most probable that a count of the number who were ever seen alive after having been hit, but who later died, must exceed by some unknown margin the number recorded as dying of wounds. Plainly, the dividing line between the KIA and the DOW is an arbitrary one, dependent upon reporting practice with respect to men dying before admission to an aid station, but after receiving aid on the battlefield, and upon the speed with which the mortally wounded can be admitted to aid stations. If the terrain, the tactical situation, or shortages of personnel conspire to keep aid men from bringing in the wounded very promptly, correspondingly more will inevitably be classified as KIA.

It would be desirable to know what proportion of the men hit are instantly killed and what proportion of the rest could be saved by instantaneous medical attention, however unrealistic that may seem, in order to have a basis for determining the actual and potential contribution of forward surgery in saving life. Specifically, a complete accounting of deaths would require information on:

1. Proportion instantly killed and proportion surviving stated lengths of time without medical aid.
2. Proportion seen alive by medical personnel.
3. Proportion reaching aid stations alive.
4. Proportion surviving to reach installations equipped for major surgery.
5. Proportion given initial surgery.
6. Proportion surviving initial surgery.

With accurate quantitative information on these six points coupled with additional details regarding space and time, one could demonstrate satisfactorily the full achievement of modern forward surgery and indicate the direction which further improvements might take. The data presently available for such an analysis fall far short of this degree of completeness but are used in the following discussion for what they are worth. Coding practices for the years 1944 and 1945 were such that The Surgeon General will be able to publish systematic data on all these points except the first.

[2]*Instructor's Guide for Medical Department Training Program* 8-101, Medical Field Service School, Carlisle Barracks, Pa., Jan. 1944.

HISTORICAL TREND

Although the various wars cannot be studied with confidence in the close comparability of the various estimates of the proportion dying of wounds, it may be accepted that the margin in favor of World War II is real. Its precise size cannot be established, however, for the reasons already stated. For example, in moving surgical facilities farther forward a greater number of hopelessly wounded may have been admitted than would have received care under the conditions which prevailed in World War I. Accordingly, one would expect higher fatality rates for wounded in World War II were it not for major advances in surgical practice. Table 21 lists values for some of the more important wars

Table 21

PERCENTAGE OF WOUNDED DYING OF WOUNDS, VARIOUS WARS*

War	Nationals	Years	Number Wounded	Percentage of Wounded Dying of Wounds
Peninsular	British	1808-1811	19,300	14.
Mexican War	U. S.	1846-1848	3,400	14.9
Italian Campaign	French	1859	19,700	15.1
Crimean War	British	1854-1856	12,100	16.7
Do.	French	–do–	39,900	22.1
Do.	Russian	–do–	81,300	19.5
American Civil War	U.S., North	1861-1865	318,200	14.1
Russo-Turkish War	Russian	1877-1878	56,900	12.
Franco-Prussian War	German	1870-1871	96,200	11.5
Do.	French	–do–	140,000	15.
Spanish-American War	U.S.	1898	1,600	6.7
Boer War	British	1899-1901	23,000	8.8
Russo-Japanese War	Russian	1904-1905	146,000	4.2
Do.	Japanese	–do–	173,000	6.6
World War I (Excludes Gas)	U.S.	1917-1918	153,000	8.1
World War I (Includes Gas)	–do–	–do–	224,000	6.1
Do.	British	1914-1918	2,172,000	7.7
Do.	French	–do–	3,000,000	8.3
Do.	German	–do–	4,800,000	6.0
World War II	U.S.	1941-1945	598,500	4.5

*DUNCAN, L. C.: *The Medical Department of the United States Army in the Civil War, Washington,* 1911; LONGMORE, T.: *Gunshot Injuries,* London, Longmans Green, 1877, pp. 588-590; *SGO Weekly Health Report,* Vol. 5, No. 48, 30 November 1945; *The Medical Department of the U. S. Army in the World War,* Vol. XV, Statistics, Part 2, pp. 1023-1028, Washington, 1925; MITCHELL, T. J.: *History of the Great War, Medical Services, Casualties and Medical Statistics of the Great War,* London, 1931; FRANZ, CARL: *Lehrbuch der Kriegschirurgie,* Springer-Verlag, Berlin, 1942; and *Battle Casualties of the Army,* 1 July 1946, published by The Adjutant General, War Department. Numbers of wounded are largely from Longmore, percentages dying of wounds from Duncan, for the period 1808-1871. Several of the counts of wounded are approximate only.

during the last 150 years. If these are plotted against time a distinctly downward progression is noted. If one were to forecast the World War II value from the other percentages in the table on the simplest assumption of a straight-line trend, one would estimate 3.1 percent for 1944. There has been fairly steady improvement in the proportion of men saved from dying after wounding, coupled, perhaps, with progressive changes in reporting. The latter need not, however, have operated to depress artificially the proportion dying, for the changes have been in the direction of including more of the wounded, and particularly the more seriously wounded, so that on a truly comparable basis the score is probably even better than it appears.

VARIATION AMONG THEATERS

During World War II large differences were observed among theaters with respect to the proportion of wounded who died of their wounds, as Table 20 reveals. Without resolution of the many reporting problems no definitive explanation can be offered, but the Southwest Pacific Area, for which the percentage who died is highest, faced much greater difficulties in providing adequate surgical care than did the European theaters, which had fewer logistic difficulties and which benefited from higher War Department priorities on specialized medical personnel. Of particular value in any examination of theater differentials in mortality are the first substantial tabulations of Individual Medical Records, namely those covering admissions for the first half of 1944 in the three theaters active at that time. Table 22 compares the results of these tabulations with the other two series previously mentioned. The second column pertains to all the wounded for whom records were kept, including many with minor wounds who lost no time. The third column is limited to the men who lost time from duty, and the fourth to men who were admitted to hospital. Parenthetically, it should be noted that for this period, neither the Statistical Health Report nor the TAG series conforms closely with any one of the series derived from the Individual Medical Records. In the Pacific the TAG and Statistical Health Report figures are closest to the data of column (2), which include the wounded losing no time, whereas in the Mediterranean they are closest to the data of column (3), restricted to the wounded who lost time. In other words, if the series from the Individual Medical Records, which is probably the most accurate, be taken as a standard, neither of the other two series has a single clear-cut meaning in all three theaters for this period. A second incidental but important feature of the table is its confirmation that TAG counts of DOW extend to all deaths among the wounded, whether hospitalized or not.

Table 22

COMPARISON OF COUNTS OF WOUNDED AND DIED OF WOUNDS FROM VARIOUS SOURCES, JANUARY-JUNE 1944

Theater	Individual Medical Records			Statistical Health Report	Adjutant General
	Total	Lost Time	Hospitalized*		
(1)	(2)	(3)	(4)	(5)	(6)
	Total Wounded				
POA	4,672	4,025	2,980	5,433	5,122
SWPA	4,948	4,256	3,655	4,959	4,954
MTO	45,852	36,042	34,731	40,201	36,686
	Number Who Died of Wounds				
POA	223	223	118	181	276
SWPA	288	288	199	317	303
MTO	1,577	1,577	1,160	1,410	1,586
	Percentage Who Died of Wounds				
POA	4.8	5.5	4.0	3.3	5.4
SWPA	5.8	6.8	5.4	6.4	6.1
MTO	3.4	4.4	3.3	3.5	4.3

*Excludes cases returned to duty from aid stations, clearing stations, and dispensaries.

Thus it is plain that, whatever its deficiencies, all available information supports the conclusion that the fatality rate was much higher in the Southwest Pacific than in Europe. Even as late as Luzon the combat zone in the SWPA was less structured, transportation networks were poorer, and medical echelons were less closely integrated. In consequence, long litter-hauls were more frequent, and the small portable surgical hospitals doing the bulk of the forward surgery were at times cut off and unable to evacuate their transportables who were seriously wounded. Units of this type were too small for adequate postoperative care, their four doctors and 33 enlisted men comprising little more than a surgical team without its special advantages. Whether operating alone or attached to a clearing station, the portable surgical hospital was generally much weaker in terms of surgical competence, surgical specialization, and facilities for postoperative care than comparable forward units in the Mediterranean and European Theaters. Other specific differences affecting the fatality percentages include the more advanced development, in Europe, of methods for handling shock, exemplified in the more extensive use of whole blood, and in the earlier development there of an adequate system of professional supervision through the medium of highly qualified surgical consultants at the proper echelons.

MULTIPLE AND SINGLE WOUNDS

Multiple wounds undoubtedly carry a higher fatality rate than single wounds, but the differential cannot be accurately estimated from field reports presently available because of variable practice in classification. That it may be large, however, is suggested by the report of the Second Auxiliary Surgical Group[3] on abdominal wounds. In this material mortality increased about 15 percent with each additional injured viscus.

BODY REGION

Perhaps the chief determinant of the chance of death is the body region struck, and more particularly the tissues involved. The regions of the body of course differ greatly in their relative importance for survival of the organism. No matter what the source of the data, this fact is evident in each sample studied during the war, as indeed in all previous wars for which satisfactory information has been made available. For example, Longmore, who analyzed European campaigns during the period 1850-1870, obtained fatality percentages of 44 for men wounded in the abdomen, 32 for the chest, 30 for the back and spine, 24 for the head, 22 for the lower extremities, 14 for the neck, 13 for the upper extremities, and 11 for the face, the overall average being 23 percent, somewhat higher than the figures given by Duncan for this period. Table 23 compares regional fatality percentages in the U. S. Army during the Civil War and World War I.

Several different case-fatality rates are reported for the wounded in the official histories of World War I, but the average of 8.1

[3]*Forward Surgery of the Severely Wounded*, Second Auxiliary Surgical Group, 1942-1945, unpublished report on file in SGO, Historical Division.

Table 23

PERCENTAGE OF WOUNDED DYING OF WOUNDS, BY REGION OF MAJOR WOUND, U. S. ARMY

Region	Civil War*	World War I	
		Reported	Adjusted†
Head, Face, Neck	17.7	9.3	9.8
Chest	22.3	22.9	24.1
Abdomen	32.9	32.3	33.9
Upper Extremities	6.5	3.9	4.1
Lower Extremities	13.8	7.3	7.7
Total	13.6*	7.7	8.1

*Based on a sample of 233,884 wounded men. The average fatality rate differs slightly from that of 14.1 given in Table 21 for all 318,000 wounded.

†The reported regional percentages were increased in proportion to the totals.

has been generally accepted as the correct average for wounds of all locations when gas casualties are omitted. However, mortality by region was analyzed in World War I on the basis of *wounds* rather than of *men wounded* and must be adjusted to accord with the 8.1* average. Any adjustment which is feasible at this date is necessarily arbitrary.

At this writing definitive World War II regional data are not yet available. The best figures are for the first half of 1944 and are from the Individual Medical Records. They appear in Table 24. Final figures for the war period probably will not differ much from these, for Table 22 shows how close is the agreement between

*In the table covering regional data on page 1024 of volume XV, part 2, of the World War I history,[4] admissions are given as 174,296, and deaths as 13,469, for all battle injuries except gas casualties. From data on pages 1023 and 1028 it is plain that battle injuries excluding gassed totaled 153,537 wounded and 12,470 deaths. Hence the regional data almost certainly involved some men more than once, and since the deaths are inflated far less than the total wounded the average drops from 8.1 to 7.7 percent. The following table gives the details:

COMPARATIVE FIGURES ON WOUNDED, GASSED, AND DIED OF WOUNDS
WORLD WAR I MEDICAL HISTORY

Type of Case	Number of Injured	Deaths	
		Number	Percent
Gassed Only	70,552	1,221	1.7
Wounded Only	153,537	12,470	8.1
Total	224,089	13,691	6.1
Number of Wounds Given in Regional Table	174,296	13,469	7.7

[4]*The Medical Department of the U. S. Army in the World War*, Vol. XV, Statistics, Part 2, Washington, Govt. Printing Office, 1925.

Table 24

PERCENTAGE OF WOUNDED* DYING OF WOUNDS, BY REGION OF MAJOR WOUND, WORLD WARS I AND II

Region	World War II January-June 1944			World War I	
	Mediterranean Theater	Southwest Pacific Area	Pacific Ocean Areas	Reported	Adjusted
Head, Face Neck	5.7	10.1	7.0	9.3	9.8
Chest	8.1	15.0	9.3	22.9	24.1
Abdomen	17.1	19.9	21.1	32.3	33.9
Upper Extremities	1.1	1.6	0.5	3.9	4.1
Lower Extremities	2.1	3.1	3.9	7.3	7.7
Total	4.4	6.8	5.5	7.7	8.1
Number of Men	36,000	4,000	4,000	†	154,000

*Wounded or injured in action who lost time.
†Based on 174,296 wounds, not men wounded.

fatality percentages based on the Individual Medical Records and the AG records. The final AG average for the war is 4.5 percent as against 4.4 for the Mediterranean Theater for the first six months of 1944. If one takes the Mediterranean schedule as the presumptive World War II schedule, it may be said that men wounded in the head, face, and neck had a mortality risk about 30 percent above average, that men wounded in the chest had a mortality risk about 85 percent above average, and that men wounded in the abdominal region had a mortality risk about 290 percent above average. These excesses are counterbalanced by deficits of about 75 percent for upper extremities and about 50 percent for lower extremities.

The greatest relative improvement in case-fatality was evidently made in wounds of the extremities, the World War II fatality rates being but 27 percent of the adjusted World War I percentages. It would be desirable to have an accurate count of the numbers of deaths saved in World War II according to region of the body, but the differences in regional distributions of wounded for the two wars imply that the fatality ratios are not based on anatomically comparable regions. For example, if one applies the

Table 25

APPROXIMATE SAVING OF LIVES IN WORLD WAR II CREDITED TO SURGICAL ADVANCES SINCE WORLD WAR I

Region	World War I Fatality Percentages		World War II Fatality Percentages		Percentage of Expected Deaths* which were Avoided	
	As Reported	Corrected for Body Distribution	MTO Jan.-Jun. 1944	Average for the War (Infantry)	MTO Taken as Standard	War Average as Standard
Head, Face, Neck	9.3	9.8	5.7	6.4	42	35
Thoracic	22.9	14.7	8.1	9.1	45	38
Abdominal	32.3	30.0	17.1	18.0	43	40
Upper Extremities	3.9	2.7	1.1	1.1	58	58
Lower Extermities	7.3	6.8	2.1	2.4	69	65
Total	7.7	8.1	4.4	4.2	46	49

*Where World War I series, corrected for body distribution, provides basis for expected number of deaths.

World War I fatality percentages to the regional distribution of wounded for the Mediterranean Theater during the first half of 1944, the calculated numbers of deaths amount not to 8.1 percent but to 10 percent or more of the wounded. This is because the figure of 8.1 represents a set of men of whom 82 percent had wounds of the extremities, whereas the figure of 10 applies to a distribution in which wounds of the extremities number only 64 percent of the total. As will be shown in Chapter V, there is every reason to believe that the regional distribution of wounds is relatively constant. The distributions for the living wounded and all the wounded differ little in World War II, and it is believed that the differences noted with respect to World War I indicate that the body regions were conceived differently. Support for this view comes also from a study of chest wounds by Carter and De Bakey[5] who pointed out that conflicting figures were published on the relative incidence of chest wounds in World War I, and cited the opinion of Love that wounds near the shoulder girdle may have been assigned erroneously to the upper extremities. The effect of such errors would be to increase the fatality percentages for *both* regions, so that the figures of 24.1 for the thoracic region and 4.1 for the upper extremities may be regarded as too high. The adjustments necessary to bring the World War I distribution in line with the World War II standard* are rather considerable, and allocation of the deaths† an arbitrary procedure. For purposes of effecting an approximate comparison an adjustment has been made, however, and appears in Table 25 together with estimates of the deaths which were prevented by better surgical management and better surgical facilities in World War II.

The standard employed for World War II, as described on page 186, applies to Infantry troops. For all arms and services the average fatality rate, shown in Table 20, was 4.5 percent. It is estimated that, under World War I conditions, 48,600 deaths would have occurred after wounding in World War II in contrast to the 26,700 observed. The difference of 21,900 represents 45

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[5]Carter, B. N. and De Bakey, M. E.: Current Observations on War Wounds of the Chest. *Journal Thoracic Surgery,* 13:271-293, August 1944.

*Developed on pages 176 to 188 of Chapter V.

†It was assumed, for example, that shoulder girdle cases erroneously classified as upper extremity cases had a mortality rate of 10 percent, and abdominal cases erroneously classified as lower extremity cases a rate of 25 percent.

percent of the expected number of deaths for all arms and services. For Infantry alone the expected number of deaths is 38,900 and the saving just 19,000 or 49 percent. On a relative basis the savings equal or exceed 35 percent for every region of the body. Correction of the World War I regional distribution, and hence of the fatality rates, accords less weight to reduction in deaths among men who had thoracic wounds. On this basis the greatest saving, in both relative and absolute terms, occurred among men wounded in the lower extremities; about 45 percent of the saving of 21,900 lives applies to men wounded in the lower extremities. The contributions of the other regions to the total saving are: abdominal 17, thoracic 14, head, face, and neck 13, and upper extremities 11 percent.

Since each war presents a unique set of circumstances, and the determinants of case-fatality rates among the wounded are so complex, differentials between wars are not easily and directly attributed to this or that factor. World War II was a long war by World War I standards; medical units were better organized and trained, and certain theaters were able to meet and solve problems of organization before the great bulk of the casualties occurred in 1944-1945. In World War I the great concentration of casualties occurred in the period June-November, 1918, when the admission rates of the AEF were considerably higher than those of the European Theater 26 years later. How much of the 8.1 percent depends upon the particular difficulties of evacuation and surgical organization cannot be known. Similarly, the improvement in World War II must be attributed not only to plasma, whole blood, penicillin, sulfonamides, and the techniques of the operating-room, but also to better organization of surgical care, better training of personnel, and any favorable tactical or other environmental circumstances which may have characterized the handling of wounded in World War II. It is only in this broad sense that one may speak of the effect of surgical advances between the two wars.

Whereas by far the greatest number of deaths after wounding in World War I occurred in men with wounds of the lower extremities (perhaps 35 to 40 percent of all such deaths), the indications are that in World War II abdominal injuries occupied first place. Table 26 compares the proportions of deaths by region of major wound for the three active theaters in early 1944 (based on tabulations of the Individual Medical Records) and for the entire First Army hospital experience in ETO. About a third of the deaths in these series occurred among men whose major wounds were abdominal in regional location.

Table 26

PERCENTAGE DISTRIBUTION OF DEATHS AFTER WOUNDING, BY REGION OF BODY

Region	Three Active Theaters January-June 1944	First Army, ETO 1944-1945
Head, Face, Neck	26	24
Thoracic	16	26
Abdominal	33	33
Upper Extremity	6	3
Lower Extremity	19	14
Total	100	100
Number of Deaths	2,088	4,357

It is unfortunate that comparative data on the gross regions of the body are not more reliable, for they should provide the best single measure of surgical progress made from one war to the next. Evidently steps need to be taken to standardize observations as to body region in order to insure at least gross comparability. In view of the importance of regional data for surgical planning, it would appear desirable to promulgate a standard regional classification to govern medical reporting. Implemented with simple outline charts, such standardization would go far to make more valid comparisons of regional data. One such formulation has recently been proposed by Dr. Edward D. Churchill, who has kindly permitted its use here. Such a classification, it must be stressed, is to be distinguished from the procedures governing the reporting of individual wounds. The latter must be specified in detail in accordance with existing directives and supplementary material. The location of the wound must be specified as to individual structures, not merely as to surface region. Provided that individual wounds are adequately described in such detail, a standardized topographical classification, such as that proposed by Dr. Churchill, would insure much greater comparability among data from different times and places.

Dr. Churchill's surface regions are demarcated as follows:

I. Scalp. Includes the area commonly known as the *forehead,* rather than considering this part of III-Face. Because both the scalp, in common usage demarcated by the hairline, and the forehead overlie the bony *cranium,* and because the clinical significance of hits in this surface region is greatly enhanced by cranial or cerebral injury, this region may be designated as Scalp only when the wound is superficial, i.e., not involving bone or brain. Avulsion of the scalp, producing a notable problem of wound healing and disability, can be designated *Scalp* (complex).

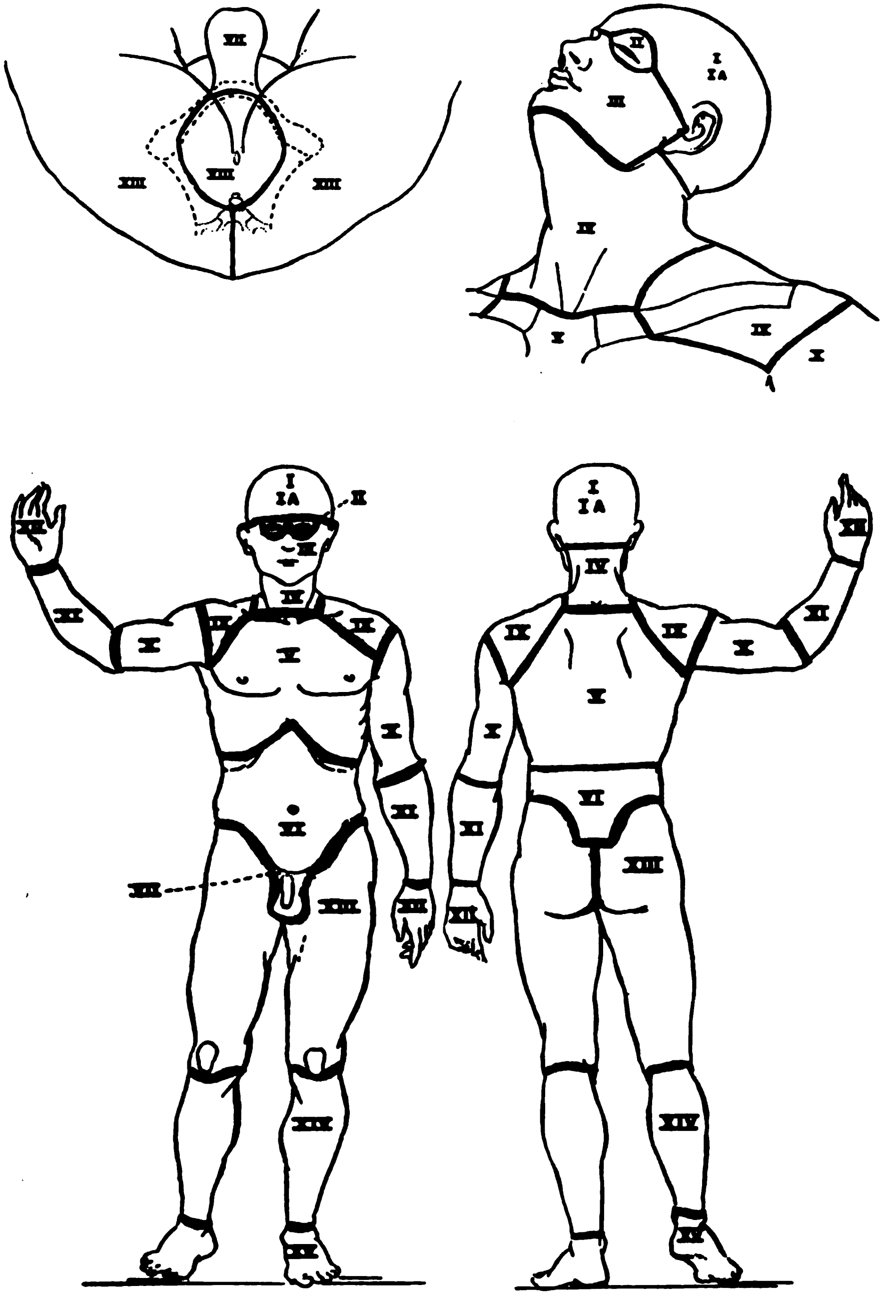
I-A. Craniocerebral. Either I-*Scalp* or I-A-*Craniocerebral* designates the *region* demarcated in front from the face by the eyebrows and supra-orbital ridges. In side view, the region lies above a line from the external canthus through the external auditory meatus. Posteriorly, demarcated from the neck by a line immediately below the lobes of the ears.

II. Eye. The globe and adjacent structures within the bony orbit, including the eyelids.

III. Face. In front, extending from the point of the chin to the eyebrows and supra-orbital ridges. In side view, demarcated from the neck by a line from the external auditory meatus to the angle of the mandible and thence along the lower border of the mandible to the chin. The area commonly known as the forehead, i.e., from the eyebrows to the hairline, is included in the region I-*Scalp* or I-A-*Craniocerebral.*

IV. Neck. The upper limits that demarcate the neck from the face and the cranium have been indicated. Laterally, the neck is demarcated from the shoulder by a line joining the juncture of the inner and middle thirds of the clavicle with the superior angle of the scapula.

Demarcation of the neck from the chest is more difficult if consideration is given underlying structures commonly identified as either cervical or thoracic. As a *surface region,* however, the neck is demarcated from the chest anteriorly by a line that follows the upper border of the inner third of the clavicle and crosses the mid-



Topographic delineation of body region.

line at the upper limit of the manubrium sterni. Posteriorly, the line separating the neck and chest passes horizontally through a point just below the prominence of the spinous process of the 7th cervical vertebra between the superior angles of the scapulae.

V. **Chest.** Demarcation of the surface region of the thorax from that of the abdomen presents difficulties, particularly if inferences are drawn concerning the course that may be taken by the missile with reference to one or both of the major body cavities. On the surface, however, the simplest line is one that approximately follows the lower limits of the pleural cavities. In front, this line passes from the lower end of the sternum obliquely downwards along the costal margin to the 8th intercostal space. A horizontal line carried around the body to meet the corresponding point on the other side will pass approximately over the midpoint of the 11th rib and the spine of the first lumbar vertebra. The chest region as described includes the entire circumference of the trunk and is not interrupted posteriorly by a "back" or "spine."

VI. **Abdomen.** Demarcation of the abdomen from the regions that lie below must be arbitrary. It is extremely important, however, to eliminate the terminology employed to designate many ill-defined areas such as "hip," "buttock," "groin," etc. It is proposed for purposes of simplification that the lower boundary of the abdomen be defined as the brim of the pelvis and the upper border of the sacrum. This establishes a *posterior surface region for the abdomen* in what is conveniently called the "back," that includes ill-defined areas such as "side," "flank," or "loin." In ordinary usage the "back" extends upward to include the posterior aspect of the chest, and its boundaries are poorly defined by anatomical landmarks. By considering that both the chest and the abdomen *extend circumferentially around the trunk,* a number of loosely defined terms can be abolished. The spine is a deep structure, ill suited to define a surface region, and is injured as frequently by obliquely directed missiles as by direct hits from behind that enter the area of its surface projection.

VII. **External Genitalia.** Vertical lines dropped from the spines of the pubis and passing outward along the inferior rami demarcate the lateral borders of the external genitalia. Above, this region is demarcated from the abdomen by the crest of the pubis, and posteriorly, from the perineum by a line marking the base of the scrotal bag.

VIII. Perineum. Demarcation of the abdomen and thigh as indicated above makes it desirable to define the *outlet* of the pelvis formed by the ischia on the sides and the great sacrosciatic ligaments and sacrum posteriorly as the perineum. The anterior boundary is the base of the scrotum. The coccyx in its entirety thus becomes a bone underlying the perineum.

IX. Shoulder. A line passing from the upper limit of the anterior axillary fold to the juncture of the inner and middle thirds of the clavicle and passing upward over the shoulder to the superior angle of the scapula and thence to the upper limit of the posterior axillary fold, demarcates the shoulder from the neck and chest. A line joining the upper limits of the axillary fold and passing over the point of the shoulder demarcates the shoulder from the arm. Such a demarcation places the anterior projection of the brachial plexus within the shoulder and neck regions.

X. Arm. A circular line from the antecubital fossa crossing just below the condyles of the humerus and above the tip of the olecranon demarcates the forearm.

XI. Forearm. The lower limits of the radius and ulna define a circular line at which the forearm terminates in the hand. The wrist is not recognized as a surface region.

XII. Hand. As defined in XI.

XIII. Thigh. The proximal portion of the lower extremity, the thigh, extends from the brim of the pelvis to the knee. A vertical line dropped from the center of the lumbosacral joint, dividing the sacrum in two parts, separates the two thighs in the midline posteriorly. The lower extremity as a whole thus becomes essentially a "hind quarter" with the exception of the symphysis pubis, that is included with the external genitalia. Below, the thigh as a surface region includes the projection of the patella and the entire femur. The surface line that divides the thigh from the leg is placed below these structures and encircles the extremity over the knee.

XIV. Leg. The tibia and fibula are bones of the leg, whereas the tarsal bones are structures identified with the foot. Over the irregularly formed mortise joint it is difficult to recognize a circular surface line that has significance in relation to underlying structures. In general, it should follow the lower limits of the malleoli.

XV. Foot. Distal to leg as defined above.

Dr. Churchill has also proposed the following grouping of his surface regions:

Head: Scalp, Craniocerebral, Eye, and Face.
Neck.
Chest.
Abdomen.
Upper Extremity: Shoulder, Arm, Forearm, and Hand.
Lower Extremity: Thigh, Leg, and Foot.
Perineum and Genitals.

ECHELON OF TREATMENT

Mortality among the wounded also varies by echelon, primarily because of the speed with which the seriously wounded die. At this writing the best available material for this purpose pertains to the experience of the Mediterranean Theater, the Southwest Pacific Area, and the Pacific Ocean Areas during the first six months of 1944 and comprises a total of 2,088 deaths after wounding. In order to complete the picture of fatality by echelon an estimate has been made of the number of KIA which parallels the DOW count, use being made of the proportions of KIA and DOW reported by The Adjutant General for ground troops over the total war period. Addition of the KIA increases the deaths from 2,088 to 13,678. Some small portion of the killed, of course, might better be classified as died of wounds, but at present there exists no basis for determining what fraction of the killed may have survived an undetermined length of time without receiving medical attention. Table 27 and Figure 21 give the experience of the Mediterranean Theater, the Pacific Ocean Areas, and the Southwest Pacific Area with respect to installation at time of death during the first half of 1944. The percentages there are not case-fatality rates but show the proportion of deaths which occurred in each type of medical installation. Admittedly, the T/O designation of medical units is not an altogether reliable guide to the characteristics of the wounded treated there, but in the MTO, at least, the major type units were employed in a fairly standard pattern. Although

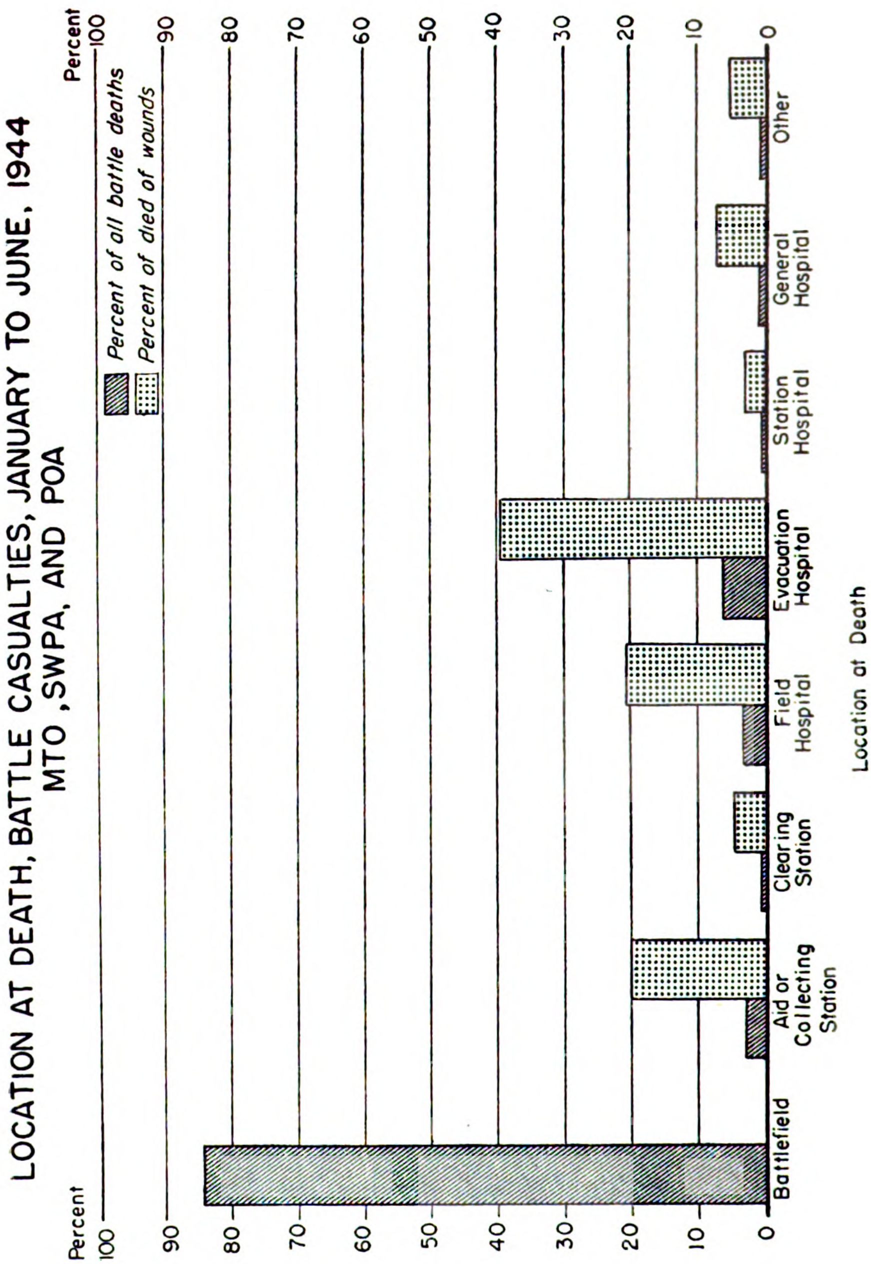

LOCATION AT DEATH, BATTLE CASUALTIES, JANUARY TO JUNE, 1944
MTO ,SWPA, AND POA
Percent of all battle deaths
Percent of died of wounds
Percent
100
90
80
70
60
50
40
30
20
10
0
Battlefield
Aid or Collecting Station
Clearing Station
Field Hospital
Evacuation Hospital
Station Hospital
General Hospital
Other
Location at Death

Fig. 21.

in the Pacific field and evacuation hospitals were not employed in the same fashion, the distribution of DOW by installation for all three theaters differs little from that based on MTO alone.

If one disregards the fact that some of the KIA were seen alive after having been hit but before they expired, and the possibility that this number may be large in relation to the number classified

Table 27

LOCATION AT DEATH, BATTLE CASUALTIES AMONG GROUND TROOPS IN ITALY, NEW GUINEA, AND THE PACIFIC, JANUARY-JUNE 1944

Location at Death	Number of Deaths	Percentage	
		Of all Deaths	Of Wounded Only
Battlefield (KIA)	11,590	84.7	
Aid or Collecting Station	418	3.1	20.0
Clearing Station	97	0.7	4.6
Field Hospital	428	3.1	20.5
Evacuation Hospital	828	6.1	39.7
Station Hospital	62	0.5	3.0
General Hospital	146	1.1	7.0
Other			
Non-Army Installation	43	0.3	2.1
Dispensary	34	0.2	1.6
Convalescent Hospital (ZI)	1	0.0	0.0
Hospital Ship or at Sea	12	0.1	0.6
Non-Medical Installation	19	0.1	0.9
Total	13,678	100.0	100.0

as DOW, one may estimate that 3.8 percent of all battle casualty deaths, and 24.6 percent of the deaths among the wounded, occurred before admission to hospital. Deaths in evacuation hospitals account for 6.1 percent of all deaths and 39.7 percent of the DOW. Before men reached evacuation hospitals 91.6 percent of all deaths, and 45.1 percent of the deaths among the wounded, had already taken place. The other installations where considerable numbers of deaths occurred are the field hospitals and the aid or collecting stations, each having about 20 percent of the deaths from wounding. Notably infrequent are deaths in division clearing stations. Perhaps most significant of all is the fact that 25 percent of the deaths from wounding had occurred before men reached installations equipped for major surgery. Obviously this group represents men with the most serious types of wounds, but the mere fact that they survived long enough to be admitted to a medical installation reflects some potentiality for survival. It may well be impractical to consider moving major surgery farther forward, but it might be possible to devise more adequate resuscitative methods which would permit patients of this type to survive long enough to make major surgery available to them without moving it farther forward.

The question of mortality in relation to echelon may also be analyzed in terms of case-fatality rates. The great differences in the case-fatality rates among the various echelons may be explained by the characteristics of the patients treated at each echelon and by its place in the chain of evacuation. In 1877, Longmore made the following relevant comment on this problem:

> "Ratios of mortality according to the situation of hospitals. It has often been noticed that the wounds of those who are treated in the villages and towns nearest to battle-fields, are followed by a larger ratio of mortality than those of the wounded treated in distant hospitals. There are several reasons why these different results may be expected to occur. In the first place, the most gravely wounded, those who are the most unfit to be removed to distant hospitals, in many instances soldiers whose wounds are inevitably mortal—are retained in the nearest field hospitals; in the second place, the hospital arrangements in these situations are usually the most makeshift in character, the surgical appliances the most defective, and the hygienic conditions, within the hospitals and around them, not unfrequently very inferior. Those of the wounded, therefore, the issue of whose wounds may be regarded as the most doubtful, are placed in circumstances nearly all of which are unfavourable to their recovery. Opposite conditions usually exist in the hospitals placed at a distance from the scene of action. To these the slightly wounded are usually sent, and those who have partly recovered from their injuries, or from the surgical operations consequent on them, in short, all those who are more likely to undergo the fatigues and exposure of the transport with impunity; while the hospitals in such situations, being for the most part fixed establishments, are generally provided with all the necessary material means for the best treatment of their inmates, and, at the same time, have a more complete professional and nursing staff. The statistics of wounds, and of the results of their treatment, in different places, will often be calculated to deceive, unless these facts are borne in mind."

In World War II the practice of supporting clearing stations with platoons of field hospitals, the latter being strengthened by surgical teams, provided life-saving surgery at a point closer to the front line than in World War I. In taking the most seriously wounded, however, particularly those who are nontransportable, the field hospitals naturally experienced high case-fatality rates. For example, in the Seventh Army the fatality rates were as follows:

Table 28

PERCENTAGE OF HOSPITAL ADMISSIONS DYING OF WOUNDS, SEVENTH ARMY HOSPITALS, AUGUST 1944-APRIL 1945

Region	Field Hospitals	Evacuation Hospitals	All Hospitals
Head, Face, Neck	12.1	4.4	4.8
Chest	9.1	3.6	5.6
Abdomen	25.6	12.3	19.8
Extremities	4.9	0.3	0.5
Total	13.2	1.4	2.5

For mortality at the level of the field hospital it is possible to make an interesting comparison with World War I data which illustrates the great advance made in handling shock in World War II. Field Hospital No. 127, serving the 32nd Division in World War I, was used in an essentially modern manner to care for the nontransportable wounded, after triage at a point close by. The cases are described as "abdomens, sucking chests, serious heads, cases in shock or apparently standing transportation poorly, and those showing evidence of hemorrhage . . ."[6]. Table 29 compares the experience of Field Hospital No. 127 during a seven-day battle, as reported one day later, with that of a field hospital in Italy[7]. The World War I report states that "of these 256 (admissions), 41 were so seriously wounded that they died within a few hours after admittance. Blood transfusions, intravenous injections of gum, and other methods used to combat shock failed to be of benefit in these cases." It is striking, first, that the handling of

[6]*The Medical Department of the U. S. Army in the World War*, Vol. XI, Surgery, Part I, Washington, Govt. Printing Office, 1927, pp. 109-111.

[7]*ETMD* February 1944 from the North African Theater of Operations, 1 Mar. 1944, pp. 58-59.

shock was so superior in World War II as to permit operation on all admissions of this particular unit, and second, that the subjection of poorer risks to operation in World War II raised the operative mortality rate insignificantly above that for World War I. The superior management of shock in World War II did not, of course, enable to survive all those who, in World War I, would have died without operation. The net result was a decline of 35 percent in total mortality.

Table 29

MORTALITY EXPERIENCE OF FIELD HOSPITAL, 1918 AND 1943

	Field Hospital No. 127 in 1918	Platoon of Field Hospital No. 33 in 1943
Days included	7	30
Cases admitted	256	297
Deaths without operation	41	0
Deaths after operation	34	56
Operative mortality rate, percent	*16*	*19*
Total mortality rate, percent	29	*19*

SURGICAL TIME-LAG

A fundamental determinant of mortality among the wounded is the speed with which they are given medical care, particularly first aid, resuscitation, and initial surgery. Although the importance of this factor is generally recognized, its full implications are not always understood, and observational data are extremely difficult to obtain. Wounds involving the great vessels, for example, will result in early exsanguination unless bleeding can be controlled effectively. Similarly, contaminated wounds and those with extensive amounts of dead or devitalized tissue invite wound infection somewhat in proportion to the delay in their care. The wounded may be classified into several groups: (1) those whose wounds are such that modern surgery offers them no hope of survival regardless of how soon they are aided; (2) those whose wounds are quite severe but who can survive with prompt surgery; (3) those whose wounds demand surgical attention, but less urgently

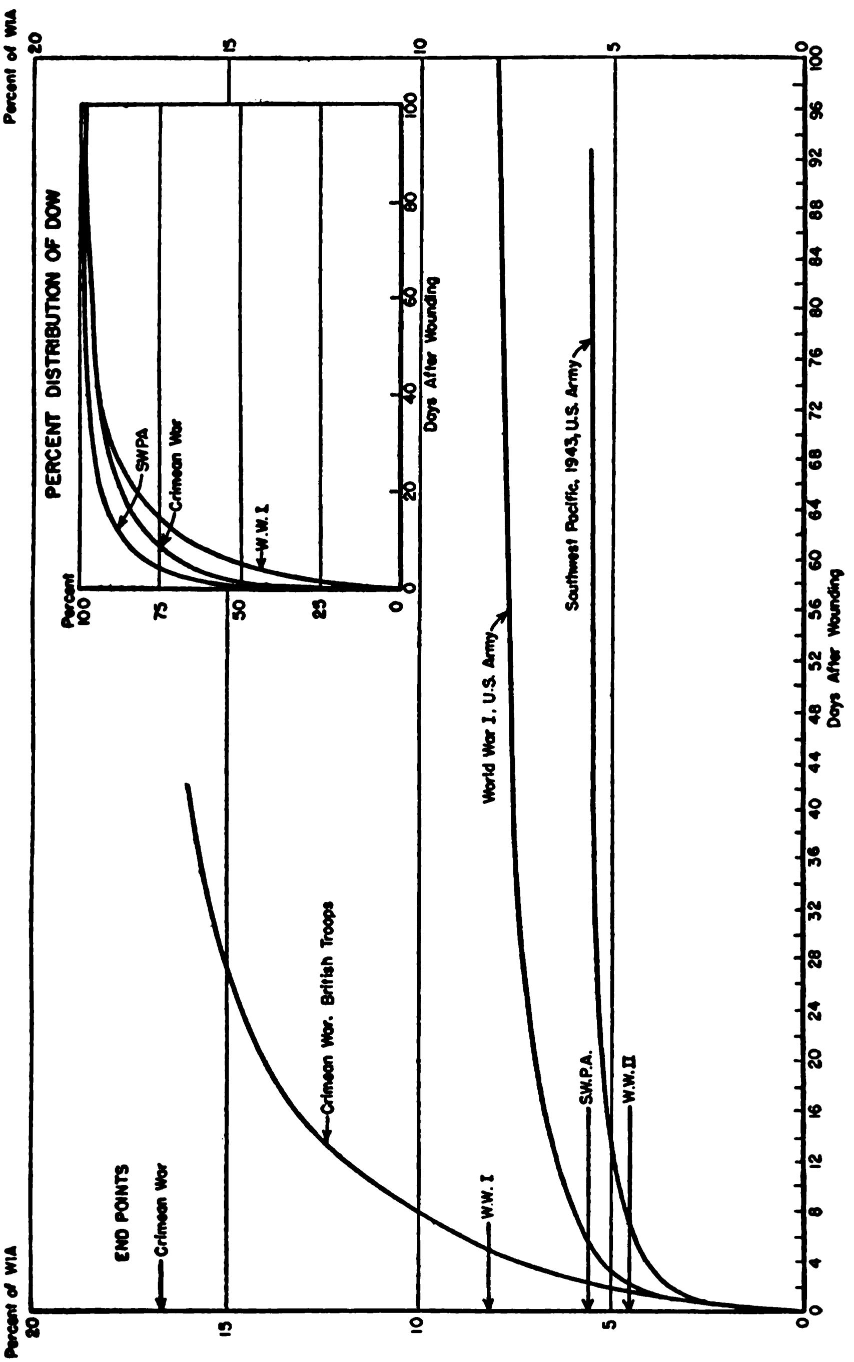

CUMULATIVE CASE-FATALITY RATES FOR WOUNDED, BY INTERVAL AFTER WOUNDING, VARIOUS WARS
Percent of WIA
PERCENT DISTRIBUTION OF DOW
SWPA
Crimean War
W.W. I
Days After Wounding
END POINTS
Crimean War
W.W. I
S.W.P.A.
W.W. II
Crimean War. British Troops
World War I, U.S. Army
Southwest Pacific, 1943, U.S. Army
Days After Wounding

Fig. 22.

than the second group; and (4) the trivially wounded who require only first aid. The third group includes, in addition to some who are not seriously wounded, certain of the more seriously wounded whose treatment may be delayed for some hours without appreciable effect upon their chances of survival. Without surgical care deaths would occur at a rapid but unknown rate. The only established pattern with respect to time is that shown in Figure 22 for men afforded the best surgery possible under the circumstances of their wounding. Under these conditions the greatest number of deaths occurs on the first day, somewhat less on the second, and so on.

Any delay in treatment of other than the hopelessly or the trivially wounded will add to the mortality among the wounded by denying care to some who could have survived with early surgery. The measure of mortality used here is based upon a representative sample of wounded *selected at the time of wounding*. Because most mortality data are collected *at the time of treatment* at a certain echelon rather than upon samples selected at the time of wounding, they often exclude such an important part of the deaths that statements as to mortality are inevitably inconclusive if not actually misleading. Table 30 illustrates the process on the assumption that mortality among the untreated is twice* that among

Table 30

HYPOTHETICAL ILLUSTRATION OF EFFECT OF DELAYED MEDICAL CARE ON MORTALITY RATES AMONG WOUNDED

Sample	Number Wounded	Interval of Pick-up	Number Picked Up	Deaths after Wounding: By Interval 1	2	3	4	5	All Intervals	After Pick-up	Percent Dying: Among 1,000	Among Those Picked Up
1	1,000	1	1,000	20	10	5	2	1	38	38	3.8	3.8
2	1,000	2	960	40	10	5	2	1	58	18	5.8	1.8
3	1,000	3	940	40	20	5	2	1	68	8	6.8	0.8
4	1,000	4	930	40	20	10	2	1	73	3	7.3	0.3
5	1,000	5	926	40	20	10	4	1	75	1	7.5	0.1

*In the light of the recorded values for death from wounding in earlier wars an average factor of four or five would perhaps be more reasonable, in the extreme case, but there is no way of knowing whether one factor would be applicable for all time-intervals after wounding.

the treated. The illustration consists of five identical samples of wounded whose medical care is begun at specified periods after wounding. Without any allowance for the extra mortality involved in delayed care, the underlying mortality rate would be constant, 3.8 percent of each 1,000 wounded. However, by virtue of their exclusion of the early deaths the samples numbered 2 to 5, which involve progressive delay in treatment, have lower apparent mortality rates. In each instance 1,000 men are wounded, but in the first all men are picked up in the first interval and the deaths are 20 in that interval, and 10, 5, 2, and 1 in succeeding intervals, making a mortality rate of 3.8 percent. In the second sample, the untreated have twice the mortality they would otherwise have had in the first interval, but the treated survive as well in the second and subsequent intervals. If the fatality rate is computed from the point of pick-up rather than from the time of wounding, the mortality rate of 5.8 percent is reduced to 1.8 percent. The divergence is more extreme the longer the delay in bringing the wounded under surgical care. The illustration is also useful in illuminating what has been called a paradox of modern surgery, namely that the farther forward surgery is pushed the higher is the attendant mortality rate. The "paradox" results merely from altering the composition of the wounded and is readily dissipated once one accepts the necessity for basing fatality estimates upon some more constant group, e.g., all the wounded, subject though it may be to very real variation because of the tactical situation. The extreme right-hand column of the table shows what happens when the calculus pertains to only such patients as are admitted to medical care; the sooner men are picked up the higher the fatality rate, and vice versa. The same phenomenon was seen earlier in the fatality rates of various echelons of medical care, and largely explains why rear hospitals have a more favorable mortality record than do forward hospitals and why hospitals have lower mortality rates than have all medical installations combined. Too few men are returned to duty along the line to offset the effect of the early deaths.

U. S. Army surgeons in World War II strove to bring surgical treatment to their patients within the "golden period" of the first six hours after wounding. How nearly they attained this objective is not a matter of record, but two samples of data gathered by

Table 31

INTERVAL FROM WOUNDING TO INITIAL SURGERY, ABDOMINAL AND THORACIC WOUNDS, EUROPE

Hours to Surgery	Number	Percent	
		Simple	Cumulative
0 - 5	708	21.4	21.4
6 - 11	1,548	46.8	68.2
12 - 17	579	17.5	85.7
18 - 24	230	6.9	92.6
24 or more	245	7.4	100.0
Total	3,310	100.0	100.0

Source: *Report of Fifth Auxiliary Surgical Group*, September 1944-May 1945; *Forward Surgery of the Severely Wounded*, Second Auxiliary Surgical Group, 1942-1945.

auxiliary surgical groups suggest the distribution which prevailed for nontransportable, high-priority cases in both European theaters. These are summarized in Table 31 with respect to interval between wounding and operation. The injuries were all abdominal, thoracic, or thoraco-abdominal in nature. In this series only 21 percent were operated on within the "golden period" of less than six hours after wounding, but the bulk of the wounded, 47 percent, were operated on within the next six hours, so that about 68 percent had received initial surgery within the first 12 hours. Seven percent were forced to wait for 24 hours or more. In view of the speed with which the severely wounded die every effort to make surgery promptly available to these men must have paid large dividends, but the selective process governing access to surgery is such that ordinary case-fatality rates for lag-intervals may fail to support this surgical tenet. Table 32 provides an illustration from the report of the Second Auxiliary Surgical Group. There is but a suggestion of increasing mortality with time, and statistically it is insignificant. It may be countered, of course, that abdominal wounds are not typical of all high-priority wounds in this respect. Data of the Fifth Auxiliary Surgical Group reveal a considerable differential in relation to time-lag, but only because of a highly significant relationship for 132 thoracic wounds, the case-fatality percentages being 7 for thoracic wounds operated upon within 12 hours and 30 for those

Table 32

RELATION BETWEEN TIME-LAG AND CASE-FATALITY RATES IN ABDOMINAL WOUNDS, SECOND AUXILIARY SURGICAL GROUP, 1942-1945

Hours to Surgery	Number of Wounded	Deaths	
		Number	Percent
0 - 5	611	139	22.7
6 - 11	1,399	304	21.7
12 - 17	506	128	25.3
18 - 24	200	50	25.0
24 or more	210	66	31.4
Total	2,926	687	23.5

operated upon after 12 hours. Whether or not they show some increase in mortality over time, however, conventional lag-data are inevitably distorted by the opportunity given to the severely wounded to die before reaching surgery when the lag is long, with the result that mortality rates for the longer lags are depressed.

An outstanding discussion of time-lag in relation to mortality appears in the final report of the Second Auxiliary Surgical Group. Through the use of the number of abdominal organs injured as an index of severity for abdominal wounds it is shown conclusively that the longer the time-lag the less severe are the wounds of those surviving to reach surgery. But when wounds of approximately the same severity are compared, the lag between wounding and surgery is seen to be an important factor in mortality. The case-fatality rate increases about 0.5 percentage points per hour of delay in this material. The basic data are reproduced in Table 33, which also illustrates the effect of the most fundamental determinant of mortality rates, namely, severity of wound. Few attempts have been made to categorize wound-severity objectively and independently of the differential vulnerability of the various organs and tissues of the body, and the Second Auxiliary Surgical Group has made one of the best. The full range of severity is represented in the cases seen within the first eight hours. Although the relative importance of time-lag may be somewhat understated in these data, it is clear that severity is a much more important determinant of mortality. The rates of increase are fairly uniform

Table 33

Case-Fatality Rates for Abdominal Wounds in Relation to Severity of Wound and Hours from Wounding to Surgery, Second Auxiliary Surgical Group, 1942-1945

Number of Abdominal Organs Hit	Hours from Wounding to Surgery							
	0 - 7		8 - 15		16 - 23		24 or more	
	Number Wounded	Percentage Dying	Number Wounded	Percentage Dying	Number Wounded	Percentage Dying	Number Wounded	Percentage Dying
0	98	*5*	116	*8*	34	*9*	20	*15*
1	496	*10*	519	*15*	145	*17*	72	*26*
2	402	*24*	391	*29*	103	*31*	37	*30*
3	132	*42*	144	*47*	24	*50*	14	*50*
4	41	*54*	38	*66*	7	*86*	2	*50*
5	13	*92*	7	*86*	1	*100*	1	*100*
6	3	*100*	2	*100*	0	—	1	*100*
Total	1,185	*21*	1,217	*24*	314	*25*	147	*29*

for the various time-periods. On the average the addition of another injured organ raises the case-fatality rate about 15 to 20 percent in this series.

Measures of wound-severity in other body-regions are less easily conceived, but one related index of wide general application is the degree of shock observed on admission to surgery. This index is far less objective than is the number of injured abdominal viscera, however. It is sensitive not only to the interval between injury and assessment of shock but also to the adequacy of any prior shock therapy. The prognostic value of a clinical assessment of shock is well illustrated by Table 34, which contains typical evidence drawn from the final report of the Second Auxiliary Surgical

Table 34

RELATION BETWEEN DEGREE OF SHOCK AND CASE-FATALITY RATE IN THE WOUNDED, DATA OF SECOND AUXILIARY SURGICAL GROUP

Degree of Shock	Number of Wounded	Deaths	
		Number	Percent
	A. Abdominal Wounds with Peritoneal Contamination		
Systolic Blood Pressure at Admission (mm. of Mercury)*			
0 - 40	140	93	*66*
41 - 70	121	61	*50*
71 -100	250	95	*38*
101 or more	446	81	*18*
Total	957	330	*35*
	B. Thoraco-Abdominal Wounds		
Severe	275	164	*60*
Moderate	174	31	*18*
Mild	76	10	*13*
None	145	8	*6*
Unknown	233	34	*15*
Total	903	247	*27*
	C. Penetrating Wounds of the Head		
Moderate to Severe	71	23	*32*
Mild	95	17	*18*
None	288	23	*8*
Total	454	63	*14*

*The clinical equivalents in degree of shock are given as: profound or preterminal, severe, moderate, and incipient or none.

Group. The significance of shock apart from time-lag may be seen in the analysis, by the Second Auxiliary Surgical Group, of 641 wounded with injuries to the colon and rectum who were received within six hours after wounding. For the entire group the average case-fatality rate was 37 percent, but for men in severe shock it was 68 and for those with no or slight shock it was but 11 percent. Similar differences obtain for the other two lag-intervals in which there are adequate numbers of cases.

SPECIFIC ORGANS AND TISSUES INVOLVED

The most tangible aspect of wound-severity is the identity of the injured structures. Much of the variation in mortality associated with body-region, multiplicity, and shock really hinges upon involvement of what may be called "vital" tissues. The mere dimensions and multiplicity of lesions mean little otherwise. It is the vulnerability of specific tissues and organs of the body which constitutes the major determinant of wound-severity and thus of mortality from wounds. One small but pertinent illustration appears in Table 35. It constitutes a useful reminder of the close

Table 35

RELATION BETWEEN DEGREE OF SHOCK AND TISSUES DAMAGED, ABDOMINAL WOUNDS* WITH PERITONEAL CONTAMINATION SECONDARY TO PERFORATION OF THE GASTRO-INTESTINAL TRACT

Systolic Blood Pressure, in mm. of Mercury	Number of Wounded	Cases with Spleen or Major Vascular Injury	
		Number	Percent
0 - 40	140	43	*31*
41 - 70	121	25	*21*
71 - 100	250	39	*16*
101 or more	446	37	*8*
Total	957	144	*15*

*Treated by members of the Second Auxiliary Surgical Group.

dependence of shock upon the precise site of the injury, although factors other than splenic or vascular injury are important in producing shock.

From the standpoint of the survival of the individual *hit* (killed or wounded) the surgical experience of World War II produced no radically new findings with respect to the viability of the human organism challenged by injury to specific tissues and organs. Its contribution lies chiefly in having reduced expected case-fatality rates among the *wounded*, and in thus having greatly altered notions about the survival of the wounded in the presence of surgery. It is perhaps well, in this connection, to point out that the data of war surgery pertain, not to vulnerability *per se*, but to some residual which surgical intervention and other therapeutic measures failed to eliminate. The differentials which are found in case-fatality rates, then, serve to designate areas where surgical progress remains to be made, if possible, as well as to measure achievements already secured.

The surgical history of World War I[8] includes a detailed table of the organs and tissues injured by various missiles and of the number of associated deaths. Out of 174,296 wounds (sustained by perhaps 154,000 men), an arbitrary selection of certain organs has been made in Table 36 to exemplify the material presented there. These may be contrasted with World War I regional fatality percentages of 43 for abdomen and pelvis, 14 for head, and 7 for lower extremity, as computed for wounds (not men) on the same basis elsewhere in the history.[9] The World War I data on specific organs and tissues are based upon brief source-records (individual sick and wounded records) which would naturally be confined to the structures of greatest importance in the particular case. Moreover, the coding process often involves selection from among a variety of structures involved in one wound-track, so that the accounting process provided no basis for a count of *all* the cases in which a given site was involved. Finally the chief source-record, the Field Medical Record, was often not well filled out in the field and its coding was frequently difficult. Analogous data should eventually be available for the World War II experience and are scheduled to appear in the statistical volumes of the history. In advance of the preparation of these World War II tables the observations reported by various units and commands during the war must be drawn upon to supplement data for the body-regions. Moreover, these data represent studies of their own field experience

[8]*The Medical Department of the U. S. Army in the World War*, Vol. XI, Surgery, Part I, pp. 65-69.

[9]*Op. cit.* Vol. XV, Statistics, Part 2 p. 1024.

Table 36

CASE-FATALITY RATES FOR SELECTED ORGANS AND TISSUES, WORLD WAR I WOUNDS

Organ	Number of Admissions	Number of Deaths	Case-Fatality Percentage
Colon	222	171	77
Small Intestine	272	205	75
Liver	258	173	67
Brain	1,225	375	31
Scalp	2,179	47	2
Femur	3,771	952	25
All Others	166,369	11,546	7
All Wounds (Not Men)	174,296	13,469	8

by operating surgeons, and are more precise than gross statistical studies. Accordingly, these special studies provide a better basis for understanding the mortality from wounds of individual organs than do the gross statistical studies, although lacking the systematic character of the latter. They suffer from two great defects, however, which must constantly be borne in mind. The first is that surgeons of any particular unit may not always see a representative sample of wounds to a given organ. For example, the auxiliary surgical groups, upon whose experience much of this section rests, generally cared for the more serious wounds of any given location, and their reported mortality rates are correspondingly high. This does not mean that these data may not be employed very usefully in exposing major factors governing mortality, but it does mean that they do not necessarily yield unbiased estimates of organ-specific case-fatality rates. The second defect derives from the inability of the operating surgeon to follow-up his cases, so that his reports are usually confined to initial mortality and represent only the experience of field and evacuation hospitals. Reference to Table 27 (p. 93) will show that to the 1,256 deaths in field and evacuation hospitals one might add 515 occurring farther forward, 62 in station hospitals, and 146 in general hospitals in the rear. If one assumes that deaths among men with any specific type of injury are distributed in the same way, and takes as negligible any returns to duty forward of initial surgery, then one finds that the "initial" mortality figure must be multiplied by factors on the order of 1.3 to 1.6 in order to obtain estimates of total mortality. Thus a 10 percent figure becomes 15, 20 percent is raised to 29, 30 percent advances to 42, 40 percent increases to 54, and 50 percent to 66.*

The first considerable study of location-specific fatality was submitted by the Southwest Pacific Area in 1944[10] on all wounded incurred in the theater prior to 1 September 1943, including many immediate deaths in men who failed to reach hospitals. Although this sample is small, its careful handling according to a rational scheme of location gives it considerable importance. Table 37 summarizes the results of this study, from which may be seen the importance of penetrating wounds of the head, chest, and abdomen in determining the chance of death among the wounded. None of the groups except those involving the extremities is large enough to provide a stable estimate of fatality, but it is significant that the more vulnerable locations have case-fatality rates of 20 to 50 percent, and account for about half of the deaths.

For the period 1 August 1944 to 31 May 1945, the Fifth Army[11] tabulated its hospital admissions and deaths according to a moderately detailed plan of location of wound, permitting computation of the corresponding fatality rates. These data appear in Table 38. The highest fatality rates apply to intra-abdominal, thoraco-abdominal, and intracranial wounds, these being on the order of 20 to 26 percent. Although these categories are not sufficiently detailed to permit conclusions to be drawn concerning individual organs, the observations serve to point up the importance of paying heed to the tissues actually injured when mortality is under consideration. Their exclusion of deaths both forward and to the rear of army hospitals greatly reduces the fatality percentages

*Any mortality percentage, X, representing only deaths in field and evacuation hospitals, must be increased to (1,979 X)/1,256 = 1.58 X. In addition, 515/1,256 or .41 X must be added to the denominator for the men who died before reaching initial surgery. The approximate adjustment then consists in estimating the total percentage mortality (Y) from the initial percentage mortality (X) by means of the expression

$$Y = 100\left(\frac{1.58X}{100 + 0.41X}\right).$$

[10] *ETMD*, Southwest Pacific Area, Sept. 1944, App. "C."

[11] *U. S. Fifth Army, Annual Report to The Surgeon General, 1945.*

Table 37

CASE-FATALITY OF WOUNDED* IN SOUTHWEST PACIFIC AREA, 1942-1943, BY BROAD ANATOMICAL REGIONS AND STRUCTURES INVOLVED

Region and Tissue	Number of Wounded	Deaths	
		Number	Percent
Head	148	23	15.5
Scalp only	99	0	0
Cranial bones and brain	49	23	46.9
Face	126	7	5.6
Soft tissues only	96	0	0
Soft tissues and bones	30	7	23.3
Neck	44	3	6.8
Inner Ear	15	0	0
Chest	254	26	10.2
Non-penetrating	143	2	1.4
Penetrating	111	24	21.6
Abdomen	153	32	20.9
Parietal	123	21	17.1
Visceral	30	11	36.7
Abdomino-Thoracic	10	5	50.0
External Genitalia	8	0	0
Upper Extremity	683	1	0.1
Lower Extremity	914	27	3.0
Soft tissues only	644	18	2.8
Soft tissues, vessels, nerves, and bones	270	9	3.3
Spinal Cord and Vertebrae	44	5	11.4
Burns	32	4	12.5
Multiple Wounds	89	2	2.2
Unspecified	46	0	0
Concussion	36	10	27.8
Total	2,602	145	5.57

*Admissions to hospital and quarters.

based on these data, as is plain not only from the low average mortality figure of 2.2 percent but also from the fact that percentages for wounds of vital regions like head, chest, and abdomen are about half of those shown in Table 37.

Head and Spine Wounds. In the World War I data, wounds of the cranial bones and brain were grouped together to yield a fatality percentage of 37.1 in comparison with 13.9 percent for all head wounds and with an estimated 9.8 percent for the entire head, face, and neck region. The provisional World War II figure for head, face, and neck is 6.4 percent. For penetrating wounds of the brain the reported World War I figure is 31 percent, but the relative incidence is 0.7 percent, so far below World War II estimates of 2 to 4 percent that one can hardly accept the figure at its face value. Seventh Army experience[12] from the landing in Southern France to 1 November 1944, includes 1,176 penetrating wounds of the brain for intracranial wounds admitted to army hospitals, with 27.8 percent terminating fatally. This is close to the value given in Table 38 for all but scalp wounds in the Fifth Army. Of the 949 in which operations were performed the mortality was 14.4 percent. Similarly, First Army hospitals reported an *operative* mortality of 14.8 percent for a sample of 1,102 cases admitted from D-Day to 1 November 1944. For compound skull fractures only operative fatality rates have been reported, and these average 1.6 percent for a sample of 546 cases reported by the First and Seventh Armies for the period 6 June 1944 to 1 November 1944. Table 39 gives these data in detail and underscores the importance of pre-operative mortality in head injuries. Matson[13] has recently studied mortality in acute penetrating wounds of the brain and concluded that the operative mortality in World War II was about 14 per cent, and the total mortality about 25 percent for patients reaching evacuation hospitals alive. A First Army summary[14] for the period 6 June to 31 December 1944, divides into two parts the 11.5 percent mortality among 5,925 wounded admitted to hospital with head injuries, 6.5 percent before and 5.0 percent after operation. In spinal injuries there was an even greater pre-operative mortality, the respective figures being 9.4 and 4.4 percent. On the other hand the reverse was true for wounds of the trunk. For example, the figures are 6.2 and 16.2 for abdominal injuries, and 3.4 and 4.6 for thoracic injuries.

Additional information is given in Table 40 which is based upon individual sick and wounded records for cases admitted in January through June 1944, in MTO, SWPA, and POA. The loca-

[12]*ETMD* from ETO, 16 May 1945.

[13]Matson, Donald D.: *The Treatment of Acute Craniocerebral Injuries Due to Missiles*, Springfield, Ill., Charles C Thomas, Publisher, 1948.

[14]*U. S. First Army, Annual Report to The Surgeon General, 1944.*

Table 38

RELATIVE FREQUENCY AND FATALITY OF WOUNDS BY DETAILED LOCATIONS, FIFTH ARMY HOSPITALS, 1 AUGUST 1944-31 MAY 1945

Location	Frequency Per 1,000	Fatality Percentage
Head		
Intra-cranial	19.50	26.00
Scalp	37.75	0.00
Eye and Ear	20.00	0.00
Neck	20.70	0.87
Maxillofacial		
Bone	12.20	1.50
Soft Tissue	46.80	0.29
Chest		
Intra-thoracic	46.40	7.80
Superficial	37.30	0.24
Spine	9.40	7.10
Abdominal		
Intra-abdominal	28.40	20.00
Thoraco-abdominal	11.00	22.60
Intra- and thoraco-abdominal	5.58	16.10
Superficial	7.40	0.00
Upper Extremity		
Deep muscle	131.00	0.03
Compound fracture	54.00	0.16
Traumatic amputation	8.50	1.05
Superficial	62.00	0.00
Lower Extremity		
Deep muscle	237.00	0.34
Compound fracture	72.50	1.00
Traumatic amputation	21.00	4.30
Superficial	87.80	0.00
Other	23.00	0.55
Total	999.23*	2.20

*As obtained by summation in original source, unadjusted.

tion shown is that for the injury coded as "first diagnosis" which, in cases where multiple injuries existed on admission, would be the most serious one. Only one traumatism was coded for an injury of one particular region of the body (e.g., head), even though several portions of the body structure might be involved in a single wound track. Coding rules provided that where a major organ was involved, it would be shown as anatomic location in preference to other sites, and that fractures would be shown in

Table 39

COMPARATIVE CASE-FATALITY RATES, SELECTED HEAD INJURIES
WORLD WARS I AND II

Source of Data	Penetrating Wounds of the Brain			Skull Fractures		
	Number	Deaths		Number	Deaths	
		Number	Percent		Number	Percent
World War I	1,225	375	*31*	786	489	*62*
World War II						
ETO Armies Jun-Nov 1944 1st Army Total Operated	1,102	163	*15*	390*	5	*1*
7th Army Total	1,176	327	*28*			
Operated	949	137	*14*	156†	4	*3*
21st Army Group (British) Operated	1,248	125	*10*	§	§	§
2nd Auxiliary Surgical Group Operated	454	63	*14*	120‡	8	*7*

*Described as compound, without dural penetration.

†Described as compound depressed fractures, without dural penetration.

‡Described as depressed, without dural penetration.

§Not reported.

preference to wounds other than those involving major organs. However, the coder was limited, of course, by the detail which was recorded on the individual medical record and it appears likely that most of the cases reported and coded as compound fractures of the skull did have brain involvement. In fact, many of these cases which were so seriously wounded that they lived only a short time may actually have been rather less precisely recorded in regard to the fact of brain involvement. That this may be the case is indicated by the fact that nearly one-third of the 340 cases shown in Table 40 had the site reported only as "skull, unqualified" (as distinguished from specific bones of the skull) and for this group the case-fatality rate was nearly twice as high as for the entire group of head bone cases.

Table 40

CASE-FATALITY RATES FOR WOUNDS OF HEAD, FACE, AND NECK REGION, BY ORGANS AND TISSUES INVOLVED, ALL WOUNDED IN SWPA, MTO, AND POA, JANUARY-JUNE 1944

Area	Organs and Tissues	Number Wounded*	Deaths	
			Number	Percent
Head				
	Brain	1,438	173	*12*
	Ear	748	1	*0*
	Bones	340	116	*34*
	Nerves and blood vessels	3	0	*0*
	Head generally	1,272	103	*8*
	Total	3,801	393	*10*
Face				
	Eye	798	4	*1*
	Nose	148	4	*3*
	Mouth and other organs	158	2	*1*
	Bones	407	19	*5*
	Joints and muscles	7	0	*0*
	Face generally	1,544	25	*2*
	Total	3,062	54	*2*
Neck				
	Organs	16	5	*31*
	Muscles	8	0	*0*
	Blood vessels	6	3	*50*
	Neck generally	821	48	*6*
	Total	851	56	*7*
	Total	7,714	503	*7*

*Excludes living WIA who lost no time from duty.

In World War I men with spinal injuries fared badly, largely as a result of infection.[15] The statistical tabulations for World War I yield an average case-fatality of 56 percent for all spinal injuries, 80 percent for those with cord injuries and 42 percent with vertebral damage. In World War II the evidence is that all spinal injuries carried an average mortality of 12 to 14 percent, with injuries to the cord having a higher rate and vertebral injuries without cord damage a much lower rate. Table 41 compares the published World War I material with the figures available for

[15]*The Medical Department of the U. S. Army in the World War*, Vol. XI, Surgery, Part 1, p. 757.

Table 41

COMPARATIVE CASE-FATALITY RATES, SPINAL INJURIES, WORLD WARS I AND II

Source and Type of Case	Number Wounded	Deaths	
		Number	Percent
World War I			
Cord	220	176	*80*
Vertebrae	378	158	*42*
Total	598	334	*56*
World War II			
ETO Armies*			
First, 1944-1945	836	115	*14*
Third, 1944-1945	1,527	83	*5*
Seventh, 1944-1945	420	40	*10*
Ninth, 1945	93	12	*13*
21st Army Group, 1944-1945 (British)			
With Cord Injury	383	62	*16*
Without Cord Injury	126	3	*2*
Total	509	65	*13*
MTO Army			
Fifth Army, 1944-1945†	209	15	*7*
POA Army			
Tenth Army, 1945 (incomplete)	80	12	*15*
Theater Totals			
SWPA, 1942-1943	44	5	*11*
SWPA, POA, and MTO, Jan-Jun 1944			
Cord	47	9	*19*
Bones	270	41	*15*
Joints and Muscles	89	1	*1*
Total	406	51	*13*

* U. S. armies in ETO recorded spinal injuries together with "head" and "nerve" as neurologic. However, the data from the several armies vary so widely that one cannot guess at the objective content of the category "spine." Fifth Army data are similarly unspecified. In all other cases it is plain that both vertebral and cord injuries are included.

†Based on reports of 22,246 wounded during period August 1944 to 31 May 1945.

World War II. Taken in relation to the 154,000 WIA of World War I the recorded figures suggest an incidence of about 0.4 percent, whereas World War II data range from 0.6 (Tenth Army, 1945) to 1.7 percent (SWPA, 1943 and Third Army, 1944-1945). Thus the World War I figures are probably very incomplete, although one cannot say whether by virtue of exclusion of early deaths or of certain nonfatal cases. The World War II reports of field armies exhibit considerable variation in concept. For example, the First Army reported a case-fatality rate of 14 percent based on 0.63 percent of its total WIA count of 132,000, whereas the Third Army reported a rate of 5 percent based on 1.66 percent of its 92,000 WIA. The most convincing data are those of the British 21st Army Group, for which the average of 13 percent agrees closely with all U. S. data except those of the Third and Fifth Armies. Four small series of early laminectomies reported by Matson,[16] totalling 166 cases, have an average postoperative mortality of eight percent.

Thoracic Wounds. If the killed are taken into account, the chest ranks close to the head and abdomen as a vital region, largely because of the vulnerability of the heart and great vessels. The total fatality percentages are 47 for the head, face, and neck combined, 43 for the chest, and 51 for the abdomen. For both the head and chest the killed represent a higher portion of the total deaths, and conversely the percentages dying of wounds are much lower for the head and chest than for the abdomen. This well-known phenomenon explains why it is so hard to find data on wounds of the heart. An important exception is to be found in the final report of the Second Auxiliary Surgical Group. Among 57 men with cardiac wounds seen by the surgeons of this Group, there were 27 deaths, or 47 percent. If deaths apparently caused by other wounds are excluded the percentage falls to 35. These figures may be compared with an average case-fatality rate of 9.2 percent for all penetrating or perforating wounds of the chest treated by surgeons of this Group. The cardiac lesions ranged from contusions to perforated chambers.

For the most part the data which became available during the war provided little more than a distinction between superficial wounds and those which penetrated or perforated the thorax. Those of Tables 37 and 38 are typical in this respect.

In an early survey of thoracic wounds in World War II Carter and De Bakey[17] estimated that penetrating wounds of the chest carried an average mortality of 12 percent and nonpenetrating 3 percent. The Fifth Army figures on hospital admissions are 7.8 for

[16]Matson, Donald D.: *The Treatment of Acute Compound Injuries of the Spinal Cord Due to Missiles*, Springfield, Ill., Charles C Thomas, Publisher, 1948.

[17]Carter, B. N. and De Bakey, M. E.: *Op. Cit.*

penetrating and 0.24 for superficial thoracic wounds, a ratio of about 30 to 1, in comparison with 22 and 1.4 percent in the Southwest Pacific data. Much of the difference arises because the SWPA data are not limited to hospital admissions, because SWPA fatality rates generally exceed those of the European theaters, and because the observations cover rather different time-periods. Surgeons of the Fifth Auxiliary Surgical Group, in reviewing[18] its work with the Ninth Army in Europe, reported a fatality rate of only 8 percent for cases with intra-thoracic wounds, which is of the same order as the figure of 9 percent given by surgeons of the Second Auxiliary Surgical Group.

In their report the surgeons of the Fifth Auxiliary Surgical Group divided their cases into sucking and nonsucking wounds, but the fatality percentages did not vary appreciably. Neither was any difference in fatality observed between penetrating and perforating wounds. As has been frequently noted in the literature,[19] however, wounds produced by shell fragments appear to have caused relatively more deaths than bullets, the respective case-fatality percentages being 13.8 and 3.1 in the series of the Fifth Auxiliary Surgical Group. Hemothorax was definitely present in 77 percent of the cases and definitely absent in only 6 percent in this series. All deaths occurred among those with definite hemothorax, the fatality rate being 11 percent for this group. A suggestive relation was also noted between volume of hemothorax and fatality rate, the latter being 4.9 percent for cases with less than 1,000 cc., 12.8 percent for 1,000 to 2,000 cc., and 15.4 percent for 2,000 to 2,500 cc.

In an analysis of Tenth Army wounded treated in the field hospitals (there were no Army evacuation hospitals at Okinawa) and in a Marine Corps evacuation hospital, all thoracic deaths (13.1 percent) were credited to wounds involving sucking, pneumothorax, hemothorax, or crush.[20] A 1945 summary[21] of surgical results attained by surgical teams and forward units of the British

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18FALOR, W. H. *et al.*: 1,063 War Wounds of the Thorax and Abdomen, *Journal of Military Medicine in the Pacific,* 2:41-48, Jan. 1946.

19CARTER, B. N. and DE BAKEY, M. E.: *Op. Cit.*

20*ETMD, USAF Pacific, Aug. 1945, App. "A," The Okinawa Campaign.* Col. George C. Finney, MC, Surgical Consultant to the Surgeon, Tenth Army, 30 June 1945.

21*Penicillin Therapy and Control in 21st Army Group.* Published under the direction of the Director of Medical Services, 21st Army Group, May, 1945.

21st Army Group in ETO from D-Day to V-E Day gives a fatality percentage of 9.6 for penetrating or perforating wounds of the chest. The World War I fatality percentage for the thoracic organs[22] was 48, but this figure, like those for the Southwest Pacific Area, is based on more complete information than data pertaining only to hospitals in the army area. In contrast, all thoracic wounds carried an estimated fatality of 24 percent in World War I.

In many ways the most adequate discussion of mortality in thoracic wounds appears in the final report of the Second Auxiliary Surgical Group. Among 1,249 U. S. cases of intrathoracic wounds 9.3 percent died. In one major classification a separation was made between 1,112 cases in which the thoracic wound was major, and 137 cases in which some other wound was major. The corresponding case-fatality percentages are given as 6.3 and 33.6. A distinction as to severity of wound which bears more directly upon chest wounds concerns the nature of the initial operation which was performed. In cases requiring only debridement of a wound of the thoracic wall the case-fatality rate was only 6.9 percent, whereas it was 12.4 percent in cases requiring thoracotomy. It should be borne in mind that these percentages apply to "initial" mortality, and that adjustment for deaths forward and to the rear of the installations covered by this experience would require that they be multiplied by 1.3 to 1.6. It is probable that official World War II statistics will be rather like those of Table 42, which pertains to men wounded during the interval January-June 1944 in MTO, POA, and SWPA. Unfortunately, three-fourths of the cases could not be coded as to detailed location, and the arbitrary designation of a single structure has the disadvantages already mentioned. Nevertheless, the sharp contrast between fatality rates for the lungs and other organs, and those for the bones, etc., is noteworthy.

Thoraco-abdominal Wounds. Mortality for thoraco-abdominal wounds rather closely approaches that for abdominal wounds. In 903 thoraco-abdominal wounds studied by the Second Auxiliary Surgical Group[23] initial mortality was 27 percent which is not greatly different from the figure of 23 percent for abdominal wounds but

[22] LOVE, A. G.: War Casualties, *Army Medical Bulletin, 24*:124, 1930.

[23] *Forward Surgery of the Severely Wounded, Op. cit.* For a smaller number the figure of 25 percent is also given.

Table 42

CASE-FATALITY RATES FOR THORACIC WOUNDS, JANUARY-JUNE 1944 ADMISSIONS IN MTO, SWPA, AND POA

Organs or Tissues Involved	Number Wounded	Deaths	
		Number	Percent
Lungs	524	56	11
Heart	12	4	33
Other Organs	51	6	12
Bones	163	3	2
Joints and muscles	10	0	0
Blood vessels	4	3	75
Thorax, generally	2,545	239	9
Total	3,309	311	9.4

which stands in sharp contrast to the figure of 9.3 percent for thoracic wounds. It is the abdominal rather than the thoracic component of the thoraco-abdominal wound which determines mortality. A further reflection of this is the fact that the case-fatality rates attending the two major operative approaches in thoraco-abdominal wounds, namely thoracotomy and laparotomy, are respectively 20 and 38 percent.

Degree of shock, multiplicity and severity of wounds, and interval between wounding and surgery are all basic factors in the mortality of men with thoraco-abdominal wounds, as indeed with any serious wound. In Table 34 appear the data of the Second Auxiliary Surgical Group on the relation between shock and mortality in thoraco-abdominal wounds, the degree of shock having been qualitatively assessed on clinical grounds when the patient was first seen at the hospital. Systematic data on multiplicity of wound, e.g., number of organs hit, are not available for thoraco-abdominal cases as they are for abdominal cases (see Table 33), but there is no reason to expect any departure from the relationship shown there. As a rough check, however, Second Auxiliary Surgical Group patients with single wounds of liver, kidney, spleen, and stomach were compared with those having more than one of these organs injured, and no other. It was found that the mortality rate was 14 percent for these organs when injured singly, and 30 percent in combination, a highly significant statistical difference. A similar and statistically significant differential is given by Falor[24] in reporting on the experience of the Fifth Auxiliary Surgical Group. For wounds involving a single viscus he found a mortality rate of 18 percent in contrast with 32 percent for wounds of more than one viscus.

Characteristic of thoraco-abdominal wounds is the greater fatality attending those on the left side of the body, i.e., perforating the left diaphragm. Table 43 summarizes the observations reported by the Second and Fifth Auxiliary Surgical Groups in this respect. Although the differential is not great, it is statistically reliable in these data and is a consistent finding. One general consideration bearing upon this point is the fact that wounds of the right side usually involve the liver, which is among the least vulnerable of the abdominal organs. According to the experience of the Fifth Auxiliary Surgical Group the differential is valid *only* if thoracic viscera are damaged, but the observations published by Falor are too few to give this result statistical significance.

When wounds to the individual structures are studied, the highest case-fatality rates are found among men who sustained injuries to the mediastinum, kidneys, stomach, small intestine, and large intestine. Significantly lower are the case-fatality rates among men with injuries of the liver or the spleen. In Table 44 are summarized the findings of the Second and Fifth Auxiliary Surgical Groups in this respect. There is a great deal of overlapping among the various groups, for men with injuries to one organ often had injuries to another, and thus appear in the table more than once. Also, the case-fatality shown there is the resultant effect of all the injuries sustained by men with injuries to the particular organ; the mortality attributable to the organ itself is not shown. In the report of the Second Auxiliary Surgical Group it is shown that men with injuries to a single organ had the following fatality rates: 12 for the liver; 11 for the spleen; 37 for the stomach; and 33 for the colon. The last two are based on only 30 and 18 cases respectively, the first two on 297 and 95 cases. Statistically, the difference between the solid and hollow viscera is highly significant even in these few observations. Similarly, when the Second Auxiliary Sur-

[24]FALOR, W. H.: 1,063 War Wounds of the Thorax and Abdomen, *Journal of Military Medicine in the Pacific*, 2:35-44, Feb. 1946.

Table 43

Fatality of Thoraco-Abdominal Wounds by Side of Body Affected

Auxiliary Surgical Group	Right Diaphragm			Left Diaphragm			Total		
	Number Wounded	Deaths		Number Wounded	Deaths		Number Wounded	Deaths	
		Number	Percent		Number	Percent		Number	Percent
Second	435	103	24	448	136	30	883	239	27
Fifth	67	12	18	98	27	28	165	39	24
Total	502	115	23	546	163	30	1,048	278	27

Table 44

Case-Fatality for Thoraco-Abdominal Wounds, by Organs Involved, Second and Fifth Auxiliary Surgical Groups*

Organ	Second Auxiliary Surgical Group 1942-1945			Fifth Auxiliary Surgical Group 1944-1945		
	Number Wounded	Deaths		Number Wounded	Deaths	
		Number	Percent		Number	Percent
Liver	507	137	27	75	17	23
Spleen	279	80	29	42	10	24
Stomach	211	93	44	40	16	40
Large Intestine	191	95	50	42	16	38
Small Intestine	115	54	47	25	12	48
Kidney	121	71	59	22	7	32

*See text for statement on overlapping.

gical Group cases were separated[25] into those of hollow viscera only, solid viscera only, and both hollow and solid, case-fatality percentages of 37, 22, and 51 were obtained respectively. These differences are consistent with the findings in abdominal wounds.

Abdominal Wounds. Data on abdominal wounds are abundant, but the best material, again, relates to the experience of forward hospitals and thus does not include deaths occurring before and after these installations. Excluding thoraco-abdominal cases, the series of the Second Auxiliary Surgical Group consists of 2,315 cases with 534 deaths, a mortality of 23 percent. In the earlier section on surgical time-lag (pp. 96 to 104) the basic factors of wound-severity and lag between wounding and surgery, which govern mortality for all types of wounds, have already been discussed for abdominal wounds.

As in the case of thoraco-abdominal wounds, the evidence is that injuries to hollow viscera are more often fatal than injuries to solid. For solid viscera the fatality percentage is 14, for hollow viscera 23, and for both 40, when wounds to one or more organs are included. If attention is restricted to a single viscus, the figures remain significantly different at 11 for solid and 17 for hollow viscera.

No particular significance seems to inhere in the causative agent as a factor in case-fatality, but surgeons of the Second Auxiliary Surgical Group attached considerable importance to the season of the year. In 1944 and 1945 during the summer months (April-September) their mortality was 20 percent, and during winter months (October-March) it was 27 percent. The monthly fluctuation bears this out, January and February being the months of highest mortality. For the first quarter of the calendar year the average mortality rate was 33 percent and for the subsequent quarters it was respectively 19, 20, and 25. The phenomenon is attributed to the greater incidence of more severe shock in cold, wet weather, and to the prevalence of respiratory infections tending to increase the number of deaths from pulmonary complications.

In the report of the Second Auxiliary Surgical Group the mortality of penetrating abdominal wounds was estimated at 16 per-

[25] *ETMD* from MTO, Apr. 1945.

Table 45

Fatality of Abdominal Wounds, by Viscus, Second Auxiliary Surgical Group, 1942-1945

Viscus	All Cases			Complicated*		Uncomplicated*	
	Number	Deaths		Number	Percent Dying	Number	Percent Dying
		Number	Percent				
Colon	1106	406	*37*	855	*41*	251	*23*
Jejunum and Ileum	1168	345	*30*	815	*36*	353	*14*
Liver	829	224	*27*	490	*39*	339	*10*
Stomach	416	169	*41*	374	*42*	42	*29*
Kidney	427	149	*35*	371	*38*	56	*16*
Spleen	341	85	*25*	241	*30*	100	*12*
Rectum	155	47	*30*	91	*42*	64	*14*
Bladder	155	46	*30*	134	*34*	21	*0*
Duodenum	118	66	*56*	116	*56*	2	*50*
Pancreas	62	36	*58*	61	*57*	1	*100*
Gallbladder	53	16	*30*	53	*30*	0	*0*
Ureter	27	11	*41*	26	*42*	1	*0*

*A complicated case is one in which more than one abdominal organ was injured; an uncomplicated case has no other abdominal injury. Either may have associated extra-abdominal injuries.

cent, whereas that of perforating* wounds was given as 24 percent. Unfortunately, the sample of 2,722 abdominal and thoraco-abdominal wounds upon which the comparison was based is badly biased in that its overall case-fatality of 18 percent is well below the value of 24 percent for all 3,154 abdominal and thoraco-abdominal wounds. From the report one cannot be sure that penetrating and perforating wounds are affected in the same way by whatever factors bias the total sample of which they are parts.

Mortality for wounds of individual abdominal organs is given in Table 45, which is also drawn from the work of the Second Auxiliary Surgical Group and represents only those deaths which came to the attention of the surgeons of the Group. Similar but far less extensive data have been reported by Jones[26] for the Fifth Auxiliary Surgical Group. From examination of the column for uncomplicated wounds it is plain that the fatality rates are reliably low for the jejunum and ileum, liver, and spleen, whereas the rate for the colon is reliably high. The figure of 29 percent for the stomach is also high; in fact it is reliably higher than those for the jejunum and ileum and for the liver despite its small base of 42 cases. The percentages in Table 45 are substantially the same as those given in Table 44 for thoraco-abdominal wounds of the liver, stomach, and spleen, but appreciably less than those for the colon, small intestine, and kidney. This is probably no more than a result of the multiplicity of wounds. If the comparison is made on the basis of wounds to a single viscus the case-fatality rates for thoraco-abdominal and abdominal wounds are almost identical for injuries to the liver and spleen, and insignificantly different for injuries to the stomach and colon.

Comparison of the data of the Second Auxiliary Surgical Group with those of the first World War will be of interest, even though the adjustment of the "initial" mortality figures for World War II is only an approximate procedure. This has been done in Table 46. It will surprise many that the Second Auxiliary Surgical Group, serving the II Corps in Tunisia, the Seventh Army in Sicily, the Fifth Army in Italy, and the Seventh Army in ETO, commands

*The distinction between penetrating and perforating wounds lies in the fact that the former has no wound of exit.

[26]JONES, H. W.: 1,063 War Wounds of the Thorax and Abdomen: Wounds of the Abdomen, *Journal of Military Medicine in the Pacific*, 2:27-34, Feb. 1946.

Table 46

Comparison of World War I and World War II Data on Fatality of Abdominal Wounds

Organ	U. S. Army, World War I			Second Auxiliary Surgical Group 1942-1945		
	Wounded	Deaths		Number of Cases	Percentage Fatality	
		Number	Percent		Reported	Adjusted*
Colon	222	171	*77*†	1106	*37*	*51*
Jejunum and Ileum	408	306	*75*	1168	*30*	*42*
Liver	258	173	*67*	829	*27*	*38*
Stomach	144	99	*69*†	416	*41*	*55*
Kidney	129	75	*58*	427	*35*	*48*
Spleen	51	34	*67*	341	*25*	*36*
Rectum	102	48	*47*	155	*30*	*42*
Bladder	125	67	*54*	155	*30*	*42*

*For deaths forward and to the rear of field and evacuation hospitals; see p. 107.

†The clinical discussion on pages 458 and 461 of Vol. XI, part 2, of the Medical Department of the U.S. Army in the World War, gives 60 and 55 percent for colon and stomach respectively.

which in all sustained less than 170,000 wounded in comparison with 154,000 in World War I, reported so many more cases for each organ. For the colon, for example, the ratio is five to one. One would surmise that many of the abdominal wounds operated upon in World War II have as their World War I parallel men listed as KIA, and that the coding of wounds was such that only less complicated wounds of the abdomen were coded as to organ involved. Also, as has been noted, the World War I Field Medical Record was often incomplete. Which of these may have been most important one can only guess, but in no case would the choice tend to reduce the case-fatality margins suggested in Table 46. If the comparison of Table 46 were based on World War II data for uncomplicated wounds the differentials between World War I and II case-fatality rates would be even greater.

In wounds of the stomach the Second Auxiliary Surgical Group found a significant difference in mortality between perforating and lacerating lesions, the case-fatality percentages being 35 and 61. Lacerating wounds occurred in about 30 percent of the wounds of the stomach and were found to lead uniformly to severe peritoneal contamination. Death from shock was notably common in lacerating wounds of the stomach. The incidence of complicated wounds of the stomach, that is, wounds involving another abdominal vicus, is high, about 90 percent in the Second Auxiliary Surgical Group series, but this is only one reason for the high case-fatality of stomach wounds, as the ratio is also high for uncomplicated stomach wounds. The most frequent complicated wounds were those involving the liver (case-fatality 30 percent) and the spleen (case-fatality 19 percent).

Among the 3,154 abdominal and thoraco-abdominal wounds seen by members of the Second Auxiliary Surgical Group there were 75 in which one or more great vessels of the abdomen were injured. There were 55 deaths, or 73 percent, in this group, the highest of all the abdominal groups. It is noteworthy that 53 involved veins, and only 22 arteries; there were 33 men with lesions of the vena cava, but no man with an injury to the abdominal aorta survived to reach surgery. This is a striking instance of the way in which gravity of the wound operates to reduce the chance that the man will receive initial surgery.

Traumatic evisceration is of particular interest in wounds of the abdomen. Defined by the Second Auxiliary Surgical Group as "the protrusion of an abdominal viscus to the exterior of the abdominal cavity through a missile track which has interrupted the continuity of all layers of the abdominal wall," traumatic evisceration was observed in 312 instances among 3,154 abdominal and thoraco-abdominal cases, with a case-fatality of 40 percent, considerably higher than that of 22 percent for the 2,842 cases without evisceration.

Wounds of the Extremities. Variations in fatality among wounds of the extremities are perhaps less likely to attract interest because the average level is so low in comparison with other regions, but the number of deaths from such wounds is so large that even small differences are highly important. For example, in World War I, 60 percent of the deaths following wounding were credited to wounds of the extremities[27] whereas in World War II this figure is believed to be about 30 percent. In Table 37, covering wounds in the Southwest Pacific Area in 1942 and 1943, the only variation according to tissues affected is a small one, but in Table 38 the Fifth Army figures reveal a wide margin. The Fifth Army percentages for lower extremities are: 4.3 for traumatic amputation; 1.0 for compound fracture; 0.3 for deep muscle wounds; and 0.0 for superficial wounds. Analysis of the Tenth Army experience by its surgical consultant[28] gives an average fatality of 1.1 percent for all wounds of the extremities treated in Army field hospitals or in the Marine evacuation hospital on Okinawa. For wounds involving compound fracture the percentage fatality was 1.9, almost twice the average. Among the compound fractures those of the upper extremities carried a fatality rate of 0.9 percent, those of the lower extremities one of 2.5 percent. Patients having traumatic amputation died at the rate of 6.0 percent, or more than five times the average rate. In World War I soft tissue wounds of the lower extremities were attended with a fatality rate (including deaths at all echelons) of 6.1 percent, and wounds of long bones and joints with a rate of 17.5 percent.[29]

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[27] *The Medical Department of the U. S. Army in the World War*, Vol. XV, Statistics, Part 2, p. 1024.

[28] *ETMD*, USAF Pacific, Aug. 1945, App. "A," *Op. cit.*

[29] Love: *Op. cit.*, p. 124.

In the report of the Second Auxiliary Surgical Group 783 patients having single amputations, and having no other major injury, had an initial mortality of 2.6 percent. Table 47 provides a breakdown of these figures by gross location. Of the six possible comparisons which may be made for the two locations shown there, only the difference between the leg and the thigh is reliable, all others being statistically insignificant. For all amputations, regardless of associated injuries, the case-fatality rate was 6.8 percent, a figure essentially similar to that of 7.5 percent reported for the 21st Army Group[30] on the basis of 2,655 cases, excluding amputations below wrist and ankle. For amputations of the upper extremities the British figure is 3.3 percent, whereas for the lower it is 8.7.

Table 47

CASE-FATALITY RATE IN SINGLE AMPUTEES WITH NO OTHER MAJOR INJURY, SECOND AUXILIARY SURGICAL GROUP, 1942-1945

Location of Amputation	Number of Men	Deaths	
		Number	Percent
Thigh	278	15	*5.4*
Arm	110	3	*2.7*
Leg	359	2	*0.6*
Forearm	36	0	*0.0*
Total	783	20	*2.6*

Important data on the mortality associated with compound fractures of the long bones are also to be found in the report of the Second Auxiliary Surgical Group, data which strongly support the contention that the mortality risk is almost nil except for such hazards as derive primarily from associated injuries or from anaerobic infection. For compound fractures uncomplicated by other injuries or by anaerobic infection the average fatality rate was 0.3 percent, whereas it was 13.9 in complicated cases, and 6.3 percent in all cases. Table 48 gives this information according to the long bone which was fractured.

[30] *Penicillin Therapy and Control in 21st Army Group, Op. cit.*

Table 48

COMPARATIVE CASE-FATALITY RATES IN COMPOUND FRACTURES,
SECOND AUXILIARY SURGICAL GROUP, 1942-1945

Bones Fractured	All Cases			Complicated			Uncomplicated		
	Wounded in Action*	Died of Wounds		Wounded in Action*	Died of Wounds		Wounded in Action*	Died of Wounds	
		Number	Percent		Number	Percent		Number	Percent
Femur	668	61	*9.1*	267	57	*21.3*	401	4	*1.0*
Tibia	309	10	*3.2*	116	10	*8.6*	193	0	*0.0*
Fibula	137	4	*2.9*	59	4	*6.8*	78	0	*0.0*
Humerus	545	37	*6.8*	264	37	*14.0*	281	0	*0.0*
Radius	142	6	*4.2*	64	6	*9.4*	78	0	*0.0*
Ulna	183	6	*3.3*	76	6	*7.9*	107	0	*0.0*
Tibia and fibula	329	21	*6.4*	175	21	*12.0*	154	0	*0.0*
Radius and ulna	103	7	*6.8*	45	7	*15.6*	58	0	*0.0*
Total	2,416	152	*6.3*	1,066	148	*13.9*	1,350	4	*0.3*

*Number of men. The number of fractures was 3,354 in all, 1,792 complicated and 1,562 uncomplicated. An uncomplicated fracture was defined as one with no major blood vessel involved, no other major associated injury, and no anaerobic infection.

Table 49
FATALITY ASSOCIATED WITH "GUNSHOT" WOUNDS IN WORLD WAR I, BY AGENT*

Agent	Men Wounded	Deaths	Percentage Fatality
Gunshot missile, kind not specified	74,883	7,474	10.0
Pistol ball	242	13	5.4
Rifle ball	20,420	961	4.7
Shell	51,226	3,688	7.2
Hand grenade	880	56	6.4
Total	147,651	12,192	8.3

*In addition there were 70,552 admissions and 1,221 deaths from poisonous gases, and 5,886 wounds and 278 deaths caused by other agents.

CAUSATIVE AGENT

In Love's analysis of World War I battle casualties large differences were found among weapons with respect to case-fatality among the wounded. In *War Casualties*, Love[31] mentions fatality rates of 7.0 for "artillery wounds" and 4.8 percent from wounds caused by small arms. In the statistical volume[32] the data of Table 49 summarize the available information on what he called wounds caused by "gunshot missiles." A similar table appears in the surgical volume.[33] These differences, which are rather large, seem to be of questionable validity and of doubtful surgical significance. If a weapon, e.g., a Japanese hand grenade, should have associated with it a low case-fatality rate among the wounded (and probably also a low killing power), the latter could result only from failure of the fragments to involve vital structures with the expected frequency. In other words, any variation in fatality rates among weapons is better known from the differential character of the wounds themselves, however important it may be from an ordnance viewpoint. Of equal importance, however, is the questionable validity of the World War I figures on fatality by type of missile. This judgment stems not only from the essential nature of the characteristic observations which lie behind all such figures, but also from the fact

[31]LOVE: *Op. cit.*, p. 124.

[32]*The Medical Department of the U. S. Army in the World War*, Vol. XV, p. 1023.

[33]*The Medical Department of the U. S. Army in the World War*, Vol. XI, p. 57-64.

that half of the wounded and 60 percent of the deaths in World War I are unknown as to type of missile, so that the unknown category has the highest case-fatality rate.

Two other points about the World War I material should be made for the sake of clarity. The most important concerns the connotation of the term "gunshot," which Love employed to differentiate war weapons using explosives from those wielded by the men themselves to cut and stab, and from poisonous gases, whereas in World War II the term was redefined to apply to small arms (pistol, rifle, machine gun) which fire solid bullets rather than shells which explode. Also the categories "shell" and "shrapnel" in Love's tables have been combined in Table 49. Although the term shrapnel literally means the fragments of metal (chiefly bullets) with which explosive shells used to be filled, in both World Wars I and II it was loosely used by medical officers as synonymous with "shell fragment." The latter properly refers to fragmentation of the casing of high-explosive shells.

Throughout World War II many tactical units of divisional size or larger made periodic counts of their wounded by causative agent, including those dying of wounds at the reporting echelon. Since no one echelon is cognizant of all the deaths, the reports of tactical units are correspondingly incomplete, but Table 50 gives the First and Third Army data which exemplify the type of information available. The term bullet is inclusive of those fired from

Table 50

FATALITY OF WOUNDS AMONG HOSPITAL ADMISSIONS BY CAUSATIVE AGENT, FIRST AND THIRD U. S. ARMIES IN EUROPE, 1944-1945

Agent	Number Wounded		Percent Dying	
	First Army	Third Army	First Army	Third Army
Bullet	30,409	24,881	3.9	3.1
Shell	82,656	52,220	3.2	2.9
Bomb	6,866	4,085	4.0	2.9
Blast	4,191	2,826	2.6	1.0
Secondary missiles	509	626	0.4	0.8
Burn	1,534	1,023	2.2	2.4
Other	5,815	6,369	2.0	1.8
Total	131,980	92,030	3.3	2.8

rifles, pistols, and machine guns. Shell refers to high-explosive shells, flak, mortar shells, and cannon shells. Bomb includes the aerial and booby-trap varieties, as well as the grenade. Blast refers to transmission by air of the effect of bomb, shell, or mine. Similar data are readily available for the Fifth and Ninth Armies and for many lesser units. The variations are not impressive, and the underlying data themselves are not worthy of great confidence because of the way in which they were gathered by tactical organizations. The missile itself is often not found and its character must be inferred from the nature of the wound-track or from the testimony of the patient who, unfortunately, cannot usually be relied upon to know what struck him. A further problem, of unknown significance, concerns the word "gunshot" in view of the change in usage from that employed in the World War I history and that governing modern discussion. Often the medical record will give no more than a statement to the effect that the wound was "GSW," which was an authorized abbreviation for gunshot wound until the end of 1944, or "gunshot wound," and one must ask if all who used the term had the same understanding of its meaning. For these reasons it is not only the summary reports of tactical organizations but also the individual medical report cards themselves which must be questioned. These constituted the source of the World War I data also. Their tabulation for World War II has not yet been completed, but for the first half of 1944 it is possible to give results which should be fairly typical of the war experience. These appear in Table 51. In line with the above discussion as to why the reporting of causative agent may not be satisfactory it is worthy of note that all Individual Medical Records carrying merely the notation "GSW" or "gunshot wound" were coded for bullet wounds. The number of wounded pertains to those admitted to a medical installation and thus excludes the lightly wounded who lost no time.

Even with allowance for the small numbers in Table 51 it can hardly be said that the two theater series are reasonably consistent. The difference between the values for bullets is the only plausible one. Its stability is suggested by the fact that the figures for bullets in the two Pacific theaters (not shown separately) are identical. A possible explanation is that the small-scale Pacific fighting was more likely to involve difficult access to the wounded, and that those who were wounded while on patrol at distant or less accessible points

Table 51

PERCENTAGE OF WOUNDED DYING OF WOUNDS BY CAUSATIVE AGENT, WORLD WAR II, JANUARY-JUNE 1944

Agent	Pacific*		Mediterranean	
	Number Wounded	Percent Dying	Number Wounded	Percent Dying
Bullet	2,369	10.4	4,288	5.2
Shell	3,538	4.7	21,158	5.1
Bomb	273	6.2	842	10.5
Blast	382	1.8	2,047	1.0
Booby-trap or grenade	513	2.7	503	1.8
Land mine	66	13.6	1,390	5.3
Other	1,176	4.2	5,931	1.6
Total	8,317	6.1	36,159	4.4

*Southwest Pacific Area and Pacific Ocean Areas.

were more likely to have met small-arms fire. Otherwise no particular interpretation can be placed upon the differences between the two series shown in Table 51. There is, however, agreement on the fact of low fatality rates for blast injuries for which the observations are probably quite valid in view of the ease with which objective criteria may be applied to distinguish them. When one inquires more deeply into the fatality associated with particular weapons, e.g., machine gun versus rifle, one is confronted with the same problem which casts doubt upon the World War I material, namely, that unspecified or unknown categories tend to have the highest fatality rate. Table 52 compares fatality rates for bullets which were specified as rifle, pistol, or machine gun with those not so specified, and gives similar information for shell fragments and shell, unspecified. Plainly there is a selection of cases which is associated with severity of wound to a considerable degree. In the Mediterranean, for example, bullet wounds noted as caused by rifle, pistol or machine gun carried a fatality rate of 2.7 percent, whereas those noted as "gunshot wound," "GSW," or "bullet wound" had a rate of 8.0 percent, about three times as high. Moreover, these less specified categories have fatality rates far above the average for all wounds.

Table 52

PERCENTAGE OF WOUNDED DYING OF WOUNDS BY CAUSATIVE AGENT AND BY DEGREE TO WHICH AGENT IS SPECIFIED, WORLD WAR II
JANUARY-JUNE 1944

Theater	All Agents	Bullet		Shell	
		Specified as to Rifle or Machine Gun	Unspecified	Specified as to Fragments	Unspecified
POA	5.5	3.2	14.6	*4.0	* 4.5
SWPA	6.7	3.7	14.4	4.4	12.8
MTO	4.4	2.7	8.0	4.4	10.4

*This difference is insignificant statistically, all the others being highly significant.

In sharp contrast to routine data in point of quality, but pitifully small in number, are those from the special wound ballistics studies, notably that of Oughterson's team.[84] In its investigation of the Bougainville casualties at the time of the Japanese attack upon the U. S. perimeter, Oughterson's team was in a position to identify, with far greater precision than ordinary observers, the missiles which wounded men who then received medical care beyond first aid. The resulting observations, which appear in Table 53, display striking differences in case-fatality rates by weapon involved, despite the small number of observations. The most interesting of these concern the machine gun and the grenade. In this series the machine gun has a high relative mortality, at least partly because of its tendency to produce multiple hits, whereas the Japanese grenade is notoriously ineffective and also involves an excess of wounds of the lower extremities. Analogous results were obtained by Hopkins[85] in his careful study of 230 wounded in the New Georgia Campaign and in Burma, but the numbers are so small that the differences are unreliable. The value of these two studies is limited not only by their small size, but also by their peculiar tactical setting, by their restriction to Japanese weapons, and by the fact that the enemy troops were far from the Islands of Japan and, by that token, perhaps less well-equipped, even by Japanese standards.

[84]OUGHTERSON, A. W., *et al.: Op cit.*

[85]HOPKINS, JAMES H.: *Casualty Analysis—New Georgia and Burma, 1943-1945.* Unpublished report on file in Historical Division, Office of the Surgeon General.

Table 53

PERCENTAGE OF WOUNDED* DYING OF WOUNDS, BOUGAINVILLE CAMPAIGN, 1944, BY CAUSATIVE AGENT

Agent	Number Wounded	Deaths	
		Number	Percent
Machine gun	79	15	19.0
Artillery	162	12	7.4
Rifle	323	21	6.5
Mortar	634	23	3.6
Grenade	213	3	1.4
Other	57	1	1.8
Total	1,468	75	5.1

*Men returned to duty from aid post were excluded from the study.

As will be seen later in Chapter IV, the order of the weapons as given in Table 53 is closely parallel to that based on lethality (among all men hit, including the killed) or other indices of effectiveness. Whether such a parallelism should exist may be questioned, and it is unfortunately true that the observations required to test either view adequately are now lacking and unlikely to be available for World War II even at a later date. If one conceives of two weapons of notably different wounding and killing power, one may classify their hits according to severity of wound and draw a distribution of hits according to severity, as has been done in Figure 23. It is also reasonable to assume the index of severity to be such that a certain intensity implies immediate death, and another death after an interval of care. Then it is not difficult to conceive of a distribution such that the delayed deaths (fatality from wounding) will seem large in relation to those who survive. In other words, there is *a priori* no reason to believe that all the wounded admitted to medical installations because of hits from weapon A have the same chance of survival as those hit by weapon B if it be demonstrated that the lethality of the two weapons varies. In the illustration weapon A kills 28 percent outright and the DOW figure is 15 percent, whereas weapon B kills only 15 percent outright and the DOW figure is 10 percent. That is, some weapons will cause so many minor wounds as to offset the more serious wounds by enough to

SCHEMATIC REPRESENTATION OF MECHANISM BY WHICH MORE LETHAL WEAPON CARRIES HIGHER FATALITY RATE FOR WIA

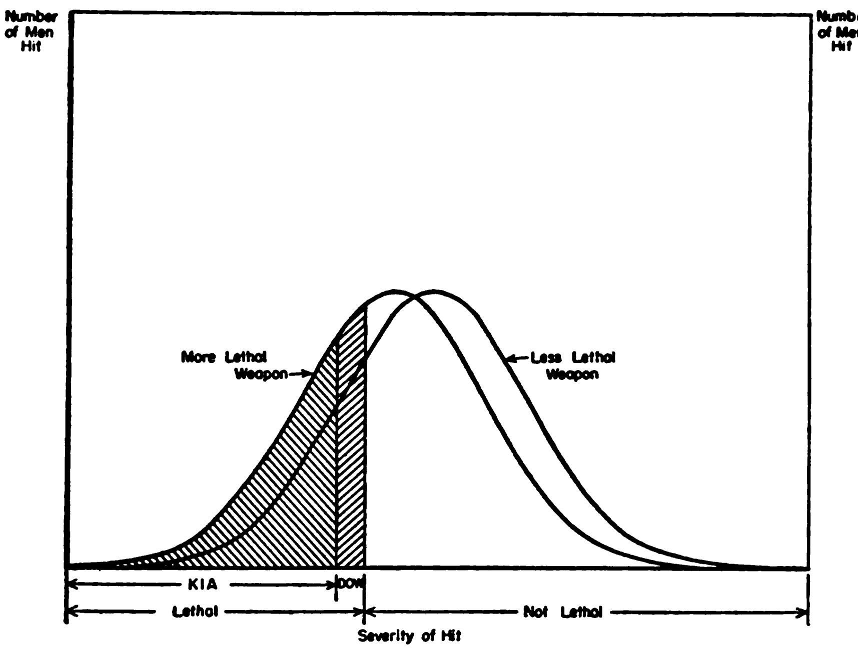

Fig. 23.

lower the fatality rate for wounded below the general average, and *vice versa.* The machine gun is probably near or at the top of the list of conventional death-dealing weapons because of its capacity for multiple hits.

In addition to the question of the chance of death among men wounded by one or another weapon there is interest in the relative importance of agents as causes of death. The latter is essentially the product of the relative frequency with which a given weapon causes wounds and the fatality rate for that weapon, divided by the fatality rate for all weapons. From the standpoint of the relative importance of the various agents as causes of death it is useful to refer to the experience of a field army, whatever the inaccuracies in the recorded data. From 6 June 1944 to 30 April 1945, First Army had 4,357 deaths among wounded admitted to hospital and the Third Army 2,576. These data are given in Table 54.

Table 54
PERCENTAGE OF MEN DYING OF WOUNDS, BY CAUSATIVE AGENT, FIRST AND THIRD U. S. ARMIES IN EUROPE, 1944-1945

Agent	First Army 1944-1945	Third Army 1944-1945
Shell fragment	60.8	58.4
Bullet	26.9	30.2
Bomb fragment	6.3	4.7
Blast	2.5	1.1
Burn	0.8	1.0
Secondary missile	0.0	0.2
Other	2.7	4.4
Total	100.0	100.0
Number of Deaths	4,357	2,576

Table 55
NUMBER OF MEN DYING OF WOUNDS, BY CAUSATIVE AGENT, FIFTH U. S. ARMY SAMPLE OF SNYDER AND CULBERTSON

Agent	Number		Percent	
Bullet		219		15.8
Unclassified	143		10.3	
Machine gun	45		3.3	
Rifle	31		2.2	
High Explosive		1,170		84.2
Shell	861		62.0	
Unclassified	160		11.5	
Mine	70		5.0	
Bomb	67		4.8	
Blast	10		0.7	
Booby-trap	2		0.2	
Total		1,389		100.0

A series of deaths in the Fifth Army, carefully analyzed by Snyder and Culbertson,[36] provides analogous data which may be more reliable because of the intensive study given to the records

[36]SNYDER, H. E. and CULBERTSON, J. W.: *Study of Fifth Army Hospital Battle Casualty Deaths*. Mimeographed at Gordone Riviera, Italy, Sept. 1945.

from which they worked, although the accuracy of the original entries on individual records must be presumed to be the same. These are presented in Table 55. The proportions of deaths from bullets and from high explosives are such as to confirm the previously described (p. 131) tabulation of individual sick and wounded records for the Mediterranean Theater during the first half of 1944.

MECHANISM OF DEATH

A critique of wound surgery must explore the cause of death from a more analytic viewpoint than is permitted by mere consideration of the nature of the wound. Although this volume is in no sense a critique of military surgery in World War II, it does provide some of the facts essential to any critical appraisal, among them being data on the cause of death. Patients "die of" penetrating wounds of head, chest, and abdomen, but not all who have such penetrating wounds die, and the way in which death occurred may throw further light upon the quality of wound surgery and upon the nature of the unconquered domain which always lies ahead. There is point, therefore, in discussing data on the immediate cause of death, stated in more physiologic terms than is customary in discussions of wound mortality. The surgeons who handled forward surgery, and the consultants who guided the professional work of Army surgeons during the war, customarily thought in terms of these mechanisms. Critical review of case-material often took the form of attempting to determine whether the patient might have been saved with different handling, for example, a process which necessarily fixes attention upon the interrelated mechanisms responsible for death and upon their possible control by surgical or other means. These mechanisms, of course, are conceived in different ways at different stages in the progress of surgery, and perhaps not all will agree, for example, that shock is a useful concept with which to describe the cause of death. However, they represent contemporary surgical thinking better than any other available set of concepts and thus point the way to the main current problems.

To only a limited extent may military deaths be studied in the detailed fashion required to specify mechanisms. Notable attempts have been made to specify the immediate as well as the secondary causes of death in this sense, and their partial success illustrates how difficult is the task. Even gross autopsies were not always performed, and microscopic sections were reported much less often. Data compiled by Snyder and Culbertson[87] suggest that gross autopsy was performed in Italy about one-third of the time early in 1944, and about 60 percent of the time throughout 1944 and 1945. Microscopic sections were reported in 7 percent of the deaths early in 1944, and in about one-third of all those occurring in 1944 and 1945. It is not surprising, therefore, that most studies of death among the wounded fail to specify cause in a large proportion of cases, and provide only incomplete specifications, e.g., "brain injury," in many others. They do provide something of a landmark in military surgery, however, and merit fuller discussion than is permitted here. Perhaps the greatest surgical advances during the war concerned the handling of shock and infection, two of the most important mechanisms of death among the wounded. Concentrated study of the death-process in such terms as these is not the only way to achieve such direction of research as will insure the advance of wound surgery, but during the war it proved its worth beyond question.

The largest series of deaths from wounds appears in the medical reports of the Third Army.[88] The concept of primary cause is used there to describe the nature of the wound whereas secondary cause is the term applied to shock, etc. The entries as to secondary cause have been grouped according to the categories which appear in Table 56. The total number, 1,875, is far short of the 2,576 reported as having died of wounds in the Third Army, not all the deaths having carried any specification as to secondary cause. The categories of the table are broad, but they suggest the importance of shock as a death-inducing or death-permitting mechanism, although its meaning may not be too precise. The individual entries are exemplified by the following terms which are among the most frequently mentioned: shock, hemorrhage and shock, hemorrhage, pulmonary edema, respiratory failure, pulmonary embolism, gas gangrene, and hemothorax.

A far more detailed and satisfactory grasp of cause of death may

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[87] *Ibid.*, App. F., Vol III.

[88] *U. S. Third Army, After-Action Report, 1 Aug. 1944 to 9 May 1945.* Vol. II, Medical Section. On file in Historical Division, Office of the Surgeon General.

be gained from the unusually valuable study by Snyder and Culbertson[89] of 1,450 deaths in Fifth Army hospitals. In their series shock dominates all other causes of death, being given in 47 percent of the 1,124 cases in which the cause was reasonably well defined. Hemorrhage alone is given as a cause in only one case. Neurologic conditions accounted for 21 percent of the deaths and infection for

Table 56

SECONDARY CAUSE OF DEATH AMONG WOUNDED, THIRD U. S. ARMY HOSPITAL ADMISSIONS, 1944-1945

Cause	Number	Percent
Shock or hemorrhage	1,286	68.6
Pulmonary disturbances and injuries	281	15.0
Intracranial disturbances and injuries	104	5.5
Peritonitis	59	3.1
Cardiac, arterial, and venous disturbances	58	3.1
Kidney dysfunction, anuria, etc.	54	2.9
Gas gangrene	22	1.2
Other	11	0.6
Total	1,875	100.0

16 percent. Table 57 gives a summary grouping of their data under somewhat arbitrary categories. The groupings are not precisely the same as those employed for the Third Army data in that an effort was made to avoid the tendency to group together mechanisms operating in a particular region or body-system in favor of more detailed specification of the mechanisms themselves. Thus pneumonia and empyema are classified as infections rather than as pulmonary disturbances. This approach has the effect of decreasing the relative importance of pulmonary disturbances in favor of infection, circulatory disorders, and the like. With this qualification the carefully analyzed series of Snyder and Culbertson, based on a detailed examination of all available medical records, places far less emphasis on shock and pulmonary disturbances, and more upon infection and neurologic conditions, than does the Third Army

[89]SNYDER and CULBERTSON: *Op. cit.*

Table 57

SNYDER AND CULBERTSON'S DATA ON CAUSE OF DEATH AMONG MEN DYING OF WOUNDS, FIFTH U. S. ARMY

Cause of Death	Number	Percent
Shock and Hemorrhage	524	46.6
Neurological Conditions	239	21.3
Brain trauma and/or intracranial hemorrhage or clot	213	19.0
Spinal cord trauma	16	0.9
Other	10	1.4
Infection	182	16.2
Peritonitis	65	5.8
Clostridial myositis	51	4.5
Pneumonia	49	4.4
Other	17	1.5
Circulatory Disorders	69	6.2
Embolisms	49	4.4
Other	20	1.8
Urological Conditions	68	6.0
Pigment nephropathy	68	6.0
Respiratory Conditions	32	2.8
Obstructions	25	2.2
Other	7	0.6
Anesthesia, etc.	8	0.7
Gastro-intestinal Conditions	2	0.2
Total Known	1,124	100.0
Other, Ill-defined and Unknown	326	——
Grand Total	1,450	——

series which apparently originated in no special study of deaths. It will be noted, however, that the leading neurologic condition is evidently a mixed one which may well include many cases which other investigators would classify under shock and hemorrhage. The table gives, in addition to the major groups, the leading individual causes. All causes credited with as many as two percent of the 1,124 deaths are listed individually. Except for shock, brain trauma, and intracranial hemorrhage or clot, the leading individual causes account for only small numbers of deaths. They are: pigment nephropathy, peritonitis, clostridial myositis, pneumonia, and embolisms of various types.

The etiology of shock is manifold and often difficult to determine in individual cases. The data of Snyder and Culbertson, reproduced in Table 58, throw some light on this problem. Trauma and hemorrhage alone are noted in 44 percent of all the cases of shock, and in 35 percent of the cases in which shock appears as the immediate cause of death. Cardiorespiratory embarrassment appears as a related etiological agent in 32 percent of all cases of shock and in 42 percent of the fatal cases. Contamination or sepsis is given as a related agent in 34 percent of all cases and in 37 percent of the fatal cases. The table also suggests that shock was more frequently assigned as the immediate cause of death in those instances in which cardiorespiratory embarrassment was involved in producing the state of shock, and less frequently when trauma and hemorrhage appeared alone.

Other data compiled by Snyder and Culbertson show that shock had been "corrected" by appropriate therapy in 339 or 27 percent of all deaths in which shock was reported. They also found successful correction doubtful in 207 or 16 percent and absent in 128 or 10 percent, in addition to the 523 or 41 percent in which it was given as the immediate cause of death. They indicated that they suspected shock as the immediate cause of death in the 128 uncorrected cases which, added to the 523 already credited to shock, would raise the deaths from shock to almost 60 percent of all "explained" deaths. Finally, they separated the 523 shock deaths in army hospitals according to the extent to which the surgical process had progressed, showing that 41 percent of the deaths from shock, or 19 percent of all the 1,124 "explained" deaths, occurred prior to induction of anesthesia, as may be seen from Table 59.

Snyder and Culbertson's tabulation of the amount of plasma therapy received before admission to hospital shows that 168 of the 523 had received none. Of those dying of shock before anesthetization, 87 or 40 percent had received no plasma therapy before admission to hospital, as contrasted with only 26 percent among those dying during or after anesthetization. Similarly, too many of the men who did not live to reach anesthesia had received only one or two units (250 cc. per unit) of plasma before admission to hospital. These differences are statistically reliable and strongly suggest that the number of deaths before anesthetization was increased by the failure to give adequate plasma therapy in time. Similar data on blood therapy after admission to hospital are less conclusive, however, perhaps because the late deaths were in men whose longer survival created more opportunities for them to re-

Table 58

TOTAL REPORTED* INCIDENCE OF SHOCK IN 1,450 BATTLE CASUALTY DEATHS, FIFTH U. S. ARMY

Etiology of Shock	Immediate Cause of Death		Contributory or Associated Condition		Total	
	Number	Percent	Number	Percent	Number	Percent
Trauma and hemorrhage (only)	182	*35*	370	*49*	552	*44*
Trauma and hemorrhage plus contamination or sepsis	120	*23*	186	*25*	306	*24*
Trauma and hemorrhage plus cardiorespiratory embarrassment	147	*28*	135	*18*	282	*22*
Trauma and hemorrhage plus cardiorespiratory embarrassment plus contamination and sepsis	72	*14*	58	*8*	130	*10*
Undetermined	2	*0*	1	*0*	3	*0*
Total	523	*100*	750	*100*	1,273	*100*

*Probably somewhat lower than the actual incidence, according to Snyder and Culbertson.

ceive blood. When the 25 deaths before admission are excluded, only 37 percent of the deaths before anesthetization are found to have had more than one blood transfusion (500 cc. per unit) while 52 percent of those who survived to reach anesthesia had more than one. Of the 254 who died of shock after surgery 66 had no plasma therapy before admission to hospital, 140 had no plasma therapy after admission but before surgery, and 210 had none during or after surgery. Also, 87 received no blood therapy before surgery, 141 had none during surgery, and 181 had none after surgery. These facts suggest that at least some of the deaths occurred in men to whom inadequate amounts of plasma and blood were administered.

Table 59

POINT IN SURGICAL PROCESS AT WHICH DEATH OCCURRED, DEATHS FROM SHOCK, FIFTH U. S. ARMY HOSPITALS

Point in Surgical Process	Deaths from Shock		Percentage of 1,124 Explained Deaths
	Number	Percent	
Before arrival	25	4.8	2.2
On admission	55	10.5	4.9
Between admission and anesthesia	135	25.8	12.0
During anesthesia induction	6	1.1	0.5
During primary surgery	48	9.2	4.3
After primary surgery	254	48.6	22.6
Total	523	100.0	46.5

Snyder and Culbertson's data on cause of death are conveniently arranged by region of major wound, so that it is possible to inquire into the major causes of death among wounds of any particular location, as has been done in Table 60. Shock is the largest single cause of death for all major regions except intracranial, intravertebral, and maxillofacial. The second leading cause is far more variable, shock, peritonitis, and clostridial myositis each being given more than once.

A less detailed but valuable study of the cause of death was made by members of the Second Auxiliary Surgical Group in a review of their experience[40] in forward hospitals throughout the

[40] *Op. cit.*, section on Deaths in Forward Hospitals.

Table 60

LEADING CAUSES OF DEATH, FIFTH U. S. ARMY HOSPITALS BY REGION OF PRINCIPAL WOUND

Region of Principal Wound		First Leading Cause		Second Leading Cause	
Region	Number	Cause	Number	Cause	Number
Intracranial	297	Neural (brain) trauma and/or intracranial hemorrhage or clot	210	Shock	15
Intravertebral	27	Spinal cord trauma or hematomyelia	16	Shock	4
Maxillofacial	8	Tracheo-bronchial obstruction	2	—*	—
Cervical	25	Shock	11	Cerebral ischemia	4
Intrathoracic	138	Shock	70	Pneumonia	7
Thoraco-abdominal	212	Shock	118	Pigment nephropathy	12
Intra-abdominal and intrathoracic	59	Shock	25	Peritonitis	7
Intra-abdominal	408	Shock	179	Peritonitis	46
Abdominal wall	3	—	—	—	—
Upper extremity, soft tissue	4	Shock	2	—	—
Upper extremity, bone and soft tissue	10	Shock	3	—	—
Lower extremity, soft tissue	31	Shock	9	Clostridial myositis	8
Lower extremity, bone and soft tissue	114	Shock	41	Clostridial myositis	21
Unclassified multiple	114	Shock	46	Embolism	8

*One death was attributed to shock.

—Although cause of death is reported, no one is a leading cause.

Table 61

Primary and Secondary Cause of Death in Forward Hospitals, Second Auxiliary Surgical Group

Cause	Number		Percentage	
	Primary	Secondary	Primary	Secondary
Shock and Hemorrhage	*430*	*108*	*41.7*	*11.2*
Infection	*225*	*162*	*21.8*	*16.7*
Peritonitis	98	91	9.5	9.4
Anaerobic	58	12	5.6	1.2
Pneumonia	37	16	3.6	1.7
Generalized	24	28	2.3	2.9
Other	8	15	0.8	1.5
Circulatory Disorder	*98*	*18*	*9.5*	*1.9*
Embolisms	55	4	5.3	0.4
Myocardial failure	20	5	2.0	0.5
Other	23	9	2.2	1.0
Miscellaneous	*78*	*532*	*7.6*	*54.9*
"Injury"	44	513	4.3	53.0
Blast or blast injury	30	12	2.9	1.2
Other	4	7	0.4	0.7
Neurologic Conditions	*80*	*14*	*7.8*	*1.4*
Lacerated brain	56	8	5.5	0.8
Other	24	6	2.3	0.6
Urologic Condition	*55*	*14*	*5.3*	*1.4*
Anuria	54	14	5.2	1.4
Other	1	0	0.1	0
Pulmonary Condition	*26*	*91*	*2.5*	*9.4*
Atelectasis	18	15	1.7	1.6
Pulmonary edema	0	71	0	7.3
Other	8	5	0.8	0.5
Anesthesia and the Therapeutic Process	*24*	*28*	*2.3*	*2.9*
Anesthesia complication	15	0	1.5	0
Other	9	28	0.9	2.9
Gastro-intestinal Conditions	*15*	*2*	*1.5*	*0.2*
Intestinal obstruction	9	1	0.9	0.1
Other	6	1	0.6	0.1
Total Known	1,031	969	100.0	100.0
Total Unknown	104	166		
Grand Total	1,135	1,135		

war in North Africa, Tunisia, Italy, and France. Deaths which occurred after patients had left their care are not included in the study. The data have been grouped according to the categories of Table 57 and are shown in Table 61. In this series both a primary and a secondary cause were noted and are shown in the table. The deaths pertain, not to all deaths in the army area, but to those occurring among high-priority, non-transportable cases. Thus, the series tends to give undue weight to abdominal and thoracic injuries at the expense of head injuries. Despite this difference in its selection the series is reasonably similar to that of Snyder and Culbertson when comparable groupings are employed.* This comparison is made in Table 62 and reveals only one major inversion in the

Table 62

CAUSE OF DEATH AMONG WOUNDED, FIFTH U. S. ARMY SERIES COMPARED WITH SECOND AUXILIARY SURGICAL GROUP

Cause of Death	Percentages of Known Causes	
	Fifth Army 1944	Second Auxiliary Surgical Group* 1942-1945
Shock and hemorrhage	46.6	45.1
Neurologic conditions	21.3	8.4
Infection	16.2	23.6
Circulatory disorders	6.2	10.3
Urological disorders	6.0	5.8
Respiratory disorders	2.8	2.7
Anesthesia, etc.	0.7	2.5
Gastro-intestinal disorders	0.2	1.6
Total	100.0	100.0
Number of Deaths	1,124	953

*In computing these percentages 78 miscellaneous cases were omitted in the interest of comparability with the Fifth Army series.

relative importance of the various sets of causes, namely in the ranking of neurologic conditions and infection.

The great importance of shock is further emphasized by the report of the Second Auxiliary Surgical Group. It was estimated

*Of 1,165 cases handled by the Second Auxiliary Surgical Group, only 380 or 33 percent occurred in the Italian campaign from January to June 1944, after which the unit was assigned to Seventh Army. The Fifth Army Series does not cover the earlier 1942-1943 period.

Table 63

CAUSE OF SHOCK, EXPERIENCE OF SECOND AUXILIARY SURGICAL GROUP

Cause	Percentage of Cases
Contamination	28
Trauma	23
Hemorrhage	18
Contamination and trauma	14
Contamination and hemorrhage	10
Trauma and hemorrhage	7
Total	100

that 62 percent of the deaths in field hospitals occurred in men admitted in severe shock, and 18 percent in moderate shock. In etiology shock was attributed to trauma, hemorrhage, contamination, or some combination of these. An assessment of etiology was made and is shown here in Table 63. The analysis is not sufficiently parallel with that of the Fifth Army data to permit comparison,

Table 64

LEADING CAUSES OF DEATH, SECOND AUXILIARY SURGICAL GROUP, BY LOCATION OF MAJOR WOUND

Region of Body	Number of Deaths	First Leading Cause*		Second Leading Cause†	
		Cause	Deaths	Cause	Deaths
Abdominal	522	Shock	187	Peritonitis	68
Thoraco-abdominal	233	Shock	84	Anuria	24
Extremity	182	Shock	62	Anaerobic infection	33
Head, Face, Neck, Spine	102‡	Lacerated brain	47	Meningitis	9
Thoracic	96	Shock	21	Pneumonia	7

*There were, in addition, the following numbers of deaths allocated to hemorrhage: 31 abdominal, 16 thoraco-abdominal, 6 extremity and 9 thoracic. Hemorrhage was used in 15 percent of the shock and hemorrhage deaths reported by the Second Auxiliary Surgical Group, but in less than 1 percent of the shock and hemorrhage deaths reported by the Fifth Army.

†Excluding deaths from hemorrhage; for the head, face, neck, and spine, encephalomalacia with 9 deaths, vies with meningitis as the second leading cause of death.

‡Includes 8 cases of burns.

but it would appear from examination of Tables 63 and 58 that contamination or sepsis was less important in the latter series, as would be expected from the selection of the cases. In addition to shock, but far below it in numerical importance, the leading individual causes of death were found to be: peritonitis, anaerobic infection, lacerated brain, embolisms, and anuria.

In the report of the Second Auxiliary Surgical Group deaths are tabulated separately by body region so that it is possible to select the leading causes of death by region, as was done in Table 60 for the Fifth Army. The results, shown in Table 64, are essentially similar to those of the Fifth Army. Shock is the leading cause except for wounds of the head, face, neck, and spine, where brain damage takes priority. The second leading causes are the same as those listed for Fifth Army in Table 60, except for the head, face, neck, and spine, where meningitis replaces shock, and for thoracoabdominal wounds in which anuria replaces pigment nephropathy.

CHAPTER IV

EFFECTIVENESS OF WEAPONS

GENERAL PRINCIPLES

SURGICAL DATA alone do not provide the basis for complete evaluation of the effectiveness of weapons, and the war failed to produce the coordination of surgical and ordnance interest which is essential to the development of a systematic appraisal of weapons. During the war special studies were conducted in the laboratory by investigators seeking to learn more about wounding mechanisms and to establish first principles upon which ballisticians might create more effective weapons. The data considered here pertain almost exclusively to field studies, only a few of which are detailed and highly penetrating, but which contain the only information developed by the U. S. Army about the anti-personnel effectiveness of specific weapons used in the field by enemy troops in World War II. Moreover, they are typical of surgical effort in the field, and it behooves the military surgeon to know them in all their weakness and strength. Only a better and more general understanding of this area of investigation on the part of military surgeons will guarantee superior observational data in the future and prevent ill-considered judgments on the basis of inadequate or biased data. Information of the highest usefulness in describing and predicting the effectiveness of weapons can come, however, only through coordinated observation and experimentation on the part of medical and ordnance scientists.

The military situation is so complex and difficult of reduction to general categories and types that the contribution of anti-personnel weapons to military advantage still awaits definitive delineation. The ever-changing character of weapons and of the principles of their use makes it doubtful that anything approaching adequate understanding can be achieved at a level which would be readily applicable to individual tactical situations. Certain obvious but general principles are helpful, however, in directing the present discussion. The military usefulness of weapons must ultimately be described in terms of their effects upon individuals, and these effects may be roughly characterized as psychologic or traumatic. Whistles have been added to aerial bombs for psychologic effect, and surely some of the appeal of chemical weapons lies in their presumed psychologic effects. Observations on the fear men have of different weapons are quite limited, however, and there is no information on the extent to which capacity to generate fear correlates with military effectiveness. Except for chemical agents the design of pre-atomic weapons, at least, appears not to have been influenced in any important way by psychologic considerations. Apart from chemical and atomic weapons, therefore, the military effectiveness of present-day weapons is their traumatic effectiveness.

The trauma produced by anti-personnel weapons has two dimensions, extent and intensity, and their mutual interdependence creates most of the problems in the design of weapons. Since exploding missiles carry a far greater probability of hits than solid projectiles of the same size, those of sufficient size to contain an explosive charge are generally so designed. However, the basic problem of the effectiveness of the exploding missile is the question of how far to go in fragmenting the casing so as to produce more hits without reducing the summation of damage by creating too many minor hits and too few major hits, the terms minor and major referring to intensity of injury. Thus stated, the problem can be formulated mathematically[1] and could be solved if a satisfactory measure of intensity could be agreed upon. It is largely this lack of agreement on a measure of intensity which hinders definitive evaluation of anti-personnel weapons. The difficulty is that differing degrees of intensity vary in military value as the tactical situation changes. In one situation, where enemy capabilities for replacement are not great, as in the attack on an isolated strong point, weapons capable of only transient impairment of efficiency, but affecting a substantial part of the enemy force, may be of greater tactical value than weapons causing more permanent wounds to a much smaller number. In another situation a premium may be placed on lethal or permanently disabling effects. The basic

[1]Gurney, R. W.: A New Casualty Criterion, *Missile Casualty Report No. 7, 31 Oct. 1944*. National Research Council, Division of Medical Sciences, Unpublished.

question is sometimes asked in such terms as the following: Are 10 casualties losing 10 days each equivalent to 100 losing one day each? Part of the difficulty may be stated as one of assessing the immediate tactical advantage as against the long-term effect upon manpower, and there could obviously be no one solution to this problem.

Surgical observations made during World War II throw no light upon the probability of hits in relation to the weapons used. Although the number of men hit is reasonably approximated as the number of casualties, information as to the quantity and type of enemy weapons used is not available in sufficiently systematic form to permit computation of probabilities of hits. Conversely, although U. S. expenditure of ammunition is reasonably well recorded, it has thus far proved impractical to relate a given expenditure to a given number of enemy casualties, much less to do this by type of weapon. The surgical contribution lies rather in the sphere of determining the chance of death, serious injury, and the like among those hit by enemy weapons. In the simplest measure of intensity of trauma one merely computes the proportion of killed, or of killed and fatally wounded, among all those hit by a given type of weapon. The military significance of lethality, of course, cannot be specified precisely, but such information is fundamental to any general understanding of wound ballistics. One may go farther and assign weights to wounds of varying severity among the living, depending chiefly upon duration of hospitalization and upon the likelihood of return to combat. In the simplest case one could employ the mean days lost, for example, with some rule for assigning values for the deaths.

If no great progress has been made in maximizing the effectiveness of any one type of weapon, considerable advance does seem to have been made in increasing the effectiveness of weapons in general by providing a greater variety from which to choose in the light of the often unique constitution of the tactical situation. In any consideration of the lethality of weapons one must accept the fact that the tactical situation gives now one and now another weapon special advantage which cannot be expected to find full reflection in mere lethality percentages.

FIELD DATA ON LETHALITY OF WEAPONS

In World War I[2] the lethality of gas was about 1.4 percent, and of missiles about 19 percent of the killed and wounded, deaths after admission to medical installations being excluded. The latter figure is less than the World War II average of 23 percent, but is about the same as the figure of 20 percent for Infantry. Among Air Corps personnel the ratio was far higher at 64 percent. It must be assumed that the concept of a hit does not apply with equal force to ground and air casualties because so many of the latter resulted from damage to aircraft and pilot personnel rather than from hits by enemy missiles.

For casualties among ground troops in World War II there are three studies of special merit, those of Oughterson,[3] Tribby,[4] and Hopkins.[5] Oughterson's classic work is the most carefully done, the broadest in conception, and the most generally useful, but is limited in its applicability by the special tactical situation existing on Bougainville at the time of the study and by the weapons available to the Japanese. Tribby's data are the only specially studied observations on ground force casualties in the European area, but suffer from exclusion of the wounded. In order to use them one must combine them with Fifth Army data on the wounded, but with no assurance that the same definitions and terminology were used. Hopkins' data on the New Georgia and Burma operations are too few to have any considerable independent value but are in good general agreement with Oughterson's material. Other samples, of which there are at least 13, cover a much greater mass of experience, but depend ultimately upon the routine mechanism of recording the agent on the EMT of the killed and on the EMT and other medical records of the wounded. Since the killed are not routinely stripped, and the missile itself is seldom seen, one cannot credit records on the killed with a high order of accuracy. Those on the wounded are doubtless better, but still by no means perfect. The surgeon must often rely upon the testimony of the patient as

[2]Love, A. G.: *Op. cit.*, p. 76. The ratios there are based on a rough estimate of 1,000 killed outright by gas. Love's ratios of 1.4 and 23.2 give killed as a percentage of wounded. Here the ratio gives killed as a percentage of total hits.

[3]Oughterson: *Op. cit.*

[4]Tribby: *Op. cit.*

[5]Hopkins: *Op. cit.*

to the character of the missile causing his wound, and the patient himself is frequently a poor source of information. One has no concern, of course, over random errors in series as large as those which are available; it is the possibility of systematic error which is disturbing. The meaning of the term "gunshot wound" has already been cited as an example. Another possibility is that, at a later date in the war, the expectation came to be so general that shell fragments were the chief cause of wounding, that too many doubtful cases were ascribed to shell fragments. A final possibility is that the killed on whom there is no record of agent represent the effects of some one or a group of agents to a far greater extent than would be expected from the recorded data on those whose wounding agent is noted. There is no evidence that any of these biases either did or did not operate to a major extent. One can neither discard nor accept at face value the data in question, therefore, but can only present them in tentative fashion and point out their probable meaning.

Different sources provide varying degrees of detail, and for some types of weapon the number of observations is small. When the data on lethality of weapons were assembled for the accompanying table no determination was entered unless based on 100 or more hits. Those representing less than 200 hits are so indicated. This means that the tabled percentages are reasonably stable, although the arbitrary criterion adopted does not make them all stable to the same degree.* For larger numbers of hits the percentages are

*The 95 percent confidence intervals for percentages based on 100 or on 200 hits are:

Percentage Observed	*95 percent Confidence Intervals* 100 hits	*200 hits*
5	1.6 – 11.3	2.4 – 9.0
10	4.9 – 17.6	6.2 – 15.0
20	12.7 – 29.2	14.7 – 26.2
30	21.4 – 39.9	23.8 – 36.8

[1]Killed in action plus died of wounds.

[2]Based on autopsy exploration performed as part of special study of killed and wounded in action.

[3]I Corps, attacking mountain strongholds in drive on Baguio, etc., and into Cagayan Valley.

[4]Based on autopsy exploration performed as part of special study of the killed.

[5]These deaths were distributed by agent in proportion to known deaths by agent.

*Based on 100 to 199 hits. All others are based on 200 or more.

†Inflated by 345 KIA in air crashes – should be about 22 percent.

‡Contains only 37 KIA in air crashes.

–Not given in breakdown by agent or less than 100 hits reported.

Table 65

Lethality of Weapons used against U. S. Army Ground Troops, World War II

Date	Campaign, Unit, or Area	Number of Killed	Percentage of Killed Unknown for Agent[5]	Lethality (100 KIA/Hits) by Agent									
						Fragments and Blast							
								Fragments Only					
											Shells		
				All Agents	Bullets	Total	Blast Only	Booby Trap or Grenade	Bomb	Mine	Total	Mortar	Artillery
A: PACIFIC DATA													
Jan.-Feb. 44	Marshalls, 7th Inf. Div.[1]	170	14	14	27	4	—	—	—	—	4	—	—
1943-1944	New Georgia-Burma (Hopkins)[2]	66	0	22	28*	11*	—	—	—	—	—	—	—
Feb.-Apr. 44	Bougainville[2]	320	0	18	33	10	—	5	—	—	10	9	16*
Jun.-Jul. 44	Saipan, 27th Inf. Div.[1]	1,028	64	28	33	23	—	—	—	—	23	—	—
Jan.-Jun. 44	Southwest Pacific, Individual Medical Records	1,716	40	29†	34	15	5	6*	27	—	15	—	—
Jan.-Jun. 44	Pacific Ocean Area, Individual Medical Records	1,239	53	23‡	40	14	6*	8	12*	—	14	—	—
Oct.-Dec. 44	Leyte, XXIV Corps	1,420	17	25	29	16	—	—	—	—	—	—	—
Feb.-Mar. 45	Luzon, 25th. Inf. Div.[1] [3]	387	7	22	25	19	—	2*	—	—	22	13*	25
Jan.-Jun. 45	Luzon, 33rd Inf. Div.[3]	356	8	19	26	13	—	6	—	—	17	—	—
Apr.-Jun. 45	Okinawa, XXIV Corps	3,548	15	20	15	22	6	—	—	—	—	—	—
B: MEDITERRANEAN DATA													
1943	Tunisia, Sicily, Italy	1,530	25	23	41	17	6	—	—	20	18	—	—
Jul.-Aug. 43	Sicily, II Corps	735	46	22	31	19	—	—	—	26	17	—	—
Sept.-Nov. 43	Italy, 3rd Inf. Div.	607	1	23	31	21	—	—	—	—	20	—	—
Jan.-Mar. 44	Anzio, 3rd Inf. Div.	885	0	23	26	21	—	—	—	30*	21	—	—
1944	Italy (Tribby)[4]	1,000	0	23	16	25	11*	—	—	—	15	—	—
Jan.-Jun. 44	Mediterranean Theater, Individual Medical Records	11,415	34	24	26	26	5	5	30	18	28	—	—

more stable as far as sampling fluctuation is concerned. Much of the minor variation evident in the table is unaccountable and suggestive of some lack of homogeneity in the basic observations. The weight of the evidence suggests that bullets were more lethal than other agents in general, including shell fragments and blast. In the table there are two important exceptions, the XXIV Corps data for Okinawa, and Tribby's data. Since Tribby's data are among the three series arising out of intensive medical study, the deviation constitutes a warning that the conclusion just drawn from the table may be erroneous. It must be borne in mind, however, that Tribby studied only the killed and that it was necessary to combine his data with Fifth Army reports on the wounded for 1944 with no guarantee of comparable standards of classification. Tribby states[6] that:

> "The data concerning missiles are copied from the Emergency Medical Tags, with the important exception that the term High Explosive does not occur on these tags. We have placed all cases under this heading which obviously died as the result of having been hit by high explosive missiles but whose Emergency Medical Tags did not indicate a missile. Also included in this category are all cases for which there was definite evidence that the missile was erroneously stated on the Emergency Medical Tag but which were manifestly hit by high explosive missiles."

The extent to which Tribby found it necessary to alter the EMT entry is not indicated in his work, but it is worthy of mention that 3rd Infantry data for September to November 1943 credit about 26 percent of the killed to bullets, and for Anzio about 23 percent, whereas Tribby found only 11 percent to have been killed by bullets. These facts are cited, not to raise doubts as to Tribby's procedure, but to suggest the extent to which he may have found it necessary to alter EMT records. There is no assurance that the parallel data on the wounded were reviewed with the same care and criteria. Hence, it is possible that the low value of bullets means only that two unlike series have been combined. If the "true" lethality percentages for bullets and fragments are about the same, any systematic error involving both killed and wounded in the same proportion would not disturb the lethality percentages appreciably. However, if the errors were not of the same kind and proportion

[6]TRIBBY: *Op. cit.*

for the killed and the wounded, a serious disturbance of derived lethality estimates would result. In the case of the Okinawa data there is no reason to believe that any change occurred in methods of observation and reporting after Leyte, but the lethality figure for bullets is halved.

In constructing the table it was found that in many of the samples some of the killed were not distributed by agent. In these cases it was assumed that the unknowns could be correctly distributed by following the pattern of the knowns. It is conceivable, of course, that deaths from fragments should find their way into the unknown category more often than chance could indicate, as in cases of severe mutilation. For this reason it was believed that the lethality figures for bullets might be overstated in those cases where large proportions of the killed were arbitrarily allocated in the fashion described. By means of regression analysis it can be shown that there is a suggestive relationship* between percentage lethality and the percentage of killed which was distributed according to the pattern of the knowns. From the regression line, in turn, it can be calculated that, in cases in which the agent was known for all the killed, the lethality figure for bullets would average 25 percent. The four instances in the table in which this was true yield an average of 26 percent.

The more detailed data of the table are less satisfactory in terms of bulk. In six instances it was possible to segregate enough blast cases to make a lethality percentage meaningful. These average 6 percent, about one-fourth of the average for all agents. It seems likely that blast cases would be less subject to uncertainty than either bullet or fragment cases, and thus the recorded data seem reasonably trustworthy. Injuries credited to grenade fragments and booby-traps are separately reported in six samples which are in good agreement and suggest that the lethality of these weapons is low. Only one sample, however, that from the Individual Medical Records from MTO for the first half of 1944, gives information on grenades and booby-traps for the European area, so that the conclusion applies with less force to German weapons than to Japanese.

*The linear correlation coefficient of + 0.50 is barely significant at the 5 percent level. A least-squares fit gives an equation $Y = 25.47 + 0.17X$, where Y is the percentage lethality for bullets and X the percentage of the killed not classified as to agent.

The average value is five killed per 100 hit by fragments from grenades and booby-traps, about one-fifth of the average figure for all weapons.

Shell fragments vary considerably in their reported lethality, especially in the Pacific where the values average about 16 percent in contrast to 25 percent in the European area. The suggestion is strong that the artillery and mortar weapons used by the Japanese in the earlier phases of the Pacific war, when fighting was largely in jungles and on atolls, were less lethal than those characteristically employed in Europe. The reason for this is not obvious, and it is not presumed here to evaluate these weapons from an ordnance standpoint. One hypothesis suggested by the data, however, is that Japanese mortar fire, at least until Okinawa, was less lethal than artillery either in the Pacific or in Europe. In many of the Pacific samples fragments from artillery shells are surely far less important numerically than those from mortar shells and this may explain many of the low values observed for fragments. Only two Pacific samples give separate detail on mortar and artillery shell fragments. Their observations are shown in Table 66 and are numerically large enough to sustain the judgment that the differences lie outside the chance range. The available information does not suggest why the Luzon values should exceed those for Bougainville, however, and further examination reveals that only the set for artillery shell fragments manifests a difference which is outside the chance range.

Table 65 provides variable estimates of the lethality of bombs, although three series pertain to near-final tabulations of theater totals for the period indicated. They represent 68, 13, and 363 deaths in the order in which they appear in the table, so that numerically greater weight must be given to the MTO estimate of

Table 66

RELATIVE LETHALITY OF MORTAR AND ARTILLERY SHELL FRAGMENTS, TWO PACIFIC SAMPLES

Sample		Artillery		Mortar	
Year	Campaign	Total Hit	Percent KIA	Total Hit	Percent KIA
1944	Bougainville	193	*16.1*	693	*8.5*
1945	Luzon, 25 Inf.	578	*24.6*	198	*12.6*

Table 67

APPROXIMATE PERCENTAGES KILLED AMONG TOTAL HIT, BY AGENT AND BY THEATER

Agent	Pacific	Mediterranean
Bullet	23	23
Fragment and Blast	16	21
Blast only	5	5
Shell Fragment	14	22
Artillery	19	*
Mortar	10	*
Mine Fragment	*	17
Grenade or Booby-trap Fragment	5	5
Bomb Fragment	18	26
All Agents	21	20

*Not given in breakdown by agent, or less than 100 hits reported.

30 percent, about the same as that obtained for shell fragments. The four values for hits by land-mine fragments range from 18 to 30 percent and are based on 330, 78, 34, and 313 deaths in the order in which they appear in the table.

The foregoing may be summarized in tabular form with separate estimates for the Pacific and the Mediterranean experience. These estimates were made by first averaging the samples from the different areas and then adjusting the fatality percentages by agent so that the averages for all agents would agree with the slightly lower values based on AG tabulations for the two theaters. The amount of information behind each estimate may be judged from Table 65. According to these estimates, which apply to ground combat only, almost identical average ratios prevailed in the Pacific and the Mediterranean because the lower value for fragments and blast in the Pacific was offset by the greater frequency of hits by bullets.

To the presentation of all the pertinent data on lethality, drawn from numerous sources with no guarantee of comparability, can be added the highly reliable findings of Oughterson's group[7] in its

[7]OUGHTERSON: *Op. cit.*

Table 68
RATIO OF KILLED TO TOTAL HIT BY WEAPON,
OUGHTERSON AND HOPKINS' DATA

Weapon	Men Hit	Men Killed	
		Number	Percent
Machine gun	261	110	*42*
Rifle	522	138	*26*
Artillery	218	33	*15*
Mortar	734	65	*9*
Grenade	260	14	*5*
Other	89	26	*29*
Total	2,084	386	*19*

study of 1,788 casualties on Bougainville. Because they are essentially similar and serve to extend Oughterson's data and give it somewhat greater numerical stability, Hopkins' figures have been added to them in Table 68. The weapons are ranked according to lethality percentage, since most of the differences among them exceed chance expectation by wide margins. The only weapons differing insignificantly are mortar and grenade which compete for last place in the list. The reader is referred to Oughterson's original report for the identity of the Japanese weapons used at Bougainville. About 12 percent of the hits and 16 percent of the total deaths were produced by U. S. weapons according to the Oughterson report, and later in this discussion will be found comparative data on U. S. and Japanese weapons. The ranking and the values, of course, are partly a function of the peculiar tactical situation existing on Bougainville at the time of the Oughterson study and cannot be extended too readily to the entire Pacific war. On the whole, however, these values are close to those derived from a study of all the Pacific data and shown in Table 67. The effect of the tactical situation may have been to increase the lethality of bullets. U. S. troops were defending a perimeter in the jungle against repeated enemy attacks and attempts at infiltration. Although the Bougainville data are reasonably consistent with other reported Pacific material, no good coverage of the Ryukyus Campaign is available, and it may be presumed that the Bougainville data do not represent Japanese weapons at their best, especially artillery.

BOUGAINVILLE STUDY

Lethality. In any study as small as the Bougainville ballistic study the influence of body region struck may assume importance in determining average lethality for the hits under consideration. Up to this point in the discussion lethality has been defined in terms of the ratio of the killed to the hit, largely because most of the data are presented in this form, and in the available source-material the probability of death after wounding is less variable by weapon than is the probability of being killed if one is hit. In the case of the Bougainville sample the data are reported in such fashion that it is possible to evaluate weapons in relation to specific regions of the body only if *total* deaths (KIA plus DOW) are used. This is done in Table 69 for the head alone and for head, chest, and abdomen combined in order to remove the effect of hits on regions of varying vulnerability. If multiple hits are excluded, death came to 38 percent of the men hit in the head, to 38 percent of those hit in the chest, and to 42 percent of those hit in the abdomen. These three regions, then, are relatively homogeneous with respect to the chance of death (KIA or DOW) as determined in the Bougainville study. For comparison the second column of Table 69 gives the percentage killed among the hit in all regions. Plainly the relative lethality of weapons as determined on the basis of the killed among the hit, regardless of region, is maintained when hits in the more vital regions are studied. The only change in the ranking of the weapons pertains to rifle and artillery hits on the chest and abdomen.

In terms of total fatality it is also possible to compare U. S. and Japanese weapons as used in the most critical phase of the Bougainville campaign. Although the wound ballistics team was unable to make any real study of enemy casualties, there were enough hits on U. S. soldiers by U. S. weapons to deserve separate study and comment. Table 70 gives the Bougainville data for major weapons. There are two important differences worthy of scrutiny, namely those pertaining to the percentages for artillery and for the grenade. The difference for artillery is striking and, despite the small size of the samples, so large as to be expected by chance less often than once in a hundred trials. Most of the deaths and perhaps half of the hits were caused by "shorts." The grenade percentages may also seem noteworthy. The Japanese grenade attained a

Table 69

Deaths (KIA plus DOW) among Hits, by Region of Body and by Type of Weapon, Bougainville Study

Weapon	All Areas			Head, Chest, Abdomen		Head Only		Chest and Abdomen	
	Hits	Percent KIA	Percent Deaths*	Hits	Percent Deaths*	Hits	Percent Deaths*	Hits	Percent Deaths*
Machine gun	152	*48*	*58*	94	*76*	52	*77*	42	*74*
Rifle	445	*27*	*32*	215	*53*	119	*55*	96	*50*
Artillery	193	*16*	*22*	82	*40*	45	*31*	37	*51*
Mortar	693	*9*	*12*	246	*19*	128	*16*	118	*22*
Grenade	224	*5*	*6*	70	*10*	32	*3*	38	*16*
All weapons†	1,788	*18*	*22*	729	*38*	384	*38*	345	*39*

*100 (KIA+DOW)/Hits.
†Includes hits by mines, etc., not shown separately.

notorious reputation as a poor weapon, and it would be desirable to have more information on the U. S. grenade. The 19 recorded hits by grenade fragments provide a small basis for comparison, but their mortality is significantly higher than that for the 205 hits by Japanese grenade fragments.

Table 70

DEATHS AMONG MEN HIT BY U. S. AND BY JAPANESE WEAPONS, BOUGAINVILLE

Weapon	U. S. Weapons		Japanese Weapons		U. S. and Japanese Weapons	
	Hits	Percent Deaths	Hits	Percent Deaths	Hits	Percent Deaths
Machine gun	1	*100*	151	*58*	152	*58*
Rifle	52	*31*	393	*32*	445	*32*
Artillery	42	*40*	151	*17*	193	*22*
Mortar	34	*12*	659	*12*	693	*12*
Grenade	19	*26*	205	*4*	224	*6*
All Weapons*	219	*29*	1,569	*21*	1,788	*22*

*Includes those not listed separately.

Other Indices of Effectiveness. The Oughterson report provides other information on the effectiveness of weapons which may be summarized briefly in the form of rough measures of severity. These are:

(1) The proportion of all extremity hits (killed and wounded) involving fracture;
(2) The proportion of the living wounded who were incapacitated according to arbitrary surgical criteria;
(3) The proportion of the living wounded who were evacuated to the rear; and
(4) The proportion of the living wounded who were evacuated to the Z/I.

The numerical values are given in Table 71 together with the number of hits or of surviving wounded upon which each percentage is based. For purposes of assessing traumatic effectiveness of weapons it is useful to distinguish between, say, the ratio of deaths plus evacuees to all who were hit, and the ratio of the evacuees to all the living wounded. A measure like the former may be used to give a summary of losses up to any point, the latter to derive estimates which are independent of the killed. The first panel of Table 71 includes three measures which refer to all those hit and correspond to three degrees of certainty with which loss may be described. These are death, evacuation to the Z/I, and evacuation to a rear echelon. The ranking of the weapons does not change as the other losses are added to the deaths, but the relative differences among them become somewhat smaller. The grenade, which was found to cause only about one-fourth the number of deaths per hit observed for all weapons, has an effectiveness ratio of almost two-thirds of the average when evacuation to the rear is added to death as a cause of attrition. When the index is the percentage of hits resulting in death, the weapons may be ranked in the order in which they appear in Table 71 with confidence in the statistical significance (at the 5 percent level) of each ranking. When the other two indices are employed, the ranks are unchanged, but several of the relative differences are smaller and statistically insignificant. In concept the index for fracture of the extremities is more like those in panel B, but appears in panel A because its base is all those hit in the extremities rather than merely the wounded. The three measures of severity of wound are reasonably similar in the evaluation they permit of the various weapons, especially in their tendency to minimize the differences among artillery, mortar, and grenade. The designation of incapacitation was made somewhat arbitrarily by the Oughterson team, on the basis of surgical principles. The types of wounds termed incapacitating are:

(1) Those of the head and central nervous system producing unconsciousness or paralysis.

(2) Those of intrathoracic structures producing hemorrhage and shock.

(3) Those of intraperitoneal structures producing hemorrhage and shock.

(4) Those of the extremities producing fractures of long bones, severance of major blood vessels, or major traumatic amputations; and extensive wounds of soft tissue producing shock.

Different results are obtained with different indices of effectiveness, but on the whole the rifle and the machine gun seem to cause

Table 71

SUMMARY OF INDICES OF EFFECTIVENESS OF WEAPONS, BOUGAINVILLE CAMPAIGN

Weapon	Number Hit	A: Percentage of all Hits Resulting in			
		Death	Death & Evacuation to Z/I	Death & Evacuation to Rear	Fracture of Extremities*
Machine gun	152	58	78	86	43
Rifle	445	32	54	75	44
Artillery	193	22	36	56	17
Mortar	693	12	29	53	12
Grenade	224	6	23	41	9
All weapons†	1,788	22	40	61	23

Weapon	Number of Living Wounded	B: Percentage of Living Wounded Resulting in		
		Incapacitation	Evacuation to the Rear: Total	Evacuation to the Rear: To the Z/I
Machine gun	64	41	66	48
Rifle	302	30	63	32
Artillery	150	11	44	18
Mortar	611	14	47	19
Grenade	210	13	37	18
All weapons†	1,393	19	50	23

*Among hits sustained by extremities.
†Including weapons not listed.

more death and disability per man hit than the other weapons used by the Japanese in the Bougainville Campaign. Information on the probability of hits, however, would be needed in order to assess their value further.

CHAPTER V

LOCATION OF HITS AND WOUNDS

SURFACE AREA AND POSITION OF THE BODY

AN ANALYSIS of the distribution of hits and wounds must start from a consideration of certain elementary characteristics of the human body. Most important among these is its surface area which has been studied by several investigators[1-4] on the basis of rather limited work with statues, anatomical drawings, and photographs. Rather considerable variation in such measurements attends changes in position, and no investigator has provided adequate data on the position men occupy when hit. Burns and Zuckerman have accorded appropriate importance to this aspect of the problem and have arbitrarily used an average of standing, kneeling, and prone positions to represent the target area presented by the human body. Palmer[5] interviewed 100 men who became casualties in the Cassino area and learned that 90 were advancing at the time of injury, 40 being erect, and the rest lying down, kneeling, or under cover. Five were on guard and five were wounded while carrying dead out of the firing zone. The most extensive data of this type were gathered by the Oughterson team[6] during the Bougainville Campaign. Their findings are given in Table 72 and show that 37 percent of the men hit were standing, 20 percent sitting, 22 percent prone, 9 percent in pillboxes in unspecified positions, and 12 percent in trench-holes.

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[1]LONGMORE, T.: *Op. cit.*, p. 591.

[2]BURNS, B. D. and ZUCKERMAN, S.: *The wounding power of small bomb and shell fragments*, British Ministry of supply, Advisory Council on Scientific Research and Technical Development, RC 350 (October 7, 1942).

[3]BERKOW, S. G.: A method of estimating the extensiveness of lesions (burns and scalds) based on surface area proportions. *Arch. Surg.*, 8:138, 1924.

[4]MCMILLEN, J. H. and GREGG, J. R.: *NRC Missile Casualties Report* No. 12.

[5]PALMER, A.: *Specimen Casualty Survey Carried out in the Cassino Area, Jan. 20-27, 1944*. Unpublished memorandum in files of Historical Division, Office of the Surgeon General.

[6]OUGHTERSON, A. W. *et al.*: *Op. cit.*, pp. 198-202.

Table 72

POSITION AND COVER OF MEN HIT IN BOUGAINVILLE CAMPAIGN

Position	Under Cover	Not under Cover	Total	
			Number	Percent
Standing	13	567	580	*37*
Sitting	28	285	313	*20*
Prone	35	312	347	*22*
Pillbox	140		140	*9*
Trench-hole	177		177	*12*
Total	393	1,164	1,557	*100*

The term "standing" pertains to erect posture, or the position assumed when walking or running. The term "sitting" applies to the sitting, crouching, or kneeling positions. As mentioned earlier, there are no accepted markings for the regions of the body, so that variation, at times considerable, will occur among measurements of the areas into which the average human target may be subdivided.

Various estimates of surface and projection area are brought together in Table 73 for purposes of comparison. Several of them suffer from lack of detail concerning subdivisions of the upper portions of the body, and all but the Burns and Zuckerman estimate pertain to the erect position. Despite the evident care with which McMillen and Gregg analyzed anatomic drawings based on an average of 50 Negro men, restriction to the erect position and omission of projection areas for hands and feet, and for the head when the dorsal view was studied, necessarily limit the value of their data for the purpose of describing the *average* human target. The estimates of Burns and Zuckerman are, therefore, preferred. The general agreement among the several estimates is excellent for the upper extremities and for the trunk plus the head and neck regions. The fact that McMillen and Gregg omitted the hands and feet partly explains the lower percentages for the extremities in their series and it may be presumed that adjustment for this omission would align the estimates rather well for the extremities and for all other areas combined. For the separate regions other than those of the extremities the observations are too few to test agreement, but the estimate of Burns and Zuckerman may seem high for head and neck regions. Actually, as will be shown later, this region, as the locus of the major sensory equipment in the human, is probably exposed far more than even the Burns and Zuckerman value would suggest. Continuous appraisal of his situation *vis-à-vis* the enemy forces the foot-soldier to expose his head more often than any other part of his body, and truly appropriate allowance for position of the body could be made only on the basis of an extended special study. For present purposes, the estimates of Burns and Zuckerman are the best available to represent body area in the comparisons which follow.

Table 73

COMPARATIVE ESTIMATES OF PERCENTAGE DISTRIBUTION OF SURFACE AREA OF HUMAN MALE BODY BY BROAD ANATOMICAL REGIONS

Region	Percentage of Total Body Area			
	Burns and Zuckerman	McMillen and Gregg	Longmore	Berkow*
Head and Neck	12	6	9	
Thoracic	16 } 27 } 39	} 41 } 47	} 29 } 38	} 42
Abdominal	11			
Upper Extremities	22	20	21	19
Lower Extremities	39	33	41	39
Total	100	100	100	100

*Berkow reported head only as 6.2 percent, and neck plus trunk as 35.8 percent.

DIFFERENCES AMONG WEAPONS

Weapons employed by the enemy are possibly of some importance in determining the location of hits, although evidently far less so than position of the body. Any importance they might possess in this regard would, of course, vary with the tactical situation. Where combat is at close quarters, and ambush and sniping are frequent, directed fire may assume more importance than usual, and hits upon vital areas may be correspondingly more frequent. Under other circumstances, where fragments predominate, and weapons cannot be aimed at particular body regions, missiles will tend to be randomly distributed in space and hits will be a function of the frequency and extent to which the various regions of the body are exposed.

The several samples of data gathered during the war suggest that there are characteristic differences among weapons with respect to the regional distribution of hits, although the differences may well stem more from the tactical situation, the terrain, and the cover available than from the weapons *per se*. The one outstanding difference found in all seven samples studied is the greater frequency with which bullets strike the chest. A summary of the available data appears in Table 74. The samples are not all of comparable size or quality. That for the 33rd Infantry Division, and the Hopkins sample pertaining to New Georgia and Burma, reveal no significant differences between bullets and fragments, but all the rest display some variation. A detailed study of individual types of missile can be made only from Oughterson's data on the Bougainville Campaign. For the rest the only practicable separation is between bullets, on the one hand, and fragments from shells, grenades, and the like on the other. The body of the table consists of ratios of observed to expected hits for bullets or, in the case of the Bougainville sample, for individual missiles, the expected number of hits being based on the regional distribution for *all* missiles, including bullets. The percentages would diverge even more widely from 100 if the standard were not all missiles but all other missiles. Percentages are entered only if they are based upon statistically significant differences.

Table 74 reveals an excess of bullet hits in the chest and a deficit in the extremities, particularly the lower extremities. Both bullets and fragments strike the head more frequently than projection area data would lead one to believe, but only in the case of the Bougainville sample are bullets credited with proportionately more head hits than fragments and this applies only to machine gun bullets. That machine gun bullets should strike the head with greater frequency than shell fragments would seem explicable only by the advantage possessed by the machine gun bullet in having been more or less aimed. If so, this attribute should be shared by rifle bullets. Unfortunately the Bougainville sample is too small to permit any decisive answer to the question thus raised.* In their discussion of

*Rifle bullets made head hits 29 percent of the time, machine gun bullets 39 percent, and all others 24 percent. Although the difference between the 39 percent and the 24 percent is very reliable, the difference between the two types of bullet is significant only at the 5 percent level, and the third difference is quite unreliable.

Table 74

Percentage of Expected Hits in each Region Credited to Bullets or other Missiles in Various World War II Samples, Significant Deviations from Expectation only

Sample			Region of Body				
Year	Unit, Campaign, Area	Size†	Head, Face, Neck	Thoracic	Abdominal	Extremities: Upper	Extremities: Lower
			A: Percentage‡ of Expected Hits Credited to Bullets, Various Samples				
1944	3rd Inf., Anzio	2,790		126			
1945	33rd Inf., Luzon	1,188					
1944	XXIV Corps, Leyte	5,739		116		95	94
1945	XXIV Corps, Okinawa	20,117	86	118	115		
1944	7th Inf., Marshalls	1,114		130	147	84	
1943-1944	New Georgia and Burma	302					
1944	Bougainville	1,410	118				74
Agent			B: Percentage‡ of Expected Hits Credited to Specific Missiles, Bougainville Sample				
	Artillery Shells						
	Grenades		74§				130§
	Mortar Shells						114
	Rifle Bullets						83
	Machine Gun Bullets		146		167§		48

†These numbers differ from sample sizes given earlier because of the exclusion of unknowns.

‡A percentage greater than 100 indicates that the particular region was hit proportionately more often by bullets (or by other missiles in the case of the Bougainville data) than was true for all weapons. Similarly, a percentage below 100 indicates a deficit of hits in the particular region.

§All percentages are based on differences which are significant at the .01 level except those marked with this reference, which are significant at the .05 level.

the data, Oughterson and co-workers incline strongly to the thesis that it is exposure of body area rather than the aiming of missiles which explains the location of hits. The differences noted in the above table are consistent with this view only if one assumes that the proportions of the human target differ somewhat for bullets and fragments because these missiles find their mark when men are in somewhat different positions. Oughterson's data on this point are worthy of note. If the standing, sitting, and prone positions are compared for bullets and fragments hitting men without cover, only small differences characterize the proportions. For bullets the percentages are 52, 26, and 22 for the positions in the order given above, whereas for fragments they are 46, 24, and 30. If all hits are compared, the percentages are 45, 23, 21, and 11 for bullets, and 33, 18, 23, and 26 for fragments, the order being standing, sitting, prone, and pillbox or trench-hole. Even these data, however, do not prove that the target is characteristically different for the two types of missile, for they do not provide precise enough weights to be assigned to the various body regions, and even the positions assumed in pillboxes and trench-holes are not specified. The relative importance of aiming for the regional distribution of hits by bullets must, therefore, remain conjectural. It can only be said that any effect is small in comparison with the characteristics of the human target.

ENVIRONMENTAL PROTECTION AND BODY ARMOR

In addition to posture and the weapons themselves a third determinant of body location of hits may be termed environmental protection. The most obvious environmental protection derives from features of the terrain which are more appropriately subsumed under body-posture conceived in relation to the composition of the human target. Of considerable interest is the protection afforded by land vehicles, especially armored ones, aircraft, and such individual gear as the helmet and the flak suit for flyers. One small British study[7] of the distribution of wounds among tank crews suggests that head hits may have been more frequent for men in tanks than for dismounted infantry, but no reliable body of U. S. data is

[7]Military Intelligence Division, WDGS, *Military Attaché Report from Great Britain*, subject: Casualties amongst Armored Units, Report No. R2192-46, dated 9 July 1946. SGO Medical Intelligence File No. 20566.

yet at hand to test this suggestion and data for the entire Canadian 4th Armored Division[8] are quite like those for infantry in general. For air crews there are ample data, but they hardly provide an unequivocal answer to the question of regional distribution. This is primarily for two reasons:

(1) The killed are too seldom available for study to permit reliable estimates to be made; and

(2) Most data pertain to bomber crews equipped with flak suits which undoubtedly reduced the proportion of hits in the region of the trunk.

Except for the effect of body armor and of possible differences in characteristic posture there is no reason to expect air crews to have a regional distribution of hits any different from infantry.

Two main sources of data may be relied upon to illustrate the general order of the differential produced by body armor. Grow and Lyons[9] compared wounds (WIA only) sustained before and after institution of the flak suit among the bomber commands of the U. S. Strategic Air Forces in Europe (principally the Eighth Air Force). Their data, given in Table 75, suggest strongly that the use of armor, which was by no means universal among bomber crews, reduced wounds of the trunk to such an extent that the regional distribution of wounds shifted markedly. From 19 percent

Table 75

REGIONAL DISTRIBUTION OF WOUNDS BEFORE AND AFTER INTRODUCTION OF BODY ARMOR, U. S. STRATEGIC AIR FORCES

Region	Percentage of Total Wounded	
	Before Armor Mar - Sept 1943	After Armor Nov 1943 - May 1944
Head, Face, Neck	28	28
Thoracic	13	6
Abdominal	6	5
Extremity	53	61
Total	100	100

[8] Military Intelligence Division, WDGS, *Military Attaché Report from Great Britain*, subject: Abstracts from Quarterly Report, 4th Canadian, Report No. R149-45, dated 6 Jan 1945. SGO Medical Intelligence File No. 13827.

[9] GROW, M. C., and R. C. LYONS: Body armor, a brief study on the development, *The Air Surgeon's Bulletin*, 2:8-10, Jan. 1945.

of the total, trunk wounds declined to 11 percent. The difference was absorbed entirely by the extremities, according to these data, perhaps because of concomitant improvements in equipment for protecting the head. A second report, prepared by Palmer,[10] compares the regional distribution of flak hits (WIA plus KIA) among armored and unarmored crew members. Palmer's data, shown in Table 76, reveal a significant change in the proportion of hits in the

Table 76

REGIONAL DISTRIBUTION OF FLAK HITS AMONG ARMORED AND UNARMORED MEMBERS OF BOMBER CREWS

Region	Percentage of Total Hit	
	Unarmored	Armored
Head, Neck	16.1	16.1
Thoracic	9.8	5.5
Abdominal	3.5	2.7
Upper Extremity	26.5	32.5
Lower Extremity	44.1	43.2
Total	100.0	100.0
Number of Hits	571	1,075

region of the trunk. Expressed in this fashion the data are not entirely suitable for judging the efficacy of the flak suit, which requires some basis of estimating not merely the percentage distribution of hits but also their expected number, because any saving occurred through avoidance of expected hits. Data collected by Grow on hits of armored and unarmored crew members and published in *Health*[11] suggest that reductions in expected hits were on the order of 50 to 80 percent for the part of the head covered by the helmet, and for the thoracic and abdominal regions. It was also estimated there that body armor for ground troops, covering 65 percent of the area of chest and abdomen, and capable of screening out 95 percent of the fragments normally capable of wounding or killing men on the battlefield, but having no significant effect upon bullets, would reduce the expected number of casualties by

[10]PALMER, A.: *Eighth Air Force Battle Casualty Survey, 1944.* Unpublished manuscript in files of SGO Historical Division.
[11]Issue of 31 May 1945, p. 5.

8.8 percent, of which 6.1 would otherwise have been wounded and 2.7 percent killed. Relative to the number in each category of casualty these savings would amount to 12 percent of the expected number of killed and 8 percent of the expected number of wounded. Such estimates are, of course, little more than informed guesses, as it has not yet been demonstrated that a given suit of armor is capable of stopping a given proportion of missiles, although the problem is hardly an insoluble one at the experimental level. It will be noted that the estimates credit the armor with no advantage against bullets, although any substantial piece of armor would surely stop some bullets.

Zuckerman's ballistic group at Oxford made an experimental study of the value of the flak suit in which[12] it concluded that 10 percent of all hits, and 20 percent of the fatal hits, would be saved by the suit. These experiments also showed that the 22-pound flak suit stopped all fragments weighing less than 0.44 grams and moving at less than 2,000 feet per second. The flak suit weighed about twice as much as the T-62 armored vest which, in the preceding paragraph, served as the basis for the computations on the effectiveness of the armor for ground troops.

Only the U. S. Army Air Forces are known to have made significant use of body armor during World War II, although toward the end of the war the U. S. Navy embarked upon a large program of inserting plastic armor plates in the life-jackets worn by combat crews. Despite the lack of experimental evidence, armor for ground troops was summarily dismissed by responsible military authorities early in the war on the grounds of impracticability. Only at the end of the war in Europe was the Ordnance Department ready with a suit of armor which the Army Ground Forces regarded as suitable for testing under battle conditions, and by the time the suits could be shipped to the Pacific for test the war had ended. The article in *Health* for 31 May 1945 concluded with the following paragraph which the authors still regard as a fair summary of their views.

"In view of the wide range of possibility presented by modern light-weight materials, it would appear essential for the Army to do intensive work in the body armor field, not only from the bal-

[12]*An Experimental Study of the Value of the American Flak-Suit against Fragments*, Ministry of Home Security, Research and Experiments Department (Oxford Extra-Mural Unit), R. C. 434, reprinted by National Research Council as Missile Casualties Report No. 5.

listic point of view, but more particularly from the standpoint of the *costs* of using armor or protective garments of specified characteristics, e.g., weight, and the *gains* to be realized. There is apparently a paucity of information on the acceptability of possible protective devices, most work by the Army having been confined to ballistic tests of materials. Lack of such information may be partly responsible for the previous notion that body armor was an interesting but impractical idea, whereas it now seems clear that a more positive and experimental approach is indicated. If body armor for ground troops follows the course of body armor for air troops, the essential thing is to sell the men on the idea and to issue the material without waiting for the perfect garment or device to be developed. Improvements can come later. For this purpose studies need to be made into how best to evaluate such protective devices, how to overcome any initial objection which troops may offer, how to improve the design for maximum protection per unit of weight, what materials are best, what weight limits can be set, what variations in design should be made for different military occupations, and the like. Evaluation of the protection afforded by armor can best be done by skilled teams of ordnance and medical experts on the field of battle. Very little of such work has been done during the war thus

Table 77

RESULTS OF HEAD HITS ON MEN WITH AND WITHOUT HELMETS, BOMBER CREWS

Helmet	Total	Killed	Wounded	Unhurt
Without	185	65	120	0
With				
Observed	108	31	19	58
Expected*	108	38	70	0
Saving*	—	7	51	58

*Calculated on the basis of the 185 hits on men not wearing helmets.

[1]Distributions are based on the major wound and are either given or adjusted to equal the total number of men hit rather than the number of wounds.

[2]Special studies by medical teams or individuals.

*Individual Medical Records.

†The following were omitted, chiefly because of duplication: Bougainville, Marshalls, Anzio, and Palmer's data on the 8th Air Force.

‡As explained later in the text, a larger amount of material on WIA, particularly from ETO, and some additional data on the killed provide a distribution which is considered more representative of World War II combat as a whole.

§The killed are represented by a sample of 1,173.

Table 78

Percentage Distributions of Body Area and of Hits[1] by Region of Body

Date	Unit, Campaign, Area	Size	Head, Face, Neck	Thoracic	Abdominal	Extremities Upper	Extremities Lower	Total
	Body Area							
	Burns and Zuckerman	—	12	16	11	22	39	100
	Hits (KIA + WIA), World War II							
Jan.-Feb. 44	7th Inf., Marshalls	1,168	24	11	6	34	25	100
1943-1944	New Georgia-Burma (Hopkins)[2]	296	25	20	8	20	27	100
Feb.-Apr. 44	Bougainville (Oughterson)[2]	1,788	28	17	8	21	26	100
Jan.-Mar. 44	3rd Inf., Anzio	3,854	22	18	9	51		100
Jun.-Jul. 44	27th Inf., Saipan	3,669	18	11	6	40	25	100
Jan.-Jun. 44	SWPA, MD Form 52*	5,621	27	14	10	23	26	100
Jan.-Jun. 44	POA, MD Form 52*	5,226	27	12	11	24	26	100
Jan.-Jun. 44	MTO, MD Form 52*	47,128	26	11	11	20	32	100
Oct.-Dec. 44	XXIV Corps, Leyte	5,932	25	14	9	26	26	100
Feb.-Mar. 45	25th Inf., Luzon	1,834	21	19	8	23	29	100
Jan.-Jun. 45	33rd Inf., Luzon	1,870	25	19	8	22	26	100
Apr.-Jun. 45	XXIV Corps, Okinawa	20,117	22	14	8	26	30	100
Nov. 42-May 45	8th Air Force, ETO	8,355	28	11	7	54		100
Jul.-Aug. 43	II Corps, Sicily	3,674	20	14	7	59		100
Apr.-Nov. 44	5th Army (Tribby)[2]	5,000	19	14	7	25	35	100
Jun.-Aug. 44	8th Air Force, ETO (Palmer)[2]	1,117	24	5	2	25	44	100
	Average of above Samples†	—	25	13	9	23	30	100
	Final Estimate, World War II‡	—	21	13	8	23	35	100
	Hits (KIA + WIA), US Civil War§	—	15	23		31	31	100

far, and present information is sadly deficient in consequence, but if the Army is to explore the usefulness of body armor such studies must have high priority and be skillfully conducted."

There is no doubt that the M-1 helmet employed by ground troops during the war prevented a considerable number of deaths and non-fatal wounds. One is compelled to believe that head hits would have been much more frequent without it, but the size of the differential defies estimation. The only data on the helmet bearing on the point are those of Grow to which reference has already been made and which are reproduced in Table 77. However, they apply only to that region of the head which the helmet covers. For the entire head region the savings would be less than the indicated 58 out of 108, or 54 percent. For the entire head, face, and neck region the saving should be about half, or 27 percent. But if 27 percent of all missiles striking this region fail to produce casualties because of the protection afforded by the helmet, then it may be estimated that without the helmet, the head would sustain enough more hits to increase the proportion of hits there to 29 percent. In other words, the head, face, and neck are exposed so much that they represent perhaps as much as 29 percent of the human target.

DISTRIBUTION OF HITS AND WOUNDS IN WORLD WAR II

The regional distribution of hits was reported in various samples during the war, including January through June 1944 admissions in the Mediterranean Theater, the Pacific Ocean Areas, and the Southwest Pacific Area, as represented by Individual Medical Records and coded by the Medical Statistics Division, SGO. In the light of their origin in combat reports for the most part, and the

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*Data not available.

[1]Distributed in proportion to the knowns. Some samples probably omit the unknowns.

[2]Includes 119 DOW.

[3]KIA in air crashes are omitted from sample size. Data are based on Individual Medical Records.

[4]Excluded because of duplication with other samples are: Palmer's data on 8th Air Force, and Anzio.

[5]Loeffler, F.: *General-Bericht über den Gesundheitsdienst im Feldzuge gegen Dänemark*, 1864, Berlin, 1867 Erster Theil.

[6]Sauerbruch, F.: Cor-BL. f. Schweiz, *Aerzte, 46*: 1315, 1916.

[7]Year of publication of report.

Table 79

Percentage Distributions of Body Area and of Fatal Wounds Among the Killed

Sample				Percentage Distribution by Region of Body					
Date	Unit, Campaign, Area	Size	Percent Unknown[1]	Head, Face, Neck	Thoracic	Abdominal	Extremities Upper	Extremities Lower	Total
	Body Area								100
	Burns and Zuckerman			12	16	11	22	39	
	US Killed in World War II								
	Special Studies								100
Feb.-Apr. 44	Bougainville (Oughterson)	320	29	52	34	10	1	3	
1943-1944	New Georgia-Burma (Hopkins)	66	0	50	50	0	0	0	100
1944	5th Army (Tribby)[2]	1,000	2	37	29	17	7	10	100
Jun.-Nov. 44	8th Air Force (Palmer)	164	8	43	28	10	19		100
	Other Studies								
Jul.-Aug. 43	II Corps, Sicily	735	74	42	28	11	19		100
Jan.-Mar. 44	3rd Inf., Anzio	862	35	45	34	14	7		100
May-Jun. 43	7th Inf., Attu	552	2	42	36	15	7		100
Jun.-Jul. 44	27th Inf., Saipan	892	73	31	10	13	29	17	100
Jan.-Jun. 44	SWPA, Theater[3]	1,365	53	51	28	12	3	6	100
Jan.-Jun. 44	POA, Theater[3]	1,201	56	54	23	15	4	4	100
Jan.-Jun. 44	MTO, Theater[3]	11,086	40	49	21	17	4	9	100
Oct.-Dec. 44	XXIV Corps, Leyte	1,391	27	50	31	12	4	3	100
Jan.-Jun. 45	33rd Inf., Luzon	356	12	47	33	13	1	6	100
Apr.-Jun. 45	XXIV Corps, Okinawa	3,505	37	45	30	16	2	7	100
Nov. 42-May 45	8th Air Force	679	0	38	25	15	22		100
	Averages								
	Four Special Studies	—		41	31	14	6	8	100
	All Studies[4]	—		47	25	15	5	8	100
	Killed in other Wars								
1860-1865	US Civil War	1,173	0	41	51		3	5	100
1864	Danish War (Loeffler)[5]	387	0	53	31	12	0	4	100
1863-1865	New Zealand War	118	0	37	50	10	0	3	100
1914-1918	World War I, German (Sauerbruch)[6]	300	0	•	37	•	•	•	100
	Civilians Killed in Air Raids								
1942[7]	Burns and Zuckerman	97	0	41	14	24	4	17	100

paucity of special studies of the type made by the Oughterson team, Tribby, Palmer, and Hopkins, the relative stability of the distribution of hits is remarkable. The available samples have been set down separately in Table 78. There are two noteworthy features of the variation among the samples shown there. One is the fact that a large excess of upper extremity hits and a deficit of hits in the abdominal region and lower extremities characterize the two short, hard-fought amphibious assaults in which debarkation was heavily resisted.* The second point concerns the low values for hits in the trunk on the part of bomber crews of the Eighth Air Force, and may be attributed largely to the flak suit. The samples which do not completely duplicate others are averaged and shown together with the final estimate of the distribution of hits based on a much larger amount of information and giving greater weight to the higher incidence of hits in the lower extremities reported by armies in the European Theater.

The final estimate of the distribution of hits in World War II parallels the body area figures of Burns and Zuckerman only in part. Comment has already been made on the excess of hits in the head, face, and neck region, an excess which is complemented only in part by a deficit of hits in the region of the trunk. It is the standard of expectation, namely the figures on body area, which is open to question, for there is no reason to assume any important deviation from the view that missiles strike the various portions of the human target in approximately random fashion.

For ground troops 19.7 out of every 100 hit were killed outright and 3.6 died of their wounds, according to the official returns published by The Adjutant General, and excluding the lightly wounded who lost no time. Because of the differential vulnerability of the various body regions the distribution of hits is a poor guide to either the killed or the wounded. Of the 175,000 killed in World War II, location of the major wound has been reported on about 23,000, although most samples also have their unknowns. Table 79 summarizes these data and compares them with the few scraps of information previously reported. The distinction is made there between special studies involving medically competent examination and other studies of a more routine nature, since emphasis is ordi-

*It is not known whether the differences result from a peculiar tactical situation or from an unusual demarcation of body regions.

narily, and correctly, placed upon the need for careful examination to insure valid observations. It is surprising to find that the two sets of data agree so closely. As in the case of the distributions of hits on both the killed and the wounded, the comparative lack of variation among the samples shown in the table is perhaps its most remarkable feature. In addition to sample size there is shown the percentage of the sample originally classified as multiple, unknown, other, etc., in order that the reliability of each sample may be more fully appreciated. Thus the Saipan sample of 892, to take an extreme case, included 655 deaths which were unclassified as to location of most serious wound and which have been distributed in proportion to the 237 deaths for which location is known. Hence the effective sample size is 237, which is comparatively small. This particular sample is noteworthy for its high percentage of killed whose major wound involved the upper extremities, and the low percentage involving the chest. One must suppose that differentiation of these two regions was somewhat unorthodox, although the tactical situation may have caused exceptional exposure of the upper extremities.

Figures on body area and data from the literature covering other samples of the killed are also included in the table for reference. These are small in size and of value chiefly in providing further evidence of the general trend toward homogeneity characteristic of such observations.

Tribby's observations on Fifth Army killed suffer from their inclusion of 119 who actually died of wounds. His slightly higher values for lower extremities and abdominal region may be related to this fact of selection. As will be seen later in the present discussion, the effect of adding DOW to KIA is to reduce the importance of head hits and to increase the importance of hits in the abdominal region and in the lower extremities. Tribby's observations include the location data entered on the Emergency Medical Tags, but are presented as distributions of all wounds, rather than of major wounds only. He reports numerous errors on the tags, both as to wounds not actually present and as to frank omissions, especially in the neck, upper extremities, and abdominal region, where he found 75 to 90 percent of the tags to be in error. The tags mentioned 1,419 wounds, but Tribby found 2,398. Important as these findings are, they do not disturb the regional distributions as much as one might expect, partly because the errors are in both directions and also because less serious wounds were evidently neglected on the tags more often than serious wounds. This is shown in Table 80 which gives the percentage distributions of the wounds mentioned on the tags and of those described by Tribby, as well as of the fatal wounds reported by him. The distribution based on the tags is a

Table 80

COMPARISON OF REGIONAL DISTRIBUTIONS OF WOUNDS AS GIVEN ON EMERGENCY MEDICAL TAGS AND AS REVEALED BY EXAMINATION OF THE DEAD

Region	All Wounds		Fatal Wounds
	Tribby, by Examination	Tags	Tribby, by Examination
Head, Face, Neck	25.6	31.9	36.6
Thoracic	24.0	26.8	29.6
Abdominal	19.6	14.6	17.2
Upper Extremity	17.1	10.9	6.9
Lower Extremity	13.7	15.8	9.7
Total	100.0	100.0	100.0
Number of Wounds	2,385*	1,419	1,426

*Excludes 13 wounds from blast.

better estimate of the distribution of fatal wounds than it is for all wounds in this sample. If Tribby's findings suggest any real bias in the tag data, it is in their excess of hits in the extremities and their deficit in the head. Yet comparison with other distributions based on tags, as in Table 79, makes it plain that these have even fewer hits in the extremities and rather more in the head than Tribby's series of fatal wounds. All of the observed differences can be explained by the fact that Tribby's sample contains DOW and that

*Based on the above plus 16 lesser samples, an aggregate of 461,000 wounded, or 77 percent of the 599,000 total reported by The Adjutant General for World War II. The Pacific samples are generally high for head, face, and neck, and low for the lower extremities.

†Based on an O.S.S. study of the Russian medical literature made in 1944 and published in *Health* for April 1945.

‡Distribution based on a sample of wounds, not wounded men.

§Total number of wounded men given in Table 21, Chapter III, is 318,000.

Table 81

Percentage Distributions of Body Area and of Major Wounds among the Wounded

Sample			Percentage Distribution by Region of Major Wound					
Date	Unit, Campaign, Area	Size	Head, Face, Neck	Thoracic	Abdominal	Extremities Upper	Extremities Lower	Total
	Body Area							
	Burns and Zuckerman		12	16	11	22	39	100
	World War II							
	US Wounded							
1944-1945	First Army, ETO	131,980	14	11	5	28	42	100
1944-1945	Third Army, ETO	92,030	13	11	5	27	44	100
1943-1944	Fifth Army, MTO	62,769	14	10	5	29	42	100
1944-1945	Seventh Army, MTO & ETO	55,085	13	10	5	72		100
Apr.-Jun.45	XXIV Corps, Okinawa	16,612	17	10	6	32	35	100
	Averages:* Pacific	39,427	17	11	7	32	33	100
	Other	421,831	14	10	6	28	42	100
	Total	461,258	15	10	6	28	41	100
	Other							
1942-1943	British in Middle East	24,985	14	11	6	69		100
	Russian†		9	12	6	28	45	100
	World War I							
1917-1918	United States	174,296‡	12	4	3	36	45	100
1914-1918	French (Franz)		15	12	5	32	36	100
1914-1918	British (Franz)		17	8	5	30	40	100
1914-1918	German (Franz)		17	11	6	36	30	100
1898-1902	Spanish-American War and Philippine Insurrection	4,373	12	10	11	30	37	100
1861-1865	US Civil War§	245,790‡	11	18		36	35	100

the distribution of locations taken from the tags is not confined to most serious wounds. Hence there is no adequate reason for supposing Emergency Medical Tag material to be seriously biased in the *aggregate*, at least so far as regional distribution is concerned. Finally, the four special series diverge among themselves to an extent which forbids the use of any one of them as a standard, and Tribby's series is numerically so large as to dominate their average.

In sharp contrast to the paucity of data on the killed is the plethora of samples on the wounded. So numerous are they that space forbids individual listing for more than a few. Accordingly, Table 81 gives the five largest samples individually, and separate averages for the Pacific and for all other samples. The European data are highly consistent, and differ by small amounts from the average for the Pacific data which, being based on smaller samples, are more variable. On the whole, however, one is impressed by the close agreement of the data for the wounded, as was true of the killed and of the killed plus the wounded. One prominent exception concerns the Eighth Air Force, with 26 percent of the wounds in the head in contrast to an expected 14. Another is the excess of upper extremity wounds in the invasions of the Marshalls and Saipan, although it is possible that the shoulder girdle and axilla were included in the upper extremity rather than in the thoracic region in these series. A sample of about 8,300 Marines wounded at Iwo Jima (excluded from the Pacific average) classifies 25 percent as head, 15 as chest, 8 as abdominal, and only 52 as extremity wounds.

The distributions of wounded are close to the body area figures of Burns and Zuckerman except as regards the abdominal region. Since the data on hits provide ample reason to doubt that the figures of Burns and Zuckerman for body area are a good guide to the average human target, no particular significance attaches to their agreement with the distributions of wounded. The percentages for other wars are approximately similar, although for chest and upper extremities the U. S. World War I values are atypical and also probably erroneous, as has been explained earlier. Interpretation of any differences between wars is hardly worth while in view of the way in which such data are gathered and presented.

The foregoing may be summarized to compare the characteristic distributions for hits, killed, wounded, all deaths, and liv-

Table 82

COMPARISON OF PERCENTAGE DISTRIBUTIONS[1] OF KILLED, WOUNDED, AND TOTAL HIT BY REGION OF MAJOR WOUND

Region	Body Area[2]	Total Hit	Killed	Wounded	Died After Wounding	Living Wounded	All Deaths
Head, Face, Neck	12	21	47	15	22	14	43
Thoracic	16	13	25	10	23	10	25
Abdominal	11	8	15	6	24	5	17
Upper Extremities	22	23	5	28	7	29	5
Lower Extremities	39	35	8	41	24	42	10
Total	100	100	100	100	100	100	100

[1]Distributions combined by means of absolute numbers of KIA, WIA, and DOW among infantry troops during World War II. These are:

115,246 KIA } 590,711 Hits
475,465 WIA }
19,919 DOW } 455,546 Living Wounded

[2]Burns and Zuckerman's data.

ing wounded. Table 82 gives these distributions in relative form, combined according to the absolute totals reported by The Adjutant General for Infantry troops throughout World War II. The figures for death after wounding are also based upon the 1944 average experience of the Mediterranean Theater, the Southwest Pacific Area, and the Pacific Ocean Areas, in the sense that location-specific percentages were applied against the number wounded by region to obtain a presumptive schedule of DOW by region. The final schedule was then obtained by adjusting this series to the desired total on a proportionate basis.* The distributions for the killed and wounded dominate those for all deaths and for the living wounded, but that for deaths after wounding is very different from either. One of the more interesting features of the table, and an often neglected fact, is the high proportion of deaths after wounding which must be allocated to the lower extremities. Although the estimate of 24 percent may be somewhat high, the true value is surely not less than 15 percent of the total. The reason why the value given may be too high is that it is based on a DOW

*This last adjustment was very small, as the presumptive schedule totaled 19,664 and needed to be increased by only 1.3 percent.

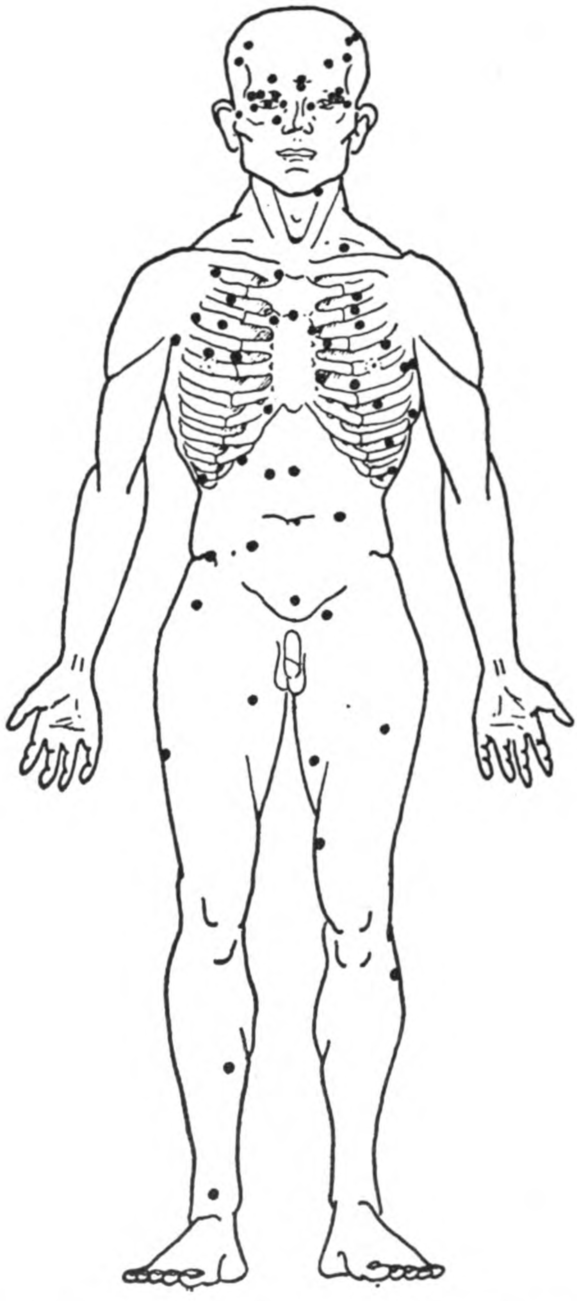

Fig. 24. Mortal Wounds of Entrance in 104 Autopsies, Anterior View.
— From Wound Ballistics Report, Bougainville Campaign, 1944, by Col. A. W. Oughterson *et al.*

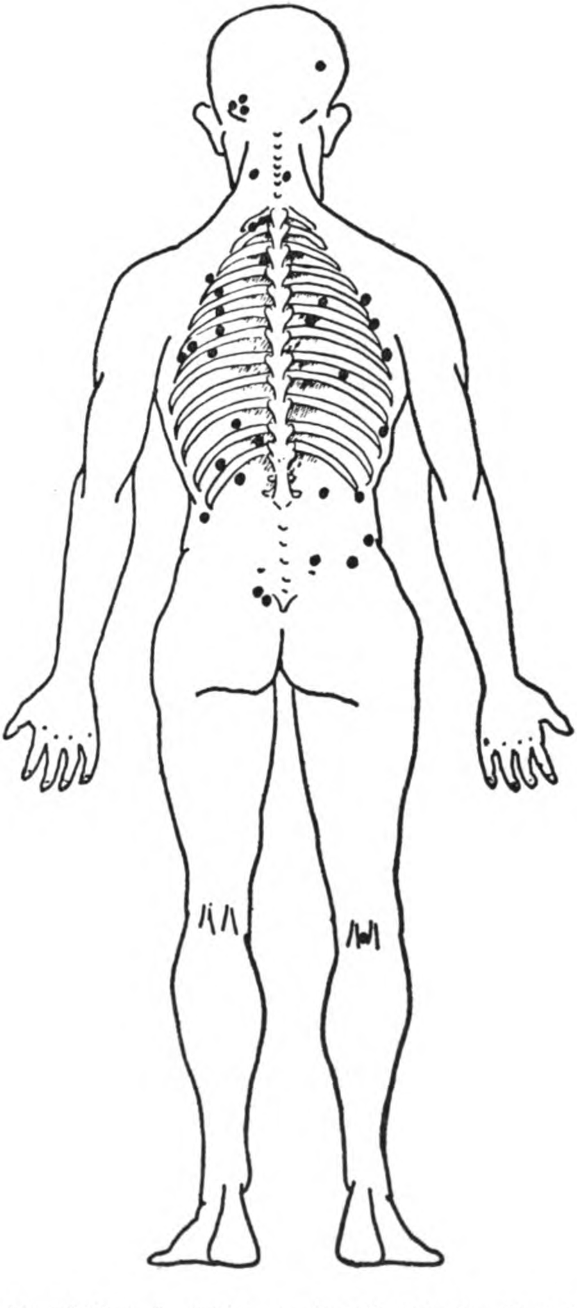

Fig. 25. Mortal Wounds of Entrance in 104 Autopsies, Posterior View.
– From Wound Ballistics Report, Bougainville Campaign, 1944, by Col. A. W. Oughterson *et al.*

figure which represents January to June 1944 experience and which may not apply to the subsequent ETO experience with its higher proportion of lower extremity wounds. Another feature of the table which holds special interest is the fact that the distribution of the living wounded differs only slightly from that for all wounded.

Formal autopsies performed by a qualified pathologist upon the killed are rare. The Oughterson team studied 395 dead (320 KIA + 75 DOW) on whom 104 post-mortem examinations were made by the pathologist available to the group. His determinations of sites of entrance for missiles causing fatal wounds are of considerable interest despite the small number of cases, and are reproduced here in the graphic form in which they appear in the Oughterson report (see Figs. 24 and 25).

For reference purposes there appear in Table 83 the frequencies for killed, all wounded, died of wounds, living wounded, and all deaths, among 10,000 men, according to the computations explained in connection with Table 82. It shows, for example, that out of 10,000 men hit by all types of missile, 372 would survive with abdominal wounds, and that 116 would be killed or would later die from wounds of the upper extremities.

Table 82 is useful not only in itself but also in suggesting the importance of such factors as the speed with which the wounded are recovered, the echelon of medical service, and the like in determining regional location of major wound. As time is allowed to elapse men who should properly be called wounded may be called

Table 83

EXPECTED DISTRIBUTION OF 10,000 HITS BY REGIONAL LOCATION AND TYPE OF CASUALTY RESULTING

Region	Type of Casualty					
	KIA	WIA	Total Hit	DOW	Living WIA	DOW + KIA
Head, Face, Neck	912	1,183	2,095	75	1,108	987
Thoracic	491	834	1,325	76	758	567
Abdominal	298	453	751	81	372	379
Upper Extremity	91	2,246	2,337	25	2,221	116
Lower Extremity	159	3,333	3,492	80	3,253	239
Total	1,951	8,049	10,000	337	7,712	2,288

killed, for example, with the result that the killed with abdominal and lower extremity wounds would probably increase in importance. Conversely, a very low proportion of abdominal wounds among the wounded is suggestive of too great a delay in the recovery of the wounded, with consequent death without opportunity for medical care. Finally, the distribution of living wounded should represent more accurately the type of case seen at the level of the evacuation and convalescent hospitals, but at any echelon of medical care the deviation from the average pattern is believed to be relatively small except in Zone of Interior hospitals, dependent upon evacuees from overseas for their wounded patients during the two world wars.

The extent to which evacuees depart from the standard of Table 82 is shown in Table 84, which includes the ratio of each pair of parallel percentages (based, however, on percentages carried to two decimal places). Thus it is plain that the evacuees include a relative excess of abdominal and lower extremity cases, and deficits of cases involving the head, chest, and upper extremities. The classification as to chest and abdomen may not be too accurate in the evacuee data because it was necessary to distribute a group of cases involving the spine and vertebrae and amounting to 2.5 percent of the total for all regions. Distribution was made in proportion to the reported frequencies for chest and abdomen. In the interest of clarity it should be noted that the ratio compares the rate of evacuation for the particular location with the rate of evacuation for all wounded and does not itself reveal what

Table 84

PERCENTAGE DISTRIBUTIONS OF ALL WOUNDED AND OF EVACUEES TO ZONE OF INTERIOR, BY LOCATION OF MAJOR WOUND

Region	All Wounded	Evacuees to Zone of Interior 1944-1945	Relative Rate of Evacuation
Head, Face, Neck	15	11	0.78
Thoracic	10	7	0.64
Abdominal	6	8	1.49
Upper Extremity	28	25	0.88
Lower Extremity	41	49	1.18
Total	100	100	1.00

proportion of wounded were evacuated. During the entire war about 194,000 or 32 percent of the wounded were evacuated to the Zone of Interior, the approximate equivalent of a 98-day evacuation policy. These data are based on all arms and services, not on the Infantry alone. For some locations, of course, more or less than 32 percent of the wounded were evacuated, as suggested by the relative rate of evacuation in Table 84. For the head, face, and neck, for example, the rate of evacuation was only 78 percent of the average of 32 percent, or roughly 25 percent, whereas for the abdomen it was about 48 percent. Since 6.8 percent of those wounded in the head, face, and neck died, and about 25 percent were evacuated, it may be estimated that approximately 68 percent were returned to duty overseas. By this means it is possible to infer the approximate percentage of returns to duty overseas for each body region, and to convert these results into a regional distribution of the returns to duty there. This has been done in Table 85.

Table 85

APPROXIMATE DISPOSITION OF WOUNDED OVERSEAS, BY BODY REGION, AND PERCENTAGE DISTRIBUTIONS OF LIVING WOUNDED AND RETURNS TO DUTY OVERSEAS

Region	Percentage Distribution by Disposition Overseas			Percentage Distribution by Body Region	
	Death	Duty	Zone of Interior	Living Wounded	Returned to Duty Overseas
Head, Face, Neck	6.8	67.9	25.3	14	16
Thoracic	9.7	69.5	20.8	10	11
Abdominal	19.1	32.5	48.4	5	3
Upper Extremity	1.2	70.2	28.6	29	31
Lower Extremity	2.5	59.2	38.3	42	39
Total	4.5	63.0	32.5	100	100

PERIPHERAL NERVE INJURIES

Although many peripheral nerve injuries are evidently minor in nature, causing only a transitory paralysis and requiring no neurosurgical intervention, more extensive injuries, especially those involving severance and requiring nerve suture, commonly cause extensive disability, both immediate and long-term. Despite the importance of this special type of injury, there is no definitive information on its incidence among Army wounded in either World War I or II.

The World War I surgical history[13] gives a count of 2,347 men with peripheral nerve injuries remaining in Army hospitals on 1 May 1919, or 1.5 percent of the 154,000 wounded, and an estimated incidence of 3,500 or 2.3 percent for the entire period of the war. Spurling and Woodhall[14] estimated that about 25,000 Army wounded with peripheral nerve injuries reached the level of the general hospital in World War II. The Army *Peripheral Nerve Registry* of neurorrhaphies and grafts, instituted[15] in October 1944 primarily in Zone of Interior neurosurgical centers, includes 7,700 men; for the entire war period the number treated by nerve-suture or graft is undoubtedly somewhat larger.

In 1944 the SGO traumatism code was amplified by the addition of qualifying terms indicative of nerve and artery involvement. Although it is not yet known precisely what proportion of the 1944 wounded were coded in this fashion, it seems probable that the great bulk of the peripheral nerve cases were coded in accordance with the revised code. A two-percent sample of 1944 wounded was found to yield 375 cases with nerve involvement, of which 77 percent involved peripheral nerves (cranial nerves being excluded). On this basis a lower limit of 25,000 is suggested for World War II Army incidence. Of the 290 cases in the sample classified as peripheral nerve injuries, at least 17 percent were treated by means of suture or graft, and possibly as many as 26 percent. This fact, combined with the size of the *Peripheral Nerve Registry*, suggests a total incidence of 30,000 to 44,000 peripheral nerve injuries, including many who were not treated by neurosurgery. On the whole, therefore, although the number of peripheral nerve injuries cannot be specified with any precision, it seems probable that it lies in the range of 35,000 $\pm$ 10,000 cases or 5.8 $\pm$ 1.7 percent of all Army wounded and 8.4 $\pm$ 2.4 percent of those wounded in the extremities.

[13]*The Medical Department of the U. S. Army in the World War,* Vol. XI, Surgery, Part I, p. 1081.

[14]SPURLING, R. G. and WOODHALL, B.: Experiences with early nerve surgery in peripheral nerve injuries, *Ann. Surg.* *123*:731-748, 1946.

[15]*War Department Circular 423,* para. II, 27 October 1944. This circular provides estimates of 5 percent for all wounded and 15 percent of those evacuated to the Z/I.

The distribution of *Peripheral Nerve Registry* cases by nerve involved has been published by Woodhall[16] and is shown in Table 86 separately for sutures and grafts. This is a distribution of nerves, not of men, as 9.3 percent of the men with one suture or graft also had another. Lesser nerve injuries, requiring no operation, exploration only, or neurolysis, do not appear in the *Registry*. The count of 7,050 nerves repaired differs from the count of 7,700 men with sutures or grafts, the former being based on a tabulation prepared before the *Registry* was closed.

Table 86

DISTRIBUTION OF PERIPHERAL NERVES TREATED BY GRAFT OR ANASTOMOSIS, ARMY PERIPHERAL NERVE REGISTRY

Nerve	Nerve Suture		Graft	Total	
	Number	Percent		Number	Percent
Brachial Plexus	138	*2.0*	1	139	*2.0*
Median	1,362	*19.5*	14	1,376	*19.5*
Ulnar	2,248	*32.2*	13	2,261	*32.1*
Radial	985	*14.1*	12	997	*14.1*
Musculo-cutaneous	87	*1.2*	—	87	*1.2*
Digital	28	*0.4*	1	29	*0.4*
Sciatic	1,186	*17.0*	5	1,191	*16.9*
Tibial	242	*3.5*	10	252	*3.6*
Peroneal	557	*8.0*	1	558	*7.9*
Femoral	21	*0.3*	—	21	*0.3*
Facial	17	*0.2*	8	25	*0.4*
All Others	112*	*1.6*	2†	114	*1.6*
Total Nerve Injuries	6,983	*100.0*	67	7,050	*100.00*

*Includes: antibrachial cutaneous (49), sural (34), axillary (20), brachial cutaneous (3), spinal accessory (3), plantar (3).
†Includes: axillary (1), cauda equina (1).

ARTERIAL INJURIES

A small but important group of cases involve wounds of the major arteries. Among the wounded, as DeBakey and Simeone[17] have shown, the proportion with arterial wounds is probably on the order of 1.0 percent. Table 87 summarizes their data on

[16]WOODHALL, BARNES: Peripheral Nerve Injuries. II. Basic Data from the Peripheral Nerve Registry Concerning 7,050 Nerve Sutures and 67 Nerve Grafts, *J. Neurosurg.* *4*:146-163, 1947.

[17]DE BAKEY, M.E. and SIMEONE, F. A.: Battle Injuries of the Arteries in World War II, *Ann. Surg.*, *123*:534-579 (April) 1946.

the Army incidence in World War II. For wounds of the extremities, their estimate is 1.4 percent. For a sample of arterial injuries in U. S. troops wounded in World War II they have also tabulated the proportionate frequency by vessel and the variation among vessels with respect to frequency of amputation. These data are reproduced here as Table 88. Although it is estimated that 40 percent of wounded with arterial injuries lost their limbs, only about 19 percent of major amputations are believed attributable to major arterial injuries, most being so-called "traumatic" amputations beyond the power of the surgeon to prevent.

As may be observed from Table 88, the site of the lesion has an important bearing on the end result. Lesions in the lower extremity, for example, are far more serious than lesions in the upper extremity, the corresponding incidences of amputation being 50 percent and 24 percent. Other important factors in determining end result revealed by this study are the presence or absence of associated injuries and time-lag between wounding and institution of therapy. Thus the incidence of amputation in arterial wounds complicated by fractures was 60 percent, whereas in those not associated with fractures it was 43 percent. With increasing time-lag there was an almost straight-line progression in the incidence of amputation, the figures being 37 percent for a time-lag of 1 to 10 hours, 49 percent for 10 to 20 hours, and 63 percent for more than 20 hours.

Arterial injuries carry a high mortality even among those who survive to reach aid stations and surgical facilities. In one sample

Table 87

INCIDENCE OF ARTERIAL WOUNDS AMONG WOUNDED, WORLD WAR II

Sample		Percentage of Wounded with Arterial Wounds	
Source	Size	All Locations	Extremities only
Southwest Pacific Area and China-Burma-India	6,198	1.6	2.3
Third U. S. Army	92,030	0.91	1.4
Fifth U. S. Army	19,396	0.98	1.5
Seventh U. S. Army	46,356	0.95	1.4
Total	163,980	0.96	1.4

Table 88

Distribution of Arterial Injuries and Frequency of Amputation, U. S. Troops, World War II

Artery	Injuries		Amputations	
	Number	Percent of Total	Number	Percent of Arterial Injuries
Aorta	3	0.12	2	66.7
Carotid	10	0.41	3	30.0
External carotid	3	0.12	0	00.0
Renal	2	0.08	2	100.0
Subclavian	21	0.85	6	28.6
Axillary	74	3.00	32	43.2
Brachial total	601	24.32	159	26.5
Above profunda	97	3.93	54	55.7
Below profunda	209	8.46	54	25.8
Radial	99	4.01	5	5.1
Ulnar	69	2.79	1	1.4
Radial and ulnar	28	1.13	11	39.3
Common iliac	13	0.53	7	53.8
External iliac	30	1.21	14	46.7
Internal iliac	1	0.04	0	00.0
Femoral total	517	20.92	275	53.2
Above profunda	106	4.29	86	81.1
Below profunda	177	7.16	97	54.8
Profunda	27	1.09	0	00.0
Popliteal	502	20.32	364	72.5
Anterior tibial	129	5.22	11	8.5
Posterior tibial	265	10.73	36	13.6
Ant. and post. tibial	91	3.68	63	69.2
Peroneal	7	0.28	1	14.3
Post. tibial and peroneal	5	0.20	2	40.0
Both tibials and peroneals	1	0.04	1	100.0
Total	2,471	100.00	995	40.3

of about 1,500 Army wounded coded by the Medical Statistics Division as battle wounds or fractures involving arteries, 21 percent were dead when the sample was studied in 1948 as a source of case-material for a follow-up study of late results of arterial wounds. Unpublished tables* on World War I give a mortality of 25 percent for 402 artery ligations reported in a sample of about 153,000 wounded. Among all 174,000 wounds in World War I, 443 were classified as arterial in location, and in 109 instances, or 25 percent, death was reported.

*Furnished by General Love.

AMPUTATION

There are as yet no accurate counts of the number of amputees or of the number of amputations in World War II. The estimate developed by the Medical Statistics Division in May 1946 is that, excluding amputations of toes and fingers, about 14,900 amputees with 16,000 stumps reached Zone of Interior hospitals during the war. Accordingly, one would estimate that about 2.5 percent of all the wounded had one or more amputations if all the amputations could be credited to wounding. This is not the case, of course, but it is as yet not known how many of the amputees were originally injured or wounded in battle and the present discussion arbitrarily assumes that all were wounded. The derivation of the estimate indicates that it is on the low side, especially in point of excluding amputees who died overseas. One observation on the magnitude of this bias comes from the experience of the Third Army,[18] for which it is reported that only 91 percent of 1,290 amputees survived to be evacuated. With a death rate of 10 percent the foregoing estimate of 14,900 could be advanced to 16,600 inclusive of deaths. Correspondingly, the percentage of the wounded suffering amputation would increase from

Table 89

ESTIMATED FREQUENCY OF MAJOR AMPUTATION IN WORLD WAR II, BY LOCATION

Location	Amputations		Percentage of Wounded Men Sustaining Amputation	
	Number	Percent	Uncorrected	Corrected for Deaths
Upper Extremity	*3,381*	*21.1*	*1.9*	*2.0*
Above elbow	1,662	10.4		
Below elbow	1,719	10.7		
Lower Extremity	*12,612*	*78.9*	*4.7*	*5.3*
Above knee	4,860	30.4		
Below knee	7,179	44.9		
Hip joint	56	0.4		
Syme's	179	1.1		
Chopart's	338	2.1		
Total	*15,993*	*100.0*	2.5	2.8

18*Semi-annual Report of the Senior Consultant in Orthopedic Surgery, ETO, 30 Jun. 1945.* In files of Historical Division, SGO.

Table 90

SURVIVORS OF AMPUTATION AMONG THE WOUNDED, WORLD WARS I AND II

Location	World War I			World War II		
	Men Wounded	Amputees Surviving*		Men Wounded	Amputees Surviving	
		Number	Percentage of WIA		Number†	Percentage of WIA
Upper Extremity	55,000	2,359	4.3	167,000	3,152	1.9
Lower Extremity	69,000	2,044	3.0	248,000	11,760	4.7
Total	154,000	4,403	2.9	599,000	14,912	2.5

*There were 25 with both upper and lower amputations who have been assigned to the two single categories on a proportionate basis.

†Unlike the World War I figures, these include an unknown number of non-battle cases and are too high to this extent.

2.5 to about 2.8 percent. Adjustment for the fact that at least some of the amputations resulted from accidental injuries would lower this figure correspondingly.

The estimate of 16,000 stumps was made by location of amputation, the details of which appear in Table 89. Parallel figures are given there as estimates of the percentage of men with upper and lower extremity wounds who suffered amputations, the arbitrary assumption having been made that the amputees having upper or lower extremity amputations occurred in the same ratio as the amputations themselves, and that none involved both upper and lower extremities. These figures are also shown with the adjustment for those who died. In making the adjustment for upper and lower extremities separately, account was taken of the fact that the case-fatality rate for lower extremity wounds is generally about twice that for upper, so that the adjustment for upper extremities is much less than that for lower extremities. Table 89 suggests, then, that amputation was suffered by about 2 percent of the men with wounds of the upper extremities, and by about 5 percent of those with wounds of the lower extremities.

In Table 90 the World War II data on men who survived amputation are compared with similar World War I observations[19] which,

[19]*The Medical Department of the U. S. Army in The World War*, Vol. XI, Surgery, p. 72.

however, do not include nonbattle cases. Table 90 has some remarkable features. One is that, despite its inclusion of any nonbattle amputees, the World War II figure of 2.5 percent of the wounded is below that of 2.9 for World War I. Either amputation was more frequent among the wounded in World War I or death occurred more often among the amputees of World War II. The latter is unthinkable, for the location-specific death rates for wounded fell about 58 percent for men wounded in the upper extremities, and 65 percent for those in the lower extremities, and death among amputees would be a major component of the fatality rate for the extremities. Moreover, infection was better controlled in World War II than in World War I, and failure to control infection would be an important cause of surgical amputation. One is compelled, therefore, to the conclusion that the likelihood of amputation was greatly reduced in World War II for men who were wounded.

Another significant fact of Table 90 is that the World War I figures give a majority of the amputations as upper in location, whereas in World War II only 21 percent involved the upper extremities. There is no reason to assume that amputations of the upper extremity were as numerous in World War II as those of the lower extremity, and the only conclusion one can draw is that mortality among men with amputations of the lower extremity was very high in World War I. The mortality estimates for World War II which underlie Table 89 are 5.1 percent for upper and 11.2 percent for lower extremity amputations. If the reductions in case-fatality rates for all wounds of the extremity also apply to case-fatality percentages for amputees, it may be estimated that the World War I case-fatality rates were 12 percent for amputations of the upper extremity and 32 percent for those of the lower extremity. On this basis the World War I amputations would have numbered 5,700 with 1,300 deaths, 2,700 of the upper extremities and 3,000 of the lower. Even this adjustment for mortality, then, does not bring the ratio of upper to lower amputations at all close to that for World War II, and one must suppose that the reduction in the frequency of amputation was far greater for the upper than for the lower extremities, or that the mortality among the men with amputations of the lower extremity was considerably greater than 32 percent, or both. This conclusion appears to follow whether or not the fatality rate for upper extremity amputations fell by as much as 58 percent. In favor of the view that the World War I fatality rate for amputations of the lower extremity carried a high fatality is the fact that even the mortality allowance of 32 percent increases original incidence to only 4.3 percent, whereas World War II incidence (including nonbattle) is about 5.3 percent when the allowance for deaths is added. It seems doubtful that as many as 20 percent of the amputations were of nonbattle origin, so that the conclusion seems reasonable that "true" World War I incidence exceeded 4.3 percent, and that fatality surpassed 32 percent for amputations of the lower extremities.

The estimate of amputees surviving to reach Zone of Interior hospitals in World War II also provides a breakdown of cases as to the number of limbs involved. This is given in Table 91 together with an allowance for deaths, the latter not being subdivided, however. It would be expected that proportionately more of those who died might have had more than one stump than is true of the survivors. Although the chance of amputation was about 28 per 1,000 wounded, the likelihood of surviving with more than one stump was only about 2 per 1,000 wounded according to

Table 91

DISTRIBUTION OF WORLD WAR II WOUNDED ACCORDING TO NUMBER OF AMPUTATION STUMPS

Amputee Status and Number of Stumps	Wounded Men		
	Number	Percentage	
		Of All Wounded	Of Men Surviving Amputation
Not Amputees	581,959	97.2	—
Amputees			
Died	1,657	0.3	—
Survived			
One	13,844	2.3	92.8
Two	1,057	0.2	7.1
Three	9	0.0	0.1
Four	2	0.0	0.0
Total	598,528	100.0	100.0

these data, which include amputations among nonbattle patients also. In terms of men wounded in the extremity these ratios are 40 per 1,000 and 2.6 per 1,000. It is of interest that the World War I figures are 4,318 surviving with one stump and 85 with two. The proportion surviving with multiple stumps is 1.9 percent, or one-fourth of the World War II percentage, which again suggests the high mortality sustained by amputees in World War I.

There is comparatively little quantitative information about the medical echelon at which amputation was performed. Surgical policy was such that most of the initial amputations were done in the army area, especially in evacuation hospitals, but an extensive amount of stump-revision was called for in rear hospitals, including those in the Zone of Interior. One sample of 182 amputees boarded for evacuation from the Mediterranean Theater[20] credits 9 percent to the medical battalion, 10 percent to the field hospital, 50 percent to the evacuation hospital, 18 percent to the station hospital, 12 percent to the general hospital, and one percent to the hospital ship. On this basis, admittedly slender, one would expect army figures to be from 70 to 90 percent complete, depending upon the role the station hospitals played in this particular series, and on the assumption that the army figures included deaths. Several reasonably large samples of army data are available from the First, Third, Fifth, and Seventh Armies. The Third reported[21] 2,340 amputations, or 2.0 percent of the 115,000 wounded admitted to its hospitals (92,000 were Third Army cases). One would expect total incidence to be 2.2 to 2.9 percent on this basis. The Fifth reported "traumatic amputations" to the extent of 3.0 percent, based on a sample of 22,300 wounded,[22] but this figure surely includes surgical amputation. It is worth noting that the Fifth Army series gives fatality percentages of one for upper and four for lower extremity "traumatic amputations," an average of three percent in contrast to nine percent reported for the Seventh Army. The First Army[23] reported 2,130 amputations during 1944, about 2.2 percent of 96,000 wounded. If this figure

[20] *ETMD* from MTO, April 1944.

[21] *U. S. Third Army After-Action Report, August 1944-May 1945*, Medical Annex, in files of Historical Division, SGO.

[22] *U. S. Fifth Army, Annual Report to The Surgeon General for 1945*, in files of Historical Division, SGO.

[23] *Annual Report of Medical Activities in First U. S. Army, 1944.*

were 70 to 90 percent complete a total estimate would be 2.4 to 3.1 percent of all the wounded. The Seventh Army reported 2.44 percent among 55,000 wounded in France.[24] These several counts, then, run from 2.0 to 3.0 percent of the wounded, the variation being derived doubtless from the extent to which surgical care was given to troops of other commands and to enemy and civilian casualties as well as from the inclusion or exclusion of minor amputations. The average is about 2.4 percent, which, if 70 to 90 percent complete, yields a total estimate of 2.7 to 3.4 percent. The value of 2.8 percent given in Table 89 lies well within this range.

Discussion of amputations would be incomplete without some reference to traumatic amputations. By traumatic amputation is meant a complete severance of part of a limb by a traumatic agent, or one so nearly complete as to deprive the surgeon of any choice as to procedure and to make its immediate completion mandatory. The importance of isolating this particular class of amputations lies in the fact that they do not represent surgical failures in any sense, but are part and parcel of the original injury, whereas other amputations become necessary chiefly because of failure to control progressive infection. It is a fact of great surgical significance that the great majority of major amputations in World War II were traumatic in character. De Bakey and Simeone[25] have published a classification of amputations by cause which is based upon the reports of surgeons working in hospitals of the field armies. This material, comprising 3,177 major amputations in ETO and MTO, credits 68.6 percent to extensive trauma, 12.0 percent to infection and 19.4 percent to major arterial injury. The basic data are given in Table 92.

Most counts of amputations exclude those minor ones involving only fingers or toes. Patients evacuated to the Zone of Interior as amputees would almost certainly be major cases, but if counts were made of all amputees with minor and major amputations a significant number of minor amputations would probably be picked up. Tabulations made by the Medical Statistics Division on evacuees received from November 1943 through September 1945 give 15,978 amputees whose cause of evacuation was a non-

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[24]BERRY, FRANK: *Surgery in the Seventh Army, 15 August 1944-30 April 1945.* Unpublished report by the surgical consultant, Seventh U. S. Army in files of Historical Division, SGO.

[25]DE BAKEY, M. E. and SIMEONE, F. A.: *Op. cit.*

battle injury or a battle wound. This count represents 8.5 percent of the 188,000 wounded evacuees received during this period. On this basis it may be estimated that about 16,500 amputees, both minor and major arrived in Zone of Interior hospitals during the entire war period. If the count of 14,912 major amputees given in Table 90 is correct, the number of men arriving in the Zone of Interior with minor amputations was about 1,600 or 10 percent of the evacuated amputees. Probably many minor amputees were returned to duty overseas, so that the number 1,600 gives no real clue to their total incidence. Since the estimate of 16,500 major and minor amputees differs by only 10 percent from the count of 14,912 major amputees in Table 90, it provides at least a rough confirmation of the latter estimate of major amputees who survived to reach Zone of Interior hospitals.

Table 92

DISTRIBUTION OF MAJOR AMPUTATIONS IN U. S. TROOPS IN WORLD WAR II, BY CAUSE

Cause of Amputation	Fifth U.S. Army in M.T.O.		Third U.S. Army in E.T.O.		Total	
	Number	Percent	Number	Percent	Number	Percent
Trauma	1,027	76.4	1,152	62.8	2,179	68.6
Vascular Injury	195	14.5	423	23.1	618	19.4
Gas Gangrene and other Infection	122	9.1	258	14.1	380	12.0
Total	1,344	100.0	1,833	100.0	3,177	100.0

BURNS

Before World War II little attention was paid to the burns of battle, and one seldom finds in the literature useful data on their incidence and case-fatality. Accidental burns, of course, are well recorded in Army statistics, and comparison of World War I and World War II figures reveals the influence of ever-increasing mechanization of all branches of the Army, with its far greater exposure to inflammable substances. In World War I, the U. S. Army sustained 6,148 burns which were classified as non-battle injuries and represent an incidence of 1.5 per 1,000 men per year. By 1939 the admission rate for accidental burns had risen to 4.0 and it continued to advance in 1940 and 1941, reaching its maximum of 5.3 in the latter year. In 1942 the rate dropped sharply to 3.4 and preliminary calculations for 1943 and 1944 place the rates at 3.5 and 3.9 respectively. These are admissions whose primary cause was a burn. If secondary causes are included the 1944 rate is raised from 3.9 to 5.9.

Exposure to the risk of being burned is a function of military occupation but statistical data on this point are quite unsatisfactory. They are likely to remain so because it has not proved feasible to include occupation on the Individual Medical Records made available for statistical processing. It will eventually be possible, however, to document the broad differentials existing among the arms and services, especially Infantry, Armored, and Air Corps troops. At present the best estimate of the average incidence of burns among the wounded, where the burn is the primary "wound," is 1.2 percent for U. S. ground troops. This is based on the reports of large tactical units and applies to 293,000 wounded, or very nearly half of the U. S. experience in World War II. The variation in reported incidence is comparatively slight. For example, the figure is 1.2 for the First Army, 1.1 for the Third, and 1.6 for the Ninth. For the II Corps it was 1.3 in North Africa and 1.5 in Sicily, while for the XXIV Corps it was 2.2 on Leyte and 1.0 on Okinawa. These averages pertain to all the wounded in each unit and thus cover both Infantry and Armored troops as well as other ground combat and service personnel.

A tabulation based on 1944 Individual Medical Records, but excluding the experience of the European Theater, agrees reasonably well with the estimate of 1.2 percent of the wounded among ground troops. It also indicates that aircraft crashes contributed about 19 percent of all the burns of battle. In 1943 the percentage was 27. On the other hand, aircraft crashes contributed only about 4 percent of the *nonbattle* burns in these two years. In the Eighth Air Force for the period 26 June 1943 to 1 July 1944, 336 combat crew members suffered a total of 390 separate burns. Over 95 percent of the burns were first or second degree (43.0 and 52.1 respectively), third degree burns occurring in but 4.9 percent. Taken in relation to approximate strength, this experience suggests an admission rate of about 15 per thousand flying personnel per year. A special survey[26] of Air Force units made in the Mediterranean Theater at a time of great tactical activity, concluded with the following statement:

> "This survey indicates that the incidence of burns in the 12th Air Force is low, and that the burns encountered are largely of accidental origin, from the use of gasoline for heating or in improvised stoves."

Observations have been made on armored troops in special British surveys of casualties among tank crews and other armored force personnel. In one survey[27] of 3,670 wounded of the entire 4th Canadian Armored Division during the period 28 July to 30 September 1944 in the Mediterranean Theater, there were 148 whose chief injury was a burn, or just 4.0 percent of the total. In another small sample[28] of 501 wounds sustained by personnel of the British 1st Armored Division in Africa from 27 May to 12 June 1942, 5.1 percent were burned primarily. These fragments merely illustrate the generally accepted view that armored divisions as a whole have more burn casualties in battle than do infantry divisions, and it would be necessary to have more data before stating the precise size of the differential. Presumably, casualties among tank crews are the chief reason for the difference, and on this point also British data are helpful. In another medical intelligence document[29] there is a review of a report by a British Medical Research Council Team attached to the 21st Army Group to study casualties to vehicles and personnel in armored units during the Rhine crossing. Among the nonfatal casualties in tank crews about 25 percent were primarily burns, but an additional 15 percent classified as primarily wounded were also burned. In another sample[30] of 279 men hospitalized in England and Wales, and chosen to represent severely injured members of tank crews, 25 percent were burned. In the Rhine crossing there were 0.28 men burned per damaged tank, the gunner being burned significantly

[26]*ETMD* from MTO, 27 Jan. 1944, App. J: Incidence and Management of Burns in the Twelfth Air Force.

[27]Military Intelligence Division, *Military Attaché Report from London, No. R149-45,* dated 6 Jan. 1945, subject: Extracts from Quarterly Report, 4th Canadian.

[28]Military Intelligence Division, *Military Attaché Report from Egypt, No. 2683.*

[29]Military Intelligence Division, *Military Attaché Report from London, No. R2192-46,* dated 9 July 1946, subject: Casualties Amongst Armored Units.

[30]*Ibid.*

more often than other crew members, apparently because of his slightly longer escape-time. The hands and face were the areas most often burned and 17 percent of the burns were classified as third degree or more severe. It is noteworthy that 81 percent of those with burns were returned to full duty in contrast with only 58 percent of the wounded.

Mortality among the burned varies widely in response to causative agent, severity of burn, and presence of complicating injuries, to say nothing of methods of management. For nonbattle burns in World War I the recorded case-fatality is 1.9 percent. This high figure was reduced before World War II to less than 0.5 percent. As aircraft crashes became more important, however, the average case-fatality rate rose well above the World War I level. For example, it was 3.4 in 1942, 3.9 in 1943, and 3.5 in 1944. In large part this is an artificial increase, however, because many of the deaths among the burned in these years are more appropriately termed killed, just as a distinction is made between killed and wounded among battle casualties. In Table 93, therefore, a second panel has been added so as to show the effect of excluding those who are recorded as having died with no days in hospital. The table shows plainly that the case-fatality rates for burns from air-

Table 93

PERCENTAGE CASE-FATALITY OF BURNS, U. S. ARMY

Period	Nonbattle			Battle		
	Total Burns	Aircrash Burns	Other Burns	Total Burns	Aircrash Burns	Other Burns
World War I	1.9					
1939	0.3					
1942	3.4					
1943	3.9	81.8	0.8	30.2	73.1	16.0
1944	3.5	84.8	0.8	26.2	83.0	15.0
Exclusive of those Killed Immediately*						
1943	0.6	12.8	0.4	3.6	11.5	2.3
1944	0.8	19.3	0.6	6.2	23.7	4.3

*Based on the criterion of no days in hospital.

craft crashes exceed those for other burns by a wide margin, even if the immediate deaths are excluded. The second main conclusion emerging from the table is the large differential between case-fatality rates for battle and nonbattle burns. Finally, if the burns from aircraft crashes are excluded from the World War II material, the case-fatality rate of 0.8 percent for both 1943 and 1944 is less than half the figure of 1.9 for World War I.

It may be presumed that those burned in battle are more severely burned, and are more likely to have complicating injuries, than those accidentally burned. Whether the final figures will be as high as 4.3 percent for 1944 will depend on the final tabulations of the data from the European Theater. In this connection figures from three of the four field armies in the European Theater suggest a case-fatality rate of 2.4 percent among admissions for burns incurred in battle during 1944 and 1945. This agrees closely with the 1943 average of 2.3 percent, but excludes deaths which may have occurred in fixed hospitals overseas and in the Zone of Interior. It is not known how frequent these were. A small sample[31] of British data covering the experience of the Central Mediterranean Forces from March through October 1944 also yields an estimate of 2.4 percent, but the deaths in rear hospitals are also excluded. That the omission may be significant is suggested by a British survey of casualties[32] admitted to general hospitals in the Middle East from 1 April 1942 to 31 March 1943, which gives an average mortality rate of 6.1 percent for 798 burned patients.

One is likely to retain a biased impression from a review of World War II burn casualties in ground troops unless one takes into account the experience of enemy civilians during the late phases of the war when aerial warfare used fire as a major weapon against urban population centers. In the early years of the war, as in the Battle of Britain, the evidence[33] is that about four percent of the fatalities from night raids resulted from burns, and two per-

[31]*Medical Intelligence Abstracts*, Vol. 2, No. 3, 7 Apr. 1945: British Surgical Experiences, Central Mediterranean Forces, pp. 3-4, Office of the Surgeon General, U. S. Army.

[32]WILES, PHILIP: Analysis of Battle Casualties Admitted to Middle East Hospitals April 1, 1942 to March 31, 1943. *Lancet*, 1944, *1*:523-525.

[33]*Bulletin B. 16:* Air-raid Casualties, A Survey Based on an Analysis of Casualty Data Provided by Air-raids in England, 1940-1943. Ministry of Home Security, Research and Experiments Dept.

cent from day raids, while about three percent of the seriously injured survivors of day raids were severely burned. At that time most injuries were caused by falling debris. Later, however, according to the published reports of The Strategic Bombing Survey[34, 35] on aerial warfare against both Germany and Japan, burns became a far more serious form of injury than formerly.

The Germany survey reached the conclusion that perhaps 500,000 civilian deaths occurred in Germany as a result of Allied air raids. Figures are not available as to causative agent, either for deaths or injured survivors of air raids, but it is stated that:

> "After studies and reports from other German cities became available it was evident that mechanical causes of death headed the list, as had been expected. Direct hits by bombs and the action of bomb fragments, burial under rubble, and burns, all associated with shock, were the main causes of death of air raid victims throughout Germany."

Beginning in March 1945 the four principal Japanese cities were bombed with incendiaries. A single attack on Tokyo burned to the ground a densely populated area of 15 square miles. The Summary Report of the U. S. Strategic Bombing Survey states, in part:

> "In a period of 10 days starting 9 March, a total of 1,595 sorties delivered 9,373 tons of bombs against Tokyo, Nagoya, Osake, and Kobe destroying 31 square miles of those cities at a cost of 22 airplanes . . . Total civilian casualties in Japan, as a result of nine months of air attack, including those from the atomic bombs, were approximately 806,000. Of these, approximately 330,000 were fatalities. These casualties probably exceeded Japan's combat casualties which the Japanese estimate as having totaled 780,000 during the entire war. The principal cause of civilian death or injury was burns."

An equally if not more important consideration tempering any conclusions drawn from the World War II experience of the U. S. Army is the great frequency with which burns occur in a population subjected to an atomic explosion. These burns include fire-

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[34] *U. S. Strategic Bombing Survey,* The Effect of Bombing on Health and Medical Care in Germany, Washington, D.C., 30 October 1945.

[35] *U. S. Strategic Bombing Survey,* Summary Report (Pacific War), Washington, D.C., 1 July 1946.

burns of the usual type and also distinctive, apparently infra-red, white light, and ultra-violet, burns among persons as far as several miles from the center of the explosion. The potential numbers of burned patients in any heavily populated area struck by an atomic bomb, or fire-bombed, suggest that burns will constitute a surgical problem of first importance in another war.

CHAPTER VI

LOGISTIC PROBLEMS OF PERSONNEL, HOSPITALIZATION, AND EVACUATION IN FORWARD AREAS

NEED FOR SURGICAL SPECIALISTS IN ARMY AREA

FROM information on the incidence and characteristics of wounds requiring surgical care, and from certain assumptions about the workload which specialists can handle, it should be possible to obtain requirements for surgical specialists needed by the field army. These requirements are more fundamental than conventional bed requirements, for life-saving surgery cannot be postponed with anything like the freedom with which length of stay in forward hospitals can be curtailed. Surgeons cannot, however, function without adequate ancillary personnel for pre- and post-operative care, so that large increases in the number of operations cannot be made solely by augmenting the supply of specialists.

In war, surgical specialists are inevitably in short supply, and the surgical planner is early confronted with the problem of how best to utilize this limited resource. Depending on the nature of his responsibility and experience, he may find himself debating the relative merits of placing various proportions of specialists overseas rather than in the Zone of Interior. The considerations involved go far beyond the determinants of personnel requirements in the forward area, and have to do also with the requirements of military casualties for definitive and reparative surgery, and with the needs of the civilian population. But once one undertakes to maximize the saving of lives and the returns to duty in the army area, one is committed to the investment of a considerable number of specialists there. No attempt is made here to estimate the over-all military requirements for surgical specialists at all echelons. The discussion is confined to the needs of the field army; fixed hospitals in base areas overseas and at home also have their requirements above and beyond those discussed here.

During the initial phase of wound management the primary objectives are the saving of life and the prevention or eradication of wound infection. The essential principles underlying the surgical procedures designed to achieve these purposes apply to all types of wounds in all parts of the body. A competently trained general surgeon is equipped to apply these principles to wounds of all locations. During the later phases of wound management, when reparative and reconstructive procedures are employed, the highly specialized surgeon may be more effectively employed. For these reasons general surgeons are best utilized in forward surgery, and specialists in orthopedic surgery, urologic surgery, maxillofacial surgery, and the like are best employed in hospitals behind the army area. Under certain conditions, however, it may be desirable to have a few of the more highly specialized surgeons in the forward area. For example, as long as the casualty rate is sufficiently high to produce an average daily operative load of about four head and spine cases in a single forward hospital, a neurosurgeon may be effectively employed. Accordingly, the following classes of personnel are recognized for planning purposes:

MILITARY OCCUPATIONAL SPECIALTIES

Title	*Code*
(N) Neurosurgeons	3131
(B) General surgeons	B-3150
(C) General surgeons	C-3150
(T) Thoracic surgeons	3151
(A) Anesthesiologists	3115

The general surgeon with a proficiency rating B would have training equivalent to board certification and an Army MOS of B-3150. The thoracic surgeon would be similarly qualified, but with additional training and experience in thoracic surgery. The general surgeon with a proficiency rating C would have less advanced general surgical training and experience than the B-proficiency rated general surgeon, and be classified by the Army as C-3150. The neurosurgeon would be a qualified specialist in neurosurgery with an Army MOS of 3151. Each surgeon represents the head of a team, and such ancillary personnel as the assistants are excluded from the estimates made here. The anesthetist would be qualified at the level of board certification, and would also have

Table 94

FREQUENCY OF WOUNDS BY LOCATION AND THEIR ALLOCATION TO SURGICAL SPECIALTIES

Location of Wounds	Frequency per 1,000	Surgical Specialty
Head		
Intracranial	19.50	N
Scalp	37.75	C
Eye and Ear	20.00	C
Neck	20.70	B
Maxillofacial		
Bone	12.20	B
Soft-tissue	46.80	C
Chest		
Intrathoracic	46.40	T
Superficial	37.30	C
Spine	9.40	N
Abdominal		
Intra-abdominal	28.40	B
Thoraco-abdominal	11.00	T
Intra-abdominal and thoraco-abdominal	5.58	T
Superficial	7.40	C
Extremity		
Deep muscle	368.00	B
Complete fracture	126.50	B
Traumatic amputation	29.50	B
Superficial	149.80	C
Other	23.00	C
Total	999.23	—

an assistant. The assumption is made, further, that all other necessary ancillary personnel, notably shock teams and housekeeping personnel in each hospital, would be available in adequate numbers to support the estimated surgical workload.

How the various surgeons share in the total load of wounded is shown in Table 94, where each rubric or a moderately detailed anatomic distribution of wounds is assigned to one or another. The classification is that of the Fifth Army. Table 95 presents the resulting numerical allocation of wounded to the individual surgeons, and the corresponding number of surgeons required when each operates on an average of seven per day. The need for highly skilled anesthetists is estimated at one for each two surgical teams.

Table 95

SURGICAL SPECIALISTS REQUIRED FOR INITIAL SURGERY ON 1,000 WOUNDED WHEN EACH SURGEON OPERATES ON SEVEN PER DAY

Type of Personnel	Number of Wounded per Day	Number of Surgeons and Anesthetists
Surgeons		
(N) Neurosurgeons	28.92	4.13
(B) General surgeons	585.75	83.68
(C) General surgeons	322.30	46.04
(T) Thoracic surgeons	63.03	9.01
Total	1,000.00	142.86
Anesthetists	1,000.00	71.43
Grand Total	1,000.00	214.29

Two circumstances render especially difficult the task of estimating forward requirements for surgeons:

1. The number of surgeons assigned to an army should be sufficient to cope with peak casualty loads without calling upon fixed hospitals or less active armies except for an occasional and brief emergency period; and
2. There is more intrinsic variation in casualty rates than in the working capacity of army surgeons, even with some emergency assistance from fixed hospital personnel.

Since the inherent variability in casualty rates is markedly reduced by employing averages over time-intervals of increasing length, it is well to base casualty rates not on a single day but on a somewhat longer period. It seems convenient here to employ three days as a period in which the individual surgeon can be expected to make a maximum effort, with the understanding that he cannot work at this pace for two consecutive three-day periods. Also, with a heavy influx of casualties, fixed hospitals in the rear of the army area cannot long relieve the load on forward units, whether the aid be given in the form of performing initial surgery in the rear on cases normally handled forward, or in the form of a loan of qualified personnel to forward units, or both.

Now if the WIA experience of the First U. S. Army is blocked off in successive three-day periods beginning 6 June 1944, and if the first 12 days are disregarded as a beachhead period for which special plans must be made, one finds the highest hospital admission rate to have been 5.31 WIA per 1,000 men per day for the period 30 July to 1 August. In addition, there are eight three-day periods in which the daily rate was between 3.0 and 4.0, and twelve in which it was between 2.0 and 3.0. The ratio of 5.31 to the mean of 1.62 is 3.28. If one were to estimate the average workload of a surgical specialist at, say, seven operations per day, one could hardly visualize a situation in which he could perform twenty-three per day for three consecutive days. That is, the surgical workload will vary from its average by more than the surgeon can augment his working capacity, even for a single three-day period. Furthermore, there are three consecutive three-day periods in which the daily rate was 2.1 or more times the campaign average of 1.62. For a three-day period the surgeon could certainly increase his average capacity above his normal seven operations per day, but it does not seem safe to place this maximum effort at more than 10.5 per day, or 50 percent above the average physiologic capacity. Nor could the surgeon be expected to repeat this performance for two or three consecutive three-day periods. Although it should not be necessary to staff a field army with sufficient surgeons to cope with a maximum load by performing only an average number of operations per day, it is equally plain that the number of surgeons able to cope with the average load at an average pace would be unable, even by working at maximum capacity, to cope with peak periods of the sort experienced by the First Army in World War II. One must, therefore:

1. Plan to cope with peak periods by having enough assigned personnel so that, by making a maximum effort, they can handle the peak loads without outside aid; or
2. Plan to draw upon personnel resources beyond the army to some limited extent; or
3. Adopt some combination of both plans.

Allowance must also be made for enforced inactivity of surgical specialists through illness, leave required to maintain operating efficiency, and change of assignment or location of unit. For planning purposes an average dispersion of 20 percent may be assumed, but during a period of maximum effort such dispersion can be reduced to perhaps half, or 10 percent.

The assumptions which underlie the method of estimation employed here are:

1. In periods not characterized by peak rates
   a. Surgeons of each type will average seven operations per day while they are active; and
   b. Dispersion, noneffectiveness, and other inactivity will average 20 percent of the assigned surgeons.
2. In a single three-day peak period
   a. Surgeons of each type may average up to 10.5 operations per working day, except that the peak activity of 10.5 per day cannot be maintained for more than one three-day period in succession;
   b. Dispersion can be held to 10 percent whenever necessary; and
   c. Aid from fixed hospitals or other field armies can provide additional surgeons and other requisite ancillary personnel to augment the operating capacity of army hospitals by 30 percent.
3. In a single nine-day period of peak combat activity
   a. Assigned and borrowed surgeons can perform an average of 9.0 operations per working day (28 percent increase);
   b. Dispersion can be held to as little as 10 percent if necessary; and
   c. Fixed hospitals and less active field armies can provide additional surgeons to augment the operating capacity by 20 percent.
4. At all times
   a. Surgical specialists and anesthetists assigned to army are assigned to the army surgeon, so that 100 percent utilization may be assumed, apart from the dispersion specified above;
   b. Relative variations in WIA rates are those of the First U. S. Army in the ETO; in particular, the peak three-day rate is 5.31 and the peak nine-day rate 4.11 WIA per 1,000 strength per day.

Under the foregoing assumptions, 80 percent of the surgeons working at the average physiologic capacity of seven operations per day represent 5.6 operations per assigned surgeon per day, and 90 percent of the surgeons working at a physiologic maximum of 10.5 operations per day represent an average of 9.45 operations per assigned surgeon per day for a single three-day period. To the latter may be added 2.84 as the contribution of the fixed hospital or other theater resources, for a total of 12.29 operations per day per assigned surgeon during a peak three-day period. During a peak nine-day period 90 percent of the surgeons working at an average of nine operations per day will provide an average of 8.10 operations per assigned surgeon per day without outside assistance and 9.72 operations per day with the maximum outside assistance.

In order to cope with the highest WIA rate for a three-day period experienced by the First Army, a field army of 200,000 men would require

$$\frac{5.31 \times 200}{12.29} = 86 \text{ surgeons.}$$

In order to cope with the highest WIA rate for a nine-day period experienced by the First Army, a field army of 200,000 men would need

$$\frac{4.11 \times 200}{9.72} = 85 \text{ surgeons.}$$

On the basis of the foregoing assumptions, then, 86 surgeons would be required for a field army expected to have WIA rates parallel with those of the First Army. These 86 surgeons would be distributed as in Table 95, i.e.,

(N) Neurosurgeons	2.5
(B) General surgeons	50.4
(C) General surgeons	27.7
(T) Thoracic surgeons	5.4
Total	86.0

and would require 43 anesthetists in support.

A total of 86 assigned surgeons with an average dispersion or inactivity of 20 percent would have an average capacity of 482

WIA per day, or 2.41 WIA per 1,000 per day for a field army of 200,000, and for any three-day period of maximum effort with dispersion held at 10 percent, could care for 4.06 WIA per 1,000 men per day without outside assistance, and 5.28 with assistance. For any single nine-day period of peak load, 86 surgeons could handle a daily average WIA rate of 3.48 without outside assistance, and 4.18 with assistance from fixed hospitals. It is of interest to see just how busy the 86 surgeons would be if their hypothetical army were to experience precisely the WIA rates of the First Army in ETO. This has been done in Figure 26 for three-day intervals, an arbitrary choice. Rates for nine-day periods, for example, must be examined separately because of differences in the assumptions. Several nine-day periods may be defined for the First Army experience which are not identical with the peak period already discussed, e.g., those of 9-17 July and 2-10 August when the WIA rates were 3.5 and 3.4 respectively. During these periods the surgeons of the field army would be able to handle the load without outside assistance. During the initial beachhead period casualties would be received at a rate which would necessitate mobilization of surgical personnel in fixed hospitals, even if the hypothetical field army had enough of a beachhead to set up all its hospitals, a situation hardly to be assumed. Hence the initial period of an invasion must be regarded as one in which responsibility for initial surgery is shared by fixed and army hospitals, the latter assuming responsibility as quickly as the situation allows. Thereafter the workload and the corresponding requirement depend altogether on the vagaries of the casualty rate.

After August there was but one single three-day period, 16-18 September, when the WIA rate was such as to push the workload above the physiologic average. Otherwise the rates were such that calculated workloads are well below the physiologic average and indicative of a real surplus of surgical specialists. How to predict such a surplus with any confidence, and reduce the assignment of personnel accordingly, must always remain in doubt. Certainly, however, whenever a commander is confident that his campaign has entered a final or at least enduring phase in which it is extremely unlikely that he will sustain peak rates of the sort previously experienced or used in planning personnel requirements, the surgeon should be willing to reduce his allocation of surgical

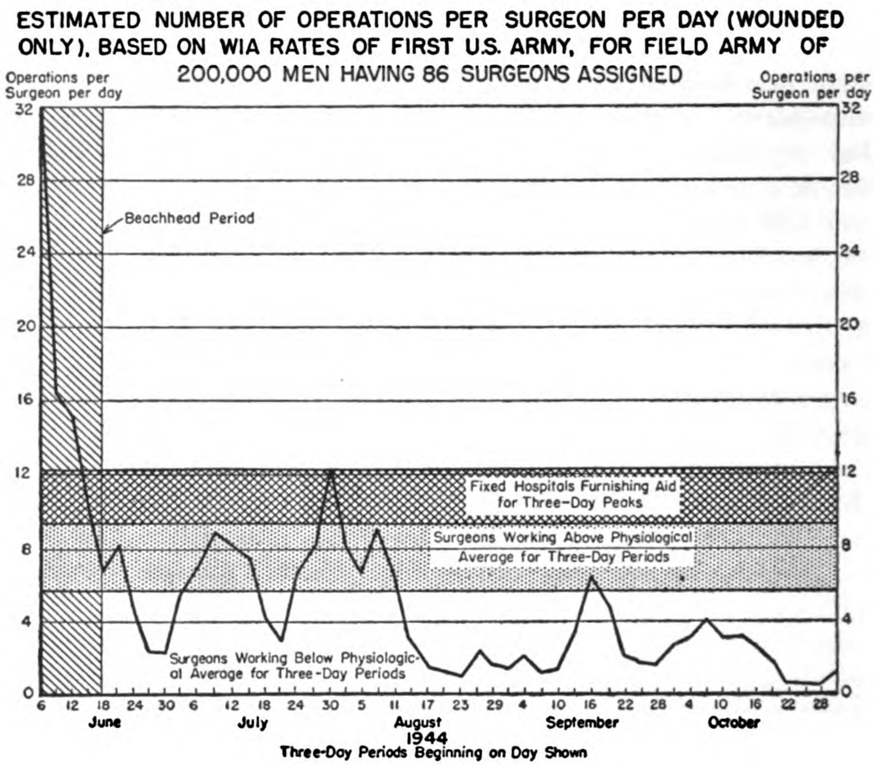


Fig. 26.

specialists. Otherwise, the temporary surplus must be regarded as a reserve against the chance that the calculated peak rate may be experienced or that it will be needed in support of another army.

Assumptions and underlying estimates must be varied with circumstances. There is no reason to believe that a single field army will provide a model for all probable applications, and accordingly it is desirable to see how well the First Army solution fits the experience of other field armies. Table 96 makes this comparison on the basis of observed hospital admission rates for wounded in the field armies in Europe. Plainly, since the First Army peak rates are above those of the other armies, its calculated requirement of 86 surgeons more than suffices for them as well. In addition, the table shows that the peak rates for the several armies display less variation than their means, so that the ratio of the peak to the mean varies considerably, from 6.8 to 3.3 in the case of three-day rates and 4.5 to 2.5 in the case of nine-day rates. Since the First Army ratios are among the lowest in this regard, they should not be used for planning purposes in conjunction with estimates of average rates. Either peak rates should be estimated directly, or larger ratios should be assumed.

Table 96

OBSERVED WIA RATES FOR FIELD ARMIES IN ETO, COMPARED WITH OPERATING CAPACITY OF ASSIGNED SURGEONS CALCULATED FROM FIRST U. S. ARMY EXPERIENCE

Field Army and Assigned Surgeons	Hospital WIA per 1,000 per Day		
	Campaign Average	Peak Rates	
		Three-Day	Nine-Day
First	1.62	5.31	4.11
Third	1.25	4.33	3.99
Fifth	0.72	3.84	3.23
Seventh	0.90	3.05	2.42
Ninth	0.60	4.08	2.42
Operating capacity of 86 surgeons*			
Physiological average	2.4	—	—
Peak performance without assistance	—	4.06	3.48
Peak performance with maximum assistance	—	5.28	4.18

*Calculated requirement based on First Army experience.

The assumptions derived from the First Army rates were also tested to see how divergent the results might be when requirements were computed on the basis of three- and nine-day periods in the other armies. In the main the agreement was close, but for the Third Army the peak three-day rate leads to a requirement of 70 surgeons and the nine-day rate leads to 82; for the Ninth Army the parallel figures are 66 and 50. This suggests that requirements be estimated on the basis of both three- and nine-day peak rates.

HOSPITALIZATION AND EVACUATION OF BATTLE CASUALTIES

Traditionally, the military value of surgery lies in the salvage of battle casualties. This is not merely a matter of saving life; it is primarily one of returning the wounded to duty, and the earlier the better. These are benefits which can be measured and incorporated into a logistic calculus. But no measurement can be proposed for the benefit to the morale of fighting troops which derives from knowledge of the accessibility of first-class surgical care, nor is it possible to state by how much the military value of a man returned to duty is increased by virtue of a shorter stay in hospital. But, whether measurable or not, these military gains can be realized only at the cost of providing an expensive apparatus for the hospitalization and evacuation of the sick and wounded. It is not for the medical planner to determine whether a commensurate effort expended on additional training or the provision of additional weapons would be of greater or lesser military value in some over-all sense. Rather, it is his function to press for facilities in such quantity as will ensure a quality of surgical care in which the medical profession and the nation at large may take justifiable pride, and to use whatever facilities are provided as efficiently as the military situation will permit.

The occurrence of a large number of battle casualties sets in motion a predictable series of consequences from which it is possible to abstract a mathematically simple system within which the exercise of various choices may be seen to affect the size of the hospital population and the number of admissions returned to duty. The elements of this system are as follows:

1. The rate at which new patients are admitted to hospital, and their proportionate distribution among battle and nonbattle casualties;
2. The number of hospital beds available;
3. The policy governing the flow of patients, and the schedule under which various types of patients are declared transportable and are evacuated, from one echelon to the next;
4. The proportion of beds held in reserve; and

5. The standardized patterns of trauma and physiologic response which determine the curves of patients remaining in hospital anywhere and disposed of in one way or another, for a given interval of time after admission to the first hospital.

Within this system one has only to substitute values for each of its elements in order to arrive at highly reliable estimates of the size of the hospital population and the number of men who would be returned to duty without further evacuation. It is the purpose of this section to illustrate the workings of this system so that those who must plan for the care of battle casualties may adapt their resources to the task of returning to duty the largest possible number of men in the shortest possible time.

Planning for the care of battle casualties cannot be done efficiently without taking into account the entire population of admissions and establishing such rules for evacuation of battle casualties and for the phasing of wound management as contribute to the most rational use of hospital facilities for all patients, whatever their diagnostic classification. The wounded may average 50 percent or more of the admissions of a field army, require more time in hospital than other admissions, and flow with an unevenness which is productive of crises. Once battle casualties become appreciable, therefore, policies governing their management and their evacuation will have a great effect upon the availability and utilization of hospital beds for nonbattle casualties, and it is the nonbattle casualties which furnish by far the greater portion of the returns to duty, even in an army area. If the wounded are kept too long in a forward area, or if the establishment of a reserve of beds for anticipated casualties forces indiscriminate evacuation of nonbattle casualties, efficiency is impaired.

The determinants of evacuation are the condition of the patient, availability of medical care at the echelons concerned, and availability of transportation. Limitations often accepted as intrinsic to the condition of the patient actually stem from factors of time and distance over which transportation would be required. Thus the more rapid and sure is the transportation the more freedom one has in the placement of surgical facilities, especially those for initial surgery. Moreover, the phasing of wound management determines transportability in large part, and the surgeon can exercise to good advantage such freedom as he has in deciding when and where certain procedures are to be performed. If a therapeutic procedure, e.g., reduction of a fracture, will render a patient nontransportable for some weeks, then consideration must be given to the choice of the proper echelon for such care. Most patients are transportable shortly after initial surgery, few soon after reparative surgery, so that considerable thought must be given to the timing of reparative surgery in relation to the requirements of evacuation.

Patterns of evacuation and the speed with which patients may be returned to duty are determined in part by medical and surgical knowledge and their application to the military situation. The concept of phased wound management, developed by Col. Edward D. Churchill in the early days of the war in the Mediterranean, had a profound effect upon the speed with which patients were evacuated, following initial surgery, to rear hospitals equipped for reparative surgery. The design of hospitals for specific functions is also an important determinant, as witness the effects of such units as the field hospital as used in ETO and MTO, and the army convalescent hospital. Future changes may render obsolete World War II concepts of surgical echelons and their location in time and space. Certainly in the closing phases of World War II there was increasing emphasis upon closer integration of all surgical echelons and upon shorter evacuation intervals among them. Had it been necessary to invade the Islands of Japan it is very likely that a large proportion of the men wounded there who were eligible for evacuation under the contemplated evacuation policy, would have been flown to the Zone of Interior for surgical care of a type previously given only overseas. There is always a pull between forces tending to concentrate medical resources at the hub or rear of military operations and those tending to place them forward nearer the fighting perimeter, and each war achieves its own peculiar equilibrium among these contending forces. Under conditions of atomic warfare there must be a greater degree of centralization than formerly, partly because of civilian casualties at home, but also because of changes in transportation and in the application of surgical principles to the military problem.

General Properties of Remaining and Returned-to-duty Curves

In his historic study of battle casualties in World War I, Love[1] described the basic mechanics of the system generated by the admission of wounded to medical installations. The structure of that system is clearly revealed by the component curves exhibited in Figure 27. The curves are for wounded admitted to hospital in North Africa during the first six months of 1943, wherever their subsequent hospitalization. The effect of evacuation policy upon the patient population and returns to duty may be perceived if one merely erects a vertical line at the desired point on the horizontal scale. The proportion to be evacuated under any particular policy is determined by the intersection of the remaining curve and the vertical line erected at the day fixed by the evacuation policy. The area under the remaining curve to the left of the vertical line will measure the total bed utilization, up to that point, of the number of patients originally admitted. Similarly, where the vertical line cuts the curve of cumulative returns to duty will indicate the number of admissions returned to duty under the particular evacuation policy. At what echelon the beds will be required and the men returned to duty, will depend upon other considerations. An *evacuation policy* for an echelon may be defined as the maximum interval allowed between first admission to hospital and disposition from that echelon. It is usually stated in days, e.g., 120 days after admission for an overseas theater or 20 days for a field army. It merely fixes the limit on duration of hospitalization, and does not otherwise specify when a patient should be evacuated. An *evacuation schedule* may be defined as the set of rules for determining when the evacuees are to be shipped out. For planning purposes a precise schedule may be assumed but in practice evacuation becomes a matter of moving individual patients and thus involves medical and surgical judgment as to their transportability, not to mention the availability of suitable transportation and of bed capacity at the next echelon.

The cumulative curve of returns to duty rises rapidly in the first 10 days after wounding, and less so thereafter. As the evacuation policy varies different proportions of admissions are returned to duty, but at a variable cost in terms of bed-days per man re-

[1] LOVE, ALBERT G.: War Casualties, Their Relation to Medical Service and Replacements, *Army Medical Bull.* No. 24, 1930.

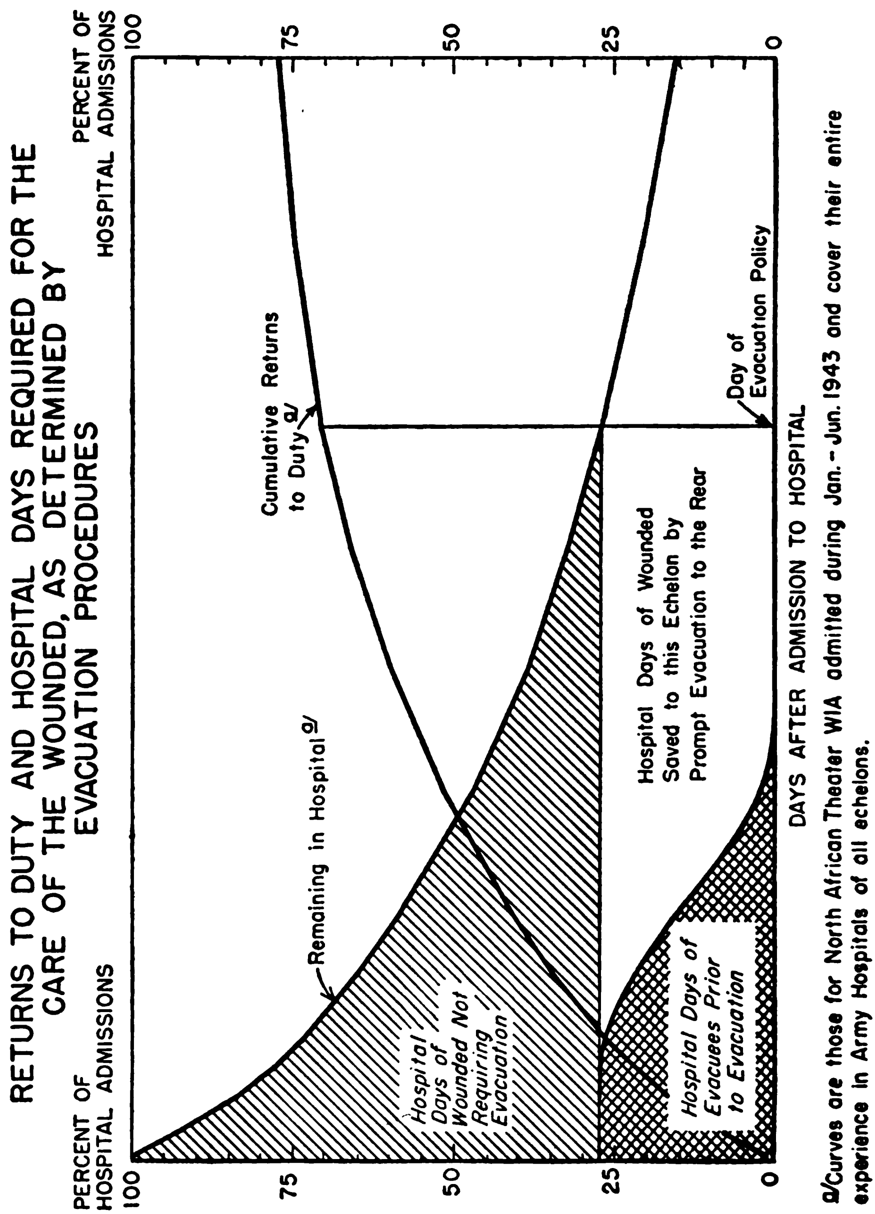

RETURNS TO DUTY AND HOSPITAL DAYS REQUIRED FOR THE CARE OF THE WOUNDED, AS DETERMINED BY EVACUATION PROCEDURES
PERCENT OF HOSPITAL ADMISSIONS
100
75
50
25
0
Remaining in Hospital a/
Cumulative Returns to Duty a/
Hospital Days of Wounded Not Requiring Evacuation
Hospital Days of Wounded Saved to this Echelon by Prompt Evacuation to the Rear
Hospital Days of Evacuees Prior to Evacuation
Day of Evacuation Policy
DAYS AFTER ADMISSION TO HOSPITAL
a/ Curves are those for North African Theater WIA admitted during Jan.-Jun. 1943 and cover their entire experience in Army Hospitals of all echelons.

Fig. 27.

turned to duty. At more forward echelons it is militarily unfeasible to place sufficient hospital capacity to permit the return to duty there of all wounded who can eventually be returned to duty. A field army must preserve its striking power by holding to a bare minimum its impedimenta and service units. A combat division is generally considered to be too mobile to have as an organic unit any hospital more elaborate than a clearing station. Also, although the number of men returned to duty increases as the evacuation policy is increased, the men in successive increments are not all of equal military value as replacements. One indication of this is shown in Figure 28, based on 7,900 Fifth Army Infantry troops wounded from 15 September to 5 November 1944. During the first 80 days after wounding the proportion returned to general duty fell from 97 to 49 percent of all those returned. The left-hand panel shows this specifically, and the right-hand panel gives the corresponding cumulative curves. The curve for return to general duty rises rapidly during the first 40 days, the average being 0.88 percent per day. Thereafter it increases much less rapidly, and during the interval 60 to 79 days the average increase is only 0.28 percent per day.

As the evacuation policy is changed for an echelon, the area under the remaining curve, which is the measure of potential bed requirements for that and any forward echelons, also varies. It is useful to subdivide that area [cf. Fig. 27] into several parts:

1. The nearly triangular area representing chiefly men returned to duty under the particular evacuation policy;
2. The part of the rectangular area which represents the hospital days required by the evacuees until they become transportable; and
3. The portion of the rectangular area which would be saved to a particular echelon (and any forward of it) if evacuees were shipped out before the last day of the evacuation policy.

From the standpoint of bed requirements, it would be highly desirable for a field army or an overseas theater not to be forced to use hospital beds for patients who cannot be returned to duty there, but this is manifestly impossible. All that can be done is to minimize that area under the remaining curve which represents the bed-cost of the evacuees to the echelon from which they are evacuated.

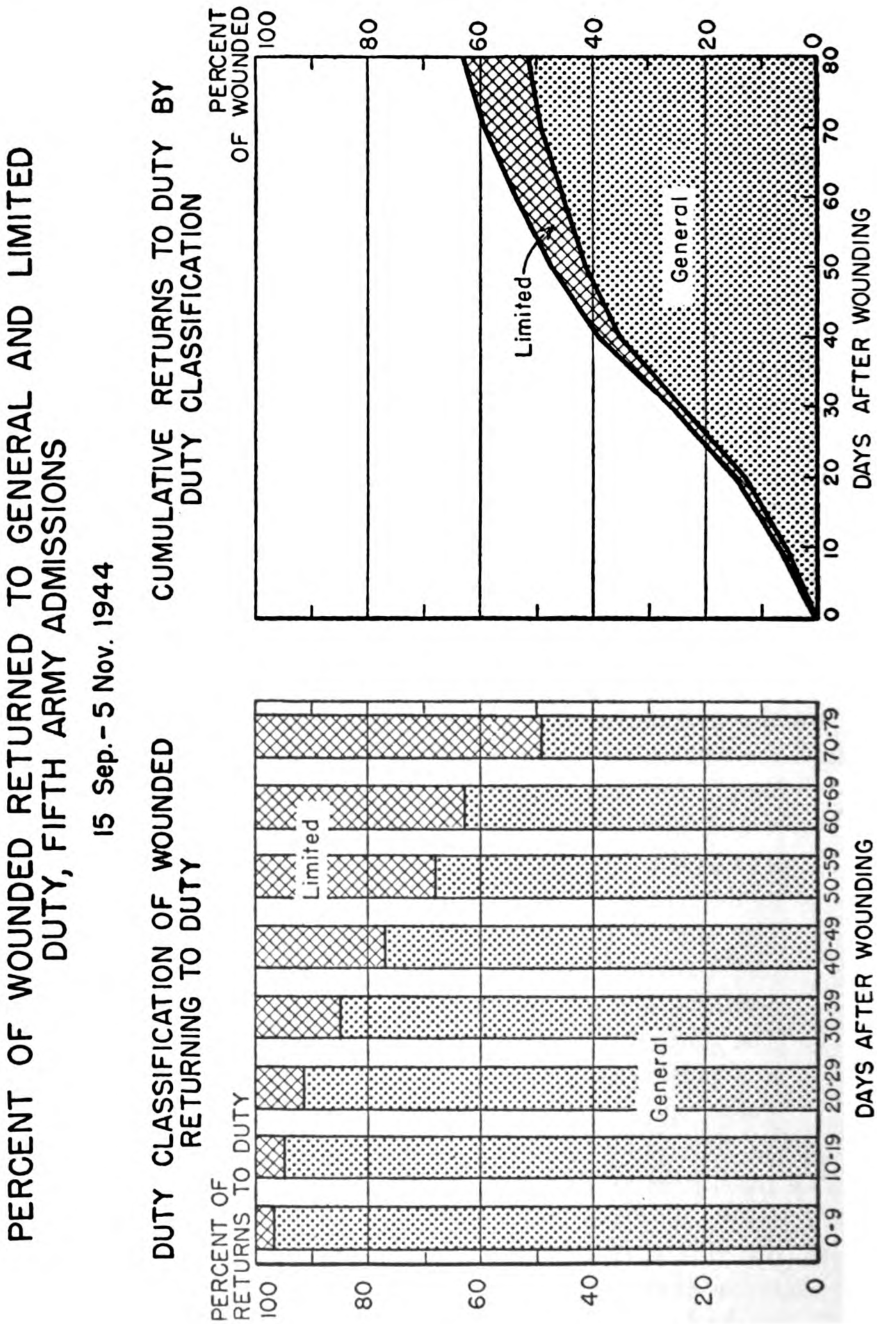

PERCENT OF WOUNDED RETURNED TO GENERAL AND LIMITED
DUTY, FIFTH ARMY ADMISSIONS
15 Sep. - 5 Nov. 1944
DUTY CLASSIFICATION OF WOUNDED
RETURNING TO DUTY
PERCENT OF
RETURNS TO DUTY
100
80
60
40
20
0
0-9
10-19
20-29
30-39
40-49
50-59
60-69
70-79
Limited
General
DAYS AFTER WOUNDING
CUMULATIVE RETURNS TO DUTY BY
DUTY CLASSIFICATION
PERCENT
OF WOUNDED
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
Limited
General
DAYS AFTER WOUNDING

Fig. 28.

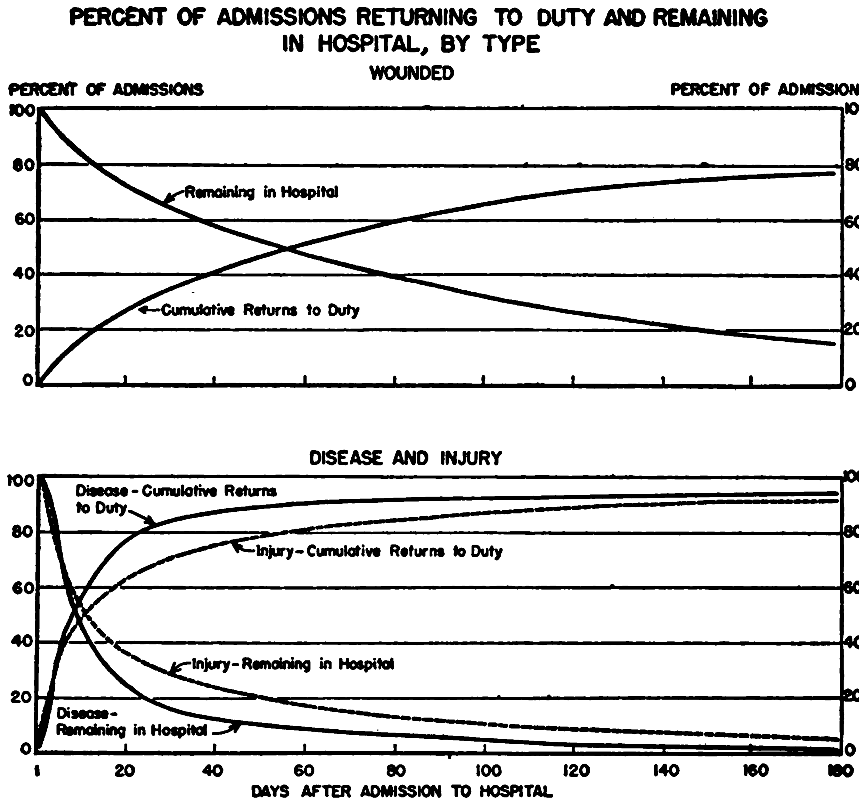


Fig. 29.

Comparative curves for wounded, disease, and nonbattle injury admissions to hospital are presented in Figure 29, and are based on NATO admissions during the first half of 1943. These curves show that, for a given number of hospital admissions, early returns to duty are much higher for nonbattle than for battle causes. The surgical planner cannot overlook the fact that the wounded represent but one component in a system which must be managed rationally and in its entirety if maximum returns to duty are to be achieved for a fixed investment in beds.

There is close interdependence among bed requirements, hospital admission rates, evacuation policy, evacuation schedule, replacement requirements, and returns to duty, an interdependence to which the curves of Figures 27 and 29 provide the key. Once the evacuation policy and the evacuation schedule are fixed, the area under any remaining curve is correspondingly fixed. Determination of that area provides a measure of the hospital-days required for the original number of admissions represented by the curve, and the ratio of these two quantities constitutes an estimate of the average number of hospital days required per admission, given the particular evacuation policy and schedule. Then an average bed requirement may be computed as the product of that average hospital stay and whatever average admission rate is assumed, except that it has been customary to provide for a cushion of beds to be held as reserve units or as unused beds within operating units. This is ordinarily done by specifying a constant percentage, e.g., that the unit reserve shall be 20 percent of the total, or that 15 percent of the beds of operating units shall be held in reserve for expansion against a sudden influx of patients. Returns to duty, similarly, may be derived by multiplying values from a return-to-duty curve by whatever admission rate be assumed. If the percentage returned to duty is determined for the day set by the evacuation policy, then the complement of that percentage is the replacement requirement in relative terms. The relative replacement requirement, e.g., 50 percent after 60 days, may be converted to a requirement per 1,000 strength by merely multiplying it by the admission rate.

Subdivision of the remaining curve according to echelon of hospitalization is illustrated in Figure 30. Defined by the army evacuation policy, the area of the uppermost triangle (ABD) represents bed-days of men who die and those who return to duty without evacuation from the army area. Immediately below is the rectangle (BDEF) measuring the hospitalization cost, up to day F set by the army evacuation policy, of those evacuated under the army policy F. The portion CDF′F of this rectangle is shifted to fixed theater hospitals by evacuating before the policy expires. Similarly, the lower triangle DGI plus the rectangle BDE′G represent the hospitalization days of the men returned to duty after evacuation from the army area without evacuation from the theater. The rectangle E′IEK represents the hospitalization days required, up to the day fixed by the theater evacuation policy, by men evacuated under that policy. It is assumed here that the portion HIJK can be shifted to the Zone of Interior by prompt evacuation.

ANALYSIS OF HOSPITAL DAYS REQUIRED AT VARIOUS ECHELONS FOR CARE OF WOUNDED

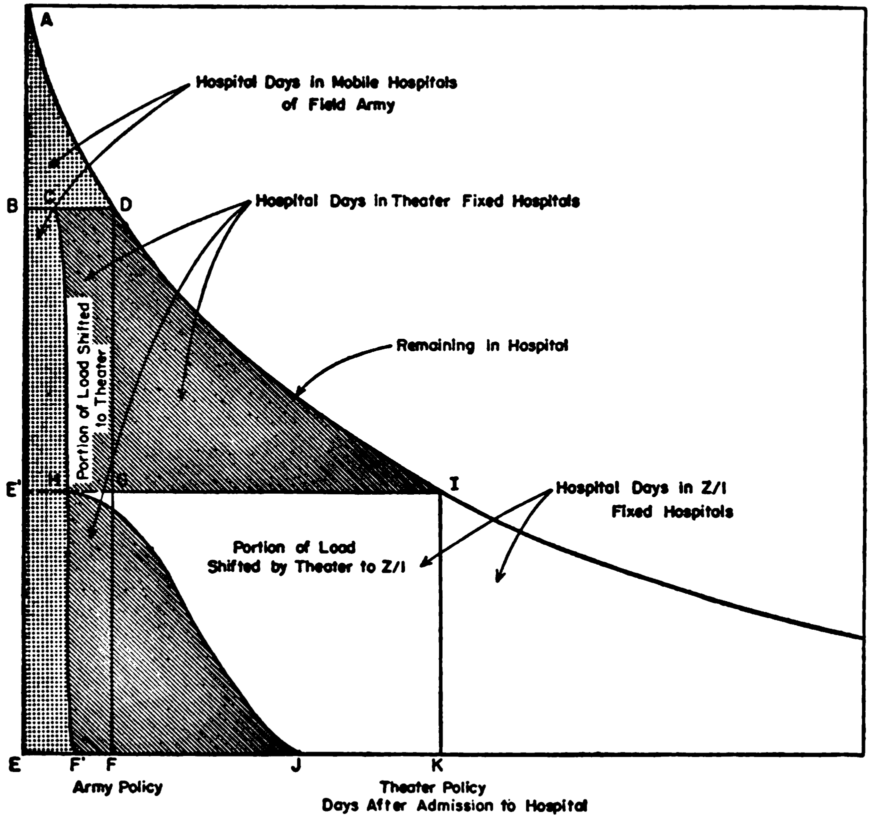


Fig. 30.

All the area to the right of the line IK is also, of course, Zone of Interior hospital cost under the theater policy of K days. Whenever attention is focused on theater or Zone of Interior hospitalization costs, appropriate deductions must be made for that part of the hospital cost already borne by forward echelons. In addition, any echelon has its own admissions, at least for nonbattle casualties, so that two sets of patients must be considered for the theater or the Zone of Interior hospital system, those admitted directly and those received by evacuation from the echelon below.

In addition to the curves presented in Figures 27 and 29 thought must be given to those representing injuries caused by

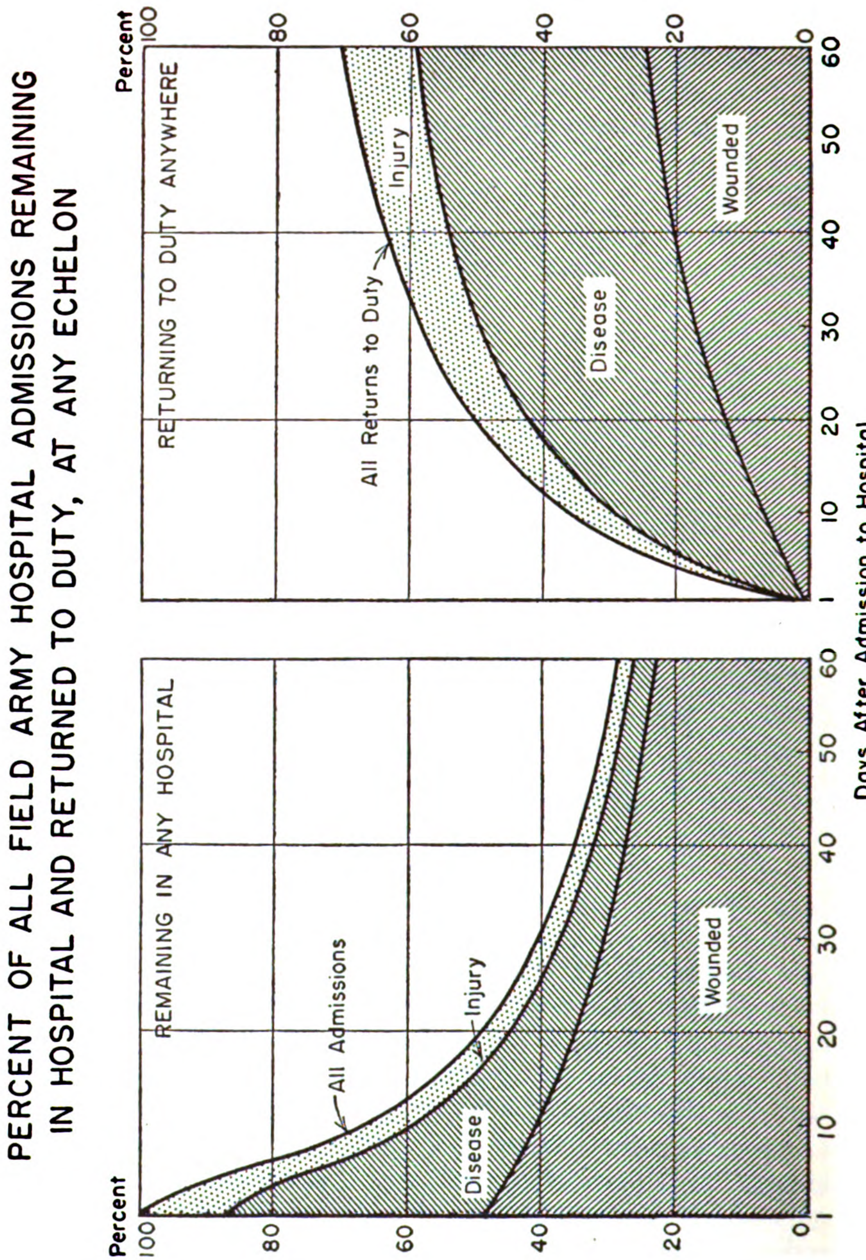

PERCENT OF ALL FIELD ARMY HOSPITAL ADMISSIONS REMAINING IN HOSPITAL AND RETURNED TO DUTY, AT ANY ECHELON
REMAINING IN ANY HOSPITAL
RETURNING TO DUTY ANYWHERE
All Admissions
Injury
Disease
Wounded
All Returns to Duty
Percent
100
80
60
40
20
0
1
10
20
30
40
50
60
Days After Admission to Hospital

Fig. 31.

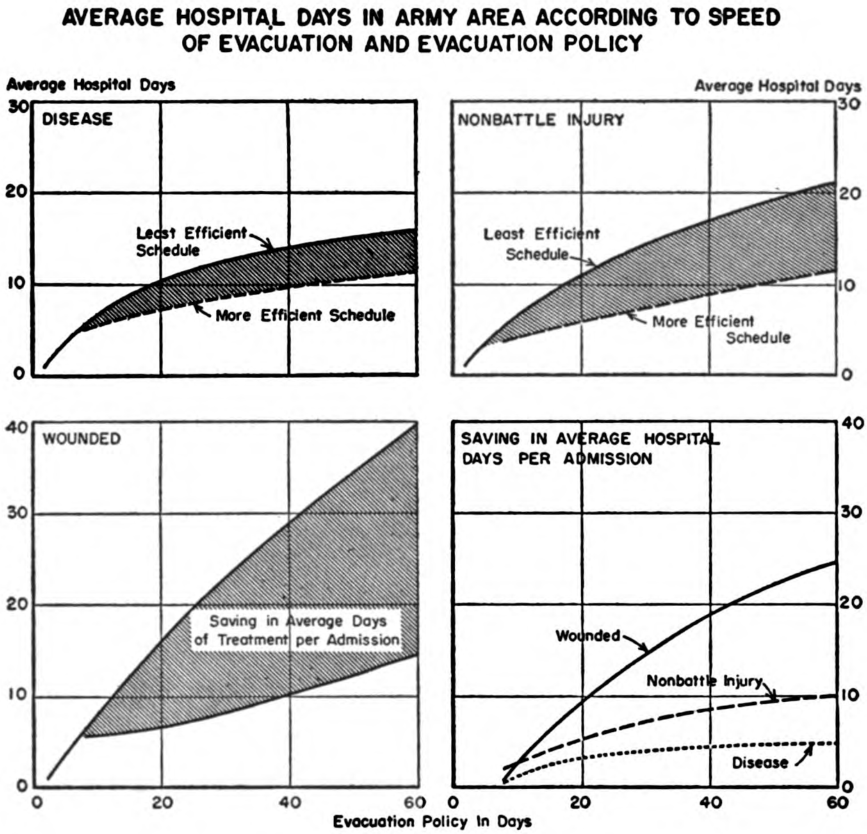


Fig. 32.

atomic weapons of one kind or another, if realistic plans are to be made for the future. Such curves will doubtless resemble those of Figures 27 and 29, but consideration of their characteristics lies beyond the scope of this work.

Forward Areas

Although the characteristics of remaining and returned-to-duty curves for disease, injury, and wounding were well known throughout World War II, largely from Love's monograph, full benefits of this knowledge were not realized, especially in forward or combat areas occupied by field armies. In part this may be because little emphasis had previously been placed on the characteristics of the entire system generated by all types of patients, chief attention having been paid to battle and nonbattle admissions as separate groups. A composite curve of all hospital admissions cannot be created without assigning proportionate weights to the several types of admission rates. If the experience of the First Army for the period 6 June 1944 to 27 April 1945 is taken as a guide in this respect, one obtains the curves plotted in Figure 31. These show how heavy is the cost of caring for the wounded in comparison with the nonbattle casualties, when returns to duty are the objective. If the hospital-days are divided by the corresponding number of men returned to duty to obtain an average cost per man returned to duty within the 60-day period, the result is 79 days for wounded and 20 for nonbattle casualties returned to duty, a difference of about four to one.

As used here, the hospitals of the army area or combat zone are: (1) the field hospital platoon when used as the mobile, housekeeping unit for surgical teams performing initial surgery on the severely wounded; (2) evacuation hospitals (400- and 750-bed types); and (3) army convalescent hospitals. The First Army, for example, had the following average assortment of units during the period October 1944-March 1945:

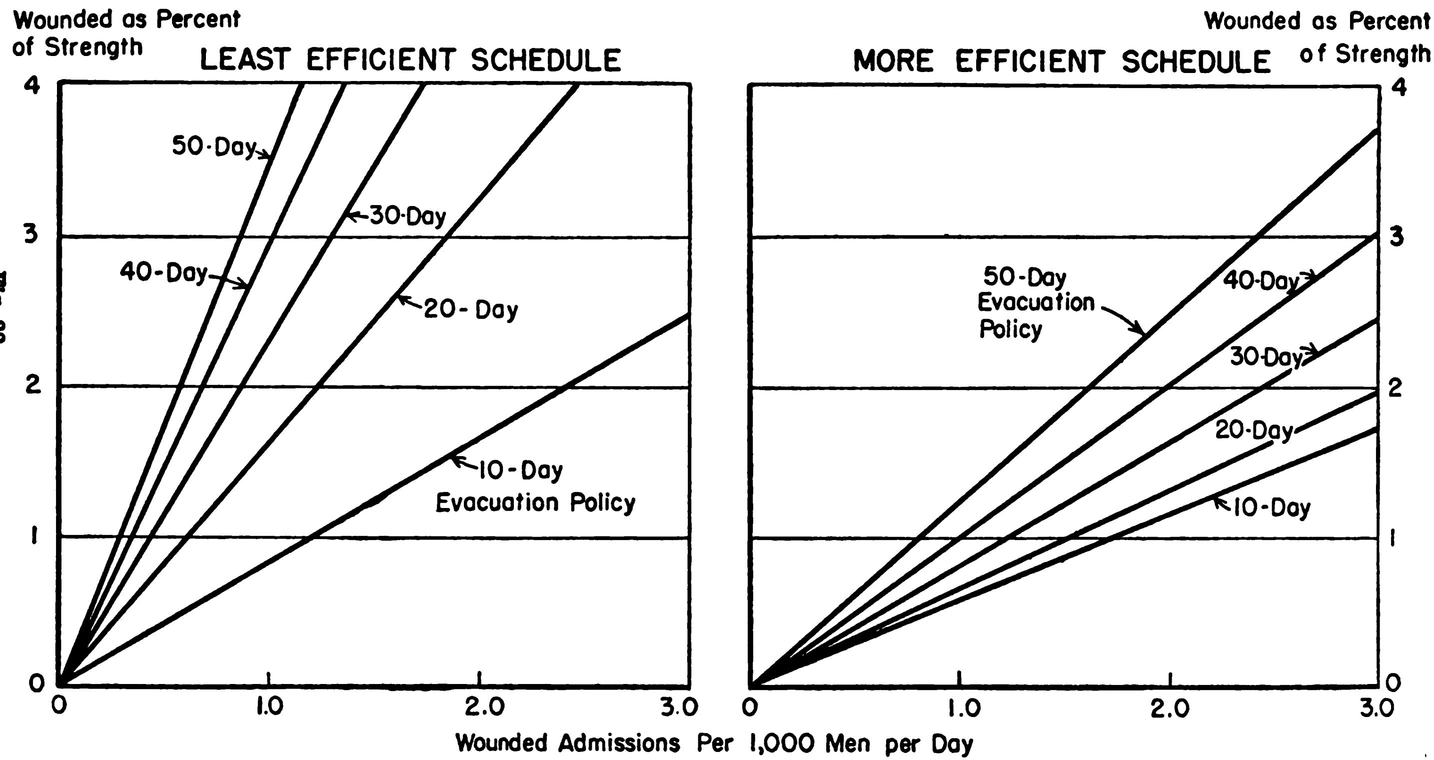
Type of Unit	*Average Number of Units*	*Average Number of Beds*
Field hospital	4.4	1,771
Evacuation hospital (750-bed)	1.0	750
Evacuation hospital (400-bed)	9.6	3,829
Convalescent hospital	1.0	3,000
TOTAL	16.0	9,350

The field hospital of World War II was at first classified as a fixed hospital, but its usefulness as the prototype of the present forward surgical hospital led to its classification as a mobile hospital when thus employed. The fixed hospitals were located in the communications zone or base areas of the theater, and comprised chiefly numbered station and general hospitals and an occasional convalescent center. The utilization of fixed hospitals is not discussed here.

Two basic errors may be identified in practice: (1) failure to evacuate, as soon as they become transportable, all patients re-

Fig. 33.

AVERAGE NUMBER OF WOUNDED IN HOSPITAL IN ARMY AREA ACCORDING TO EFFICIENCY OF EVACUATION SCHEDULE, LENGTH OF EVACUATION POLICY, AND ADMISSION RATES



quiring more days in hospital than the evacuation policy allows; and (2) failure to fix the evacuation policy so as to maximize *total* returns to duty for the available bed capacity. The effect of the first type of error may be seen in Figure 27; the area of cost saved by prompt evacuation is not as large as it should be. Figure 32 presents an additional fact of importance. Each shaded area there exhibits the region within which savings may be effected by appropriate choice of an evacuation schedule. Plainly, within the range between efficient and inefficient evacuation schedules, the average hospital days per admission varies much more for wounded than for disease or nonbattle injury admissions. The lower right-hand panel gives these results in the form of savings in hospital days per admission, the three separate shaded areas having been brought together in this panel. For purposes of computation the least efficient schedule is defined as one under which all patients are evacuated at the beginning of the day specified by the policy. The evacuees thus spend in hospital one day less than the numerical designation, e.g., 20 days, of the policy. Under the more efficient schedule it was assumed that all disease and wounded patients could be evacuated after six days in hospital, and nonbattle injury patients after four.

Another aspect of the problem of delayed evacuation is shown in Figure 33, which indicates the impact of the evacuation schedule upon the size of the hospital population in the army area, over the range of probable admission rates for wounded, and for various evacuation policies. The left-hand panel is based on the extreme assumption that evacuation of wounded never takes place until the term of the evacuation policy has expired, the right-hand panel that evacuees leave after six days in hospital. Thus a hospital admission rate of 1.62 wounded per 1,000 strength per day (that of the First Army in ETO from 6 June 1944 to 27 April 1945), and an evacuation policy of 20 days, would yield a hospital population of wounded amounting to about 2.6 percent of strength under the least efficient schedule, and about 1.1 percent under the more efficient one upon which the right-hand panel is based. The computation was carried out over a wide range of evacuation policies; 50 days is an unlikely choice for an army policy under combat conditions.

The second type of basic error is more complex and has not received the attention it warrants. In Figure 34 the height of the

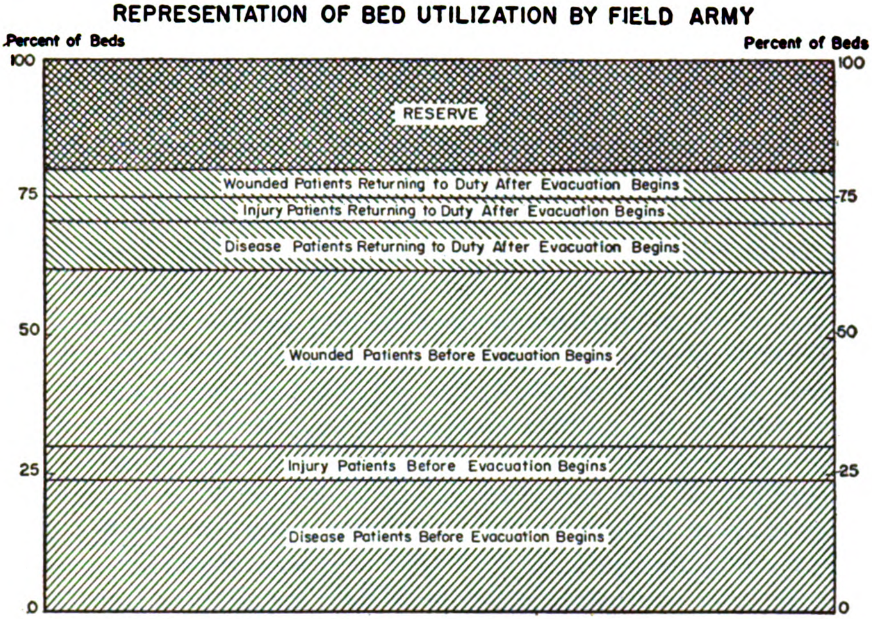


Fig. 34.

entire rectangle represents the total bed capacity of a field army. Some part of it, here estimated as 20 percent, may be kept in reserve for rest, emergency support, and forward movement. If the evacuation policy is 20 days, and if long-term disease and wounded patients are evacuated after six days and nonbattle injury patients after four, then about 62 percent of all the beds will be expended on nontransportable patients and on those who die or return to duty before evacuees become transportable, according to the remaining curves of Figure 31, which are weighted by the admission experience of the First Army. Then it can be shown that the largest number of total returns to duty from disease, injury, and wounded admissions taken together, will be achieved if the remaining beds are used only for patients who are to be returned to duty before the expiration of the limit set by the evacuation policy. Since the added cost of returning a patient to duty is precisely measured by the interval between the date of return to duty and the date he became transportable, the most efficient evacuation policy is one in which this interval is the same for all patients returned to duty immediately prior to the expiration of the evacuation policy. Thus, the evacuation policy will vary among the several groups of patients if they become transportable at different times, but for the range of values used here for the interval after which patients become transportable, so little error is introduced by employing the same evacuation policy for all types of patients, that the computations have been simplified by this assumption.

Suppose, for example, that disease, injury, and wounded patients are represented by 10,000 admissions of each type. Then from Appendix II it may be seen that 51,832 days will have been expended on disease patients by the time they become transportable, 36,360 on nonbattle injury patients, and 57,145 on battle casualties. If, now, 10,000 days remain to be used, what pattern of use would return to duty the greatest number of men? If all the days were allocated to disease patients then, according to Appendix III, 2,759 additional men could be returned to duty under an evacuation policy of about 15 days for disease patients, seven for wounded, and five for nonbattle injury. If the 10,000 days were expended so as to have the same evacuation policy of 10 days for all types of patient, then 4,203 would be returned to duty. But if the evacuation policy were 11 days for disease and wounded, and nine for nonbattle injury, then 4,257 patients could be returned to duty by the use of the 10,000 additional hospital days. The average cost per patient returned to duty is, then, in this example:

For the policy of 15 days for disease, 5 for injury, and 7 for wounded	3.6 days
For the policy of 10 days for all	2.4 days
For the policy of 11 days for disease and wounded, and 9 days for injury	2.3 days

Although the system generated by hospital admissions is not especially complex, its determinants are sufficiently numerous and responsive to changing military conditions to make it impossible to state any universally-applicable solution for the problem of hospitalization and evacuation in the army area. Rather, one must rely upon an understanding of how the system works and of the adaptations which may be made within it. It is possible, however, to illustrate the general range of effect associated with one or another change in the particular military situation, and thus to derive some useful if general principles which may be employed in adapting hospitalization and evacuation to specific military situations.

EFFECT OF BED RESERVE UPON PERCENT OF ADMISSIONS RETURNED TO DUTY IN ARMY AREA

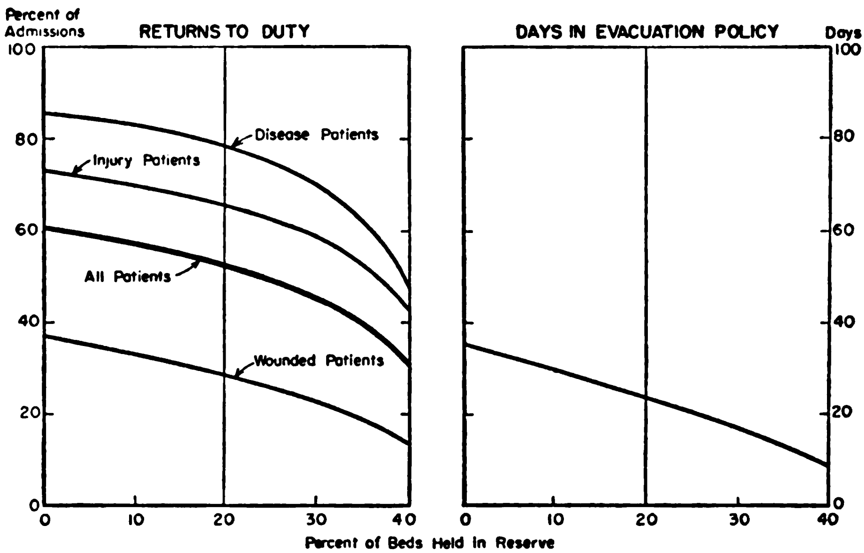


Fig. 35.

The effect of variation in the percentage of beds in reserve units may be seen from Figure 35, which is based upon the following assumptions:

1. Disease and wounded patients become transportable after six days in hospital, injured patients after four;
2. The ratio of beds to admissions is that of the First Army, 9.02;
3. The proportionate distribution of admissions by type is that of the First Army, namely;
   38.60 percent for disease
   13.27 percent for nonbattle injury
   48.13 percent for wounds
4. The evacuation policy in each instance is the same for each type of patient.

On the basis of these assumptions the percentage of all admissions returned to duty in the army area falls from 60 to 31 percent as bed-reserves are increased from 0 to 40 percent of the total available capacity. Once the bed-reserve is fixed at more than 20 percent

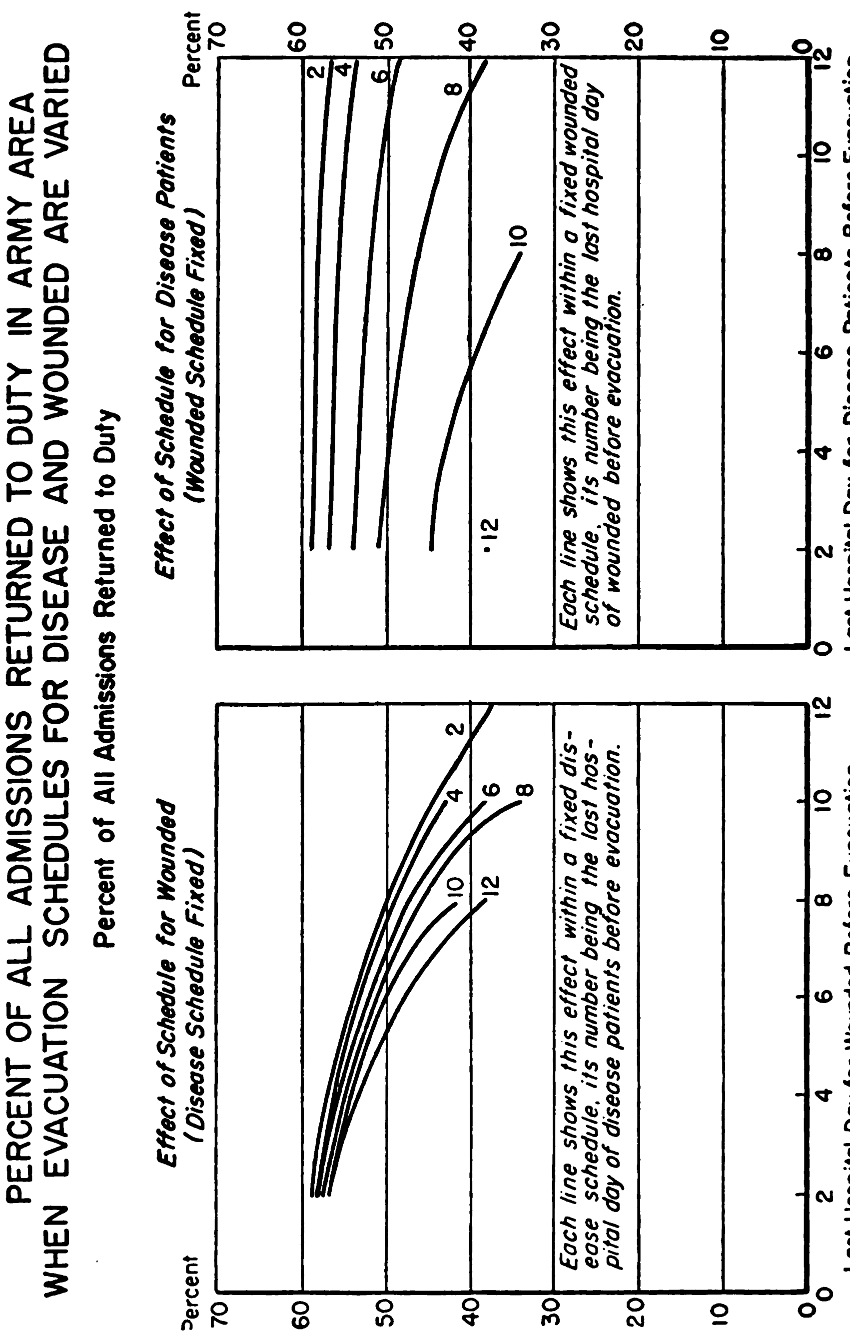

PERCENT OF ALL ADMISSIONS RETURNED TO DUTY IN ARMY AREA
WHEN EVACUATION SCHEDULES FOR DISEASE AND WOUNDED ARE VARIED
Percent of All Admissions Returned to Duty
Effect of Schedule for Wounded
(Disease Schedule Fixed)
Percent
Each line shows this effect within a fixed disease schedule, its number being the last hospital day of disease patients before evacuation.
Last Hospital Day for Wounded Before Evacuation
Effect of Schedule for Disease Patients
(Wounded Schedule Fixed)
Each line shows this effect within a fixed wounded schedule, its number being the last hospital day of wounded before evacuation.
Last Hospital Day for Disease Patients Before Evacuation

Fig. 36.

there is a rapid decline in returns to duty. The relation between the bed-reserve and the evacuation policy is also an inverse one. The evacuation policy drops from 35 to 9 days as the bed-reserve rises from 0 to 40 percent. The units designed to be held in reserve to ensure mobility to the field army are the evacuation hospitals, especially the 400-bed type. Evacuation hospitals, however, may constitute only 50 to 60 percent of the mobile beds of a field army, so that a 30 percent reserve actually means that about half of the evacuation hospitals are in reserve. Moreover, as used here the reserve-allowances are averages over time; much of the time the unit-reserve will be greater than the average and presumably will approach zero only at the peak of combat activity. The issue here is not one of minimizing the number of units held in reserve, for a premium must be placed on the availability of reserve units to facilitate movement, but rather one of balancing gains and losses from the two contradictory requirements: mobility versus retention of manpower in the army area.

The length of time evacuees must be held in the army area before they are transportable to the rear is also a major determinant of the extent to which patients can be returned to duty in the army area. Assumptions along these lines are perhaps the most arbitrary of all, and yet it is surely meaningful to employ some average figure with full cognizance that individual variation will be quite large. The fact of such variation has been omitted from earlier computations in the belief that the overall statistical picture would not be affected thereby, and because some specific assumptions must be made before any numerical results can be obtained for the effect of other variables. If the other determinants are fixed, however, and army hospital days for evacuees are allowed to vary, it is possible to show, as in Figure 36, the effect associated with this factor over the range of interest. The assumptions underlying this set of calculations are:

1. The ratio of beds to admissions is that of the First Army, 9.02;
2. The proportionate distribution of admissions by type is that of the First Army, as stated above;
3. The evacuation policy in each instance is the same for each type of patient.
4. The bed-reserve is 20 percent.

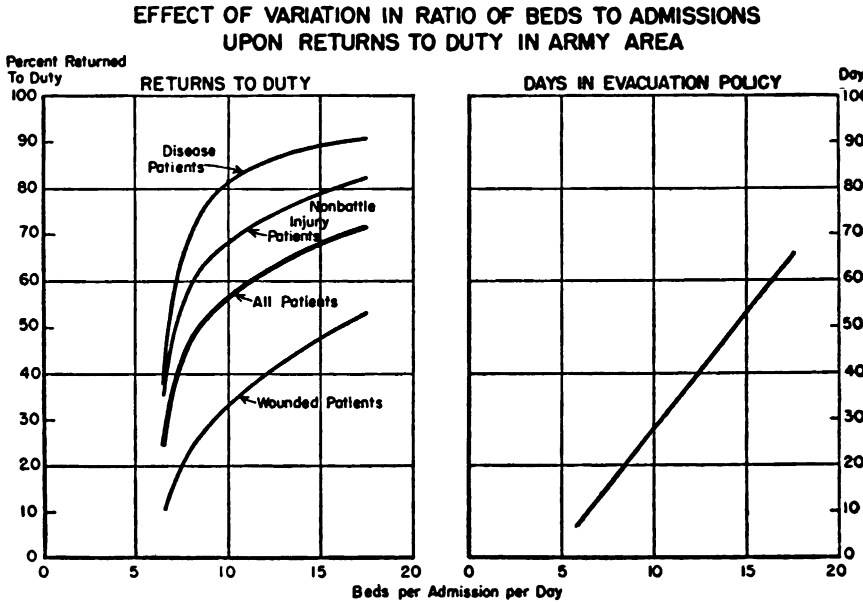


Fig. 37.

With these assumptions fixed, the evacuation schedule was allowed to range from two to 12 days for both disease and wounded patients, while that for nonbattle injury patients was held at four days. The results of each of these different combinations of evacuation schedules may be expressed in the form of the percentage of admissions returned to duty in the army area, for each type of patient and for all types combined. The curves of Figure 36 give these percentages in graphic form for all admissions. The curves for each type of admission are essentially similar. From 59 to 34 percent of all admissions, 84 to 52 percent of disease admissions, 35 to 15 percent of the wounded, and 71 to 46 percent of the nonbattle injury admissions, are returned to duty under the foregoing assumptions. The evacuation policies corresponding to the curves in Figure 36 range from 10 to 32 days.

Within each of the evacuation schedules considered here for disease patients, varying the evacuation schedule for the wounded produces a marked change in the returns to duty for all types of patients. Varying the evacuation schedule for disease patients has a large effect upon returns to duty only if the evacuation schedule for wounded is eight or more. For all the combinations of schedules from two to 10 days, a difference of one day in the evacuation schedule for the wounded changes the returns to duty by 2.4 percent of the admissions for all causes, whereas a similar difference in the evacuation schedule for disease patients effects an average change of only 0.65 percent of all admissions. Thus the evacuation schedule adopted for the wounded is of primary importance in determining how many patients will be returned to duty in the army area, whatever their diagnostic classification.

The effect of variation in the ratio of beds to admissions per day may be exhibited more simply. For the four major field armies in Europe the ratio ranged from 9.02 to 15.90 beds per hospital admission per day. The calculations designed to explore the effect of the ratio are based upon the following assumptions:

1. Beds per admission range from 6.6 to 17.5;
2. Disease and wounded patients become transportable after six days in hospital, injured patients after four;
3. The proportionate distribution of admissions by type is that of the First Army, as stated above; and
4. The bed-reserve is 20 percent.

The lower limit of 6.6 beds per admission per day represents the minimum required to support the other assumptions made here. The results of the calculations are shown graphically in the left-hand panel of Figure 37. There is a rapid rise in returns to duty as the ratio of beds to admissions is increased, but once the region of 12.5 to 15 beds per admission is reached the proportionate gains from adding more beds are rather small. The right-hand panel of Figure 37 shows the relation between the evacuation policy in days and the ratio of beds per admission per day. This indicates that some of the high values in the main chart lie beyond the range of actuality, in that evacuation policies in excess of 40 days are required to make the most efficient use of more than 12.5 beds per admission per day.

Finally, it is possible to illustrate the effect of variation in the composition of the total admission rate. Five different sets of weights were chosen to subdivide the total admission rate, as follows:

Table 97

ASSUMED PERCENTAGE DISTRIBUTIONS OF HOSPITAL ADMISSIONS, BY TYPE

Set	Disease	Injury	Wounded
a)	65	20	15
b)	58	17	25
c)	51	14	35
d)	44	11	45
e)	37	8	55

In passing it may be noted that the corresponding weights for the major field armies in Europe, derived from the Statistical Health Report, are as follows:

Table 98

DISTRIBUTION OF HOSPITAL ADMISSIONS BY TYPE, FIELD ARMIES IN EUROPE

Army	Time Period	Disease	Injury	Wounded
First	Jun 44-Apr 45	39	13	48
Third	Aug 44-Apr 45	45	12	43
Fifth	Jan 44-Apr 45	63	12	25
Seventh	Nov 44-Apr 45	47	16	37

Thus the range under scrutiny corresponds to the realities of World War II. The further assumptions underlying the computations are:

1. Disease and wounded patients become transportable after six days, injured patients after four;
2. Beds per admission are 9.02, the figure for the First Army.
3. Reserve-beds are 20 percent.

The computations lead to evacuation policies of 22 or 23 days for the five sets of ratios, with a nearly constant percentage of admissions returned to duty for disease, injury, or wounded patients, but with a sharply rising percentage for all admissions. As the percentage of wounded falls from 55 to 15, the percentage of total admissions returned to duty rises from 49 to 67. By type of patient the corresponding returns to duty are 77 or 78 percent for disease, 64 or 65 percent for nonbattle injury, and 27 or 28 percent for wounded patients, depending on whether the evacuation policy is 22 or 23 days.

It is possible to extract from the foregoing a brief set of statistical principles which should be part of the planning equipment of the forward surgeon. These are:

1. Set definite evacuation schedules according to transportability. Establish them at the lowest practical level and enforce them.
2. Fix a single evacuation policy for all types of patients. Set it at the maximum allowed by the supply of beds and the total admission rate, but change it from time to time as the admission picture changes.
3. Minimize the number of T/O beds in reserve units, observing that once the bed-reserve exceeds 20 percent the returns to duty fall off sharply. Try to get some reserve capacity by expanding beyond T/O capacity.
4. Keep a careful watch on the admission rate and bring the evacuation policy into line with any great change in the average rate for all causes.
5. Provide for an average of 7.5 to 12.5 T/O beds per admission over a considerable period. If admissions consistently exceed expectation, and the ratio falls below 7.5 beds per admission, more T/O beds should be made available.

If one were to forecast, on the basis of the foregoing analysis, the proportionate returns to duty in the major armies in Europe, one could not expect performance to approximate expectation very closely. This is because of the ebb and flow of casualties and because of variations in the percentage of beds held in reserve. It is instructive, however, to carry forward such a comparison, for it suggests that a great deal remains to be learned about how to use mobile beds most effectively. Expected values have been computed on the basis of the facts and assumptions presented in Table 99. In addition, it is assumed that admission rates are constant and that disease and wounded patients become transportable after six days in hospital, nonbattle injury patients after four. The results of these calculations are given in Table 100, together with returned-to-duty percentages based on Form 323 data for the ETO armies,

Table 99

BASIS FOR CALCULATION OF RETURNS TO DUTY IN FIELD ARMIES

Element in Calculation	Field Army			
	1	3	5	7
Time Period	Oct. 44 – Mar. 45	Oct. 44 – Mar. 45	Aug. 44 – Dec. 44	Dec. 44 – Mar. 45
Beds/Admissions*				
Form 323	9.0	10.0	15.9	11.4
Form 86ab	—	11.1	—	14.7
Proportionate Distribution of Admissions†				
Disease	46	51	66	51
Injury	18	13	11	19
Wounded	36	36	23	30
Percentage of Beds held in Reserve	20	20	20	20

*For the 3rd and 7th Armies the Statistical Health Report (86ab) and the ETO Form 323 do not agree very closely as to number of hospital admissions. For ETO armies Form 323 data were used in deriving the proportionate distributions of admissions.

†These distributions are for the time periods shown, and correspond with the available data for beds.

and on the Statistical Health Report for the Fifth Army. According to these computations, the Third and Fifth Armies were getting the most out of their hospitals over the periods shown, the Seventh somewhat less, and the First the least. Undoubtedly some of the difference, but surely less than half, between the expected and actual percentages derives from fluctuations in casualty rates. It may also be noted from Figure 35, however, that the discrepancy is the same size as would occur between calculations based on bed reserves of 20 percent and 40 percent or more.

In a discussion of statistical principles it is important not to lose sight of military and medical determinants of hospitalization and evacuation. There will be changes in tactical situation which will transform an otherwise efficient procedure into an incubus, or threaten the survival of casualties at a time of great influx. The

Table 100

EXPECTED AND OBSERVED PERCENTAGE OF HOSPITAL ADMISSIONS RETURNED TO DUTY, FIELD ARMIES IN EUROPE

Field Army		Percentage Returned to Duty by Type of Admission			
		Disease	Injury	Wounded	Total
First Oct. 44 Mar. 45	Expected	78.2	64.8	28.0	57.7
	Observed	46.6	21.6	5.6	27.4
	Observed as percent of expected	*60*	*33*	*20*	*47*
Third Oct. 44 Mar. 45	Expected*	81.9, 85.0	68.6, 72.1	32.0, 36.5	62.3, 66.0
	Observed	63.1	36.0	18.5	43.7
	Observed as percent of expected*	*77, 74*	*52, 50*	*58, 51*	*70, 66*
Fifth Aug. 44 Dec. 44	Expected	90.0	80.5	50.0	79.7
	Observed	60.5	38.7	21.9	49.2
	Observed as percent of expected	*67*	*48*	*44*	*62*
Seventh Dec. 44 Mar. 45	Expected*	85.4, 89.2	72.6, 78.9	37.1, 46.9	68.7, 74.6
	Observed	59.5	32.6	15.6	41.4
	Observed as percent of expected*	*70, 67*	*45, 41*	*42, 33*	*60, 55*

*Two estimates are given for the Third and Seventh Armies and are based on the separate bed/admission ratios of Table 99.

likelihood of tactical change will often prevent an army from operating its hospitals in a manner which may seem most efficient on paper. The pattern suggested by statistical analysis is merely an instrument to be adapted to the military situation.

If the tactical situation cannot be controlled at least the hospital system can be regarded as an adaptive mechanism. The adaptation is not a purely quantitative affair, but very largely a matter of the design of efficient hospitals and patterns for their use. It is psychologically unsound to depend entirely upon units located in the main stream of evacuation to have the administrative strength to hold patients until they are ready for return to duty. Unless the route of evacuation ramifies in the army area, taking patients out of the line of direct evacuation at various points, it can become a main highway to the base areas for an unduly large proportion of men. In the Fifth Army, where the greatest developments occurred along these lines, intensive use was made of the army convalescent hospital for most types of patients, and certain specialized groups were placed in army centers for more efficient handling. Among the latter were patients with venereal diseases, gastro-intestinal disorders, and neuropsychiatric difficulties. These centers not only relieved much of the pressure upon the evacuation hospitals, and thus reduced the indiscriminate evacuation forced by sudden influxes of wounded, but also provided for exceptionally competent diagnosis and therapy, with the result that evacuation was less conservative and treatment more expert than was ordinarily true in a forward area.

SURGICAL IMPLICATIONS OF THE EVACUATION AND DISTRIBUTION OF BATTLE CASUALTIES

By Edward D. Churchill, M.D.

General Considerations

The surgical management of wounds and the evacuation of the wounded are so closely intertwined that it is impossible to consider one without an understanding of the other. These two phases of military surgery are governed by contradictory and oftentimes inconsistent principles; either one or both may conflict with the pursuit of the military undertaking as a whole. The art of military surgery lies in ascertaining the extent to which one or the other set of principles shall be operative under given circumstances in accord with the course of action that best supports the military situation. It serves no useful purpose to ignore the wound surgeon as an idealist who cannot understand the practical demands of warfare, or to castigate the evacuation officer as a tool of an unenlightened administration. Actually, the idealist must bring his procedures into line with the facts of a military situation, and the administrator must seek guidance in an understanding of wound surgery, or both will find themselves impeding the military effort by making decisions on the impulse of the occasion.

In the following consideration of evacuation as it is related to the surgical management of the wounded, no attempt is made to state what "should" be done or what "ought" to be done. Judgments of this type can be passed only when one is confronted by an actual situation. However, the statements identified hereafter as *Propo-*

sitions have been found valid under a wide range of circumstances. Exception can be found to each. The value of identifying any one of these principles lies in the information it provides the military surgeon as to what is the likely result of certain actions.

Evacuation in theory is but an exercise in logistics in which anticipated casualties, capacity of transport facilities, the timing of transport shuttles, and available beds are the primary considerations. In actual practice, evacuation becomes a *selective* transport of casualties away from the combat area. Selection of casualties for evacuation is based on professional judgments relative to the nature of the wound and to the time, distance, and method of transport. Selective evacuation gives weight to the urgency of the wound, the likelihood of return of the wounded to duty status, the anticipated time of disability, and the conditions required for optimal recovery.

Proposition I. To the extent that evacuation of the wounded can be made selective, there will result a greater saving of life, an increased number of wounded returned to combat duty, a decreased number of noneffective man-days, and a reduction of ultimate functional disability.

The Medical Department is a supporting service, and the facilities with which it is provided are determined by decision of command. The provision of the facilities required for *complete* selectivity in evacuation would impose a logistic burden that might well endanger the success of the military undertaking as a whole. It is obvious, therefore, that:

Proposition II. While the facilities that promote selectivity in evacuation are provided by decision of command, it is the responsibility of the Medical Department to use the facilities that are available in a manner that introduces as great a degree of selection as possible.

The first decision in selective evacuation is the classification of a wounded man as transportable or nontransportable. This is an estimate of his physical condition measured against the means and duration of transport and the feasibility of providing the necessary care at the given location. The closer to actual combat, the less the element of selection enters into evacuation, and the more the movement of casualties is determined solely by transportability. At an infantry battalion aid station, the only selection may be the separation of casualties rendered noneffective by the wound and who *must* be evacuated, from those who can be returned to combat tasks almost immediately.

Proposition III. The closer to the site of combat, the less feasible it becomes to introduce selection into evacuation and the more the necessity to remove the wounded from the combat area governs action.

At the clearing station of the infantry division, evacuation becomes selective because of considerations that are both military and surgical. Only when a general retrograde movement is in progress does evacuation become a mass movement of all wounded away from the combat zone. Even then, certain groups of nontransportable patients may be left to an enemy known to respect the rules of the Geneva Convention. As one proceeds from the clearing station toward rear areas, evacuation becomes increasingly selective.

Proposition IV. The farther from the area of combat, the more can considerations other than necessity and transportability shape action, and the more possible it becomes to introduce selection into evacuation.

The principles governing selective evacuation, like those of all military surgery, are derived from two sources, military and humanitarian. The common goal is the success of the military undertaking with as little human wreckage as possible.

Military Considerations in Evacuation

The combat soldier is the most valued component of a military force. When he is struck down by the enemy, the prime responsibility of the medical service is to restore him to his former position in the line of combat in the shortest possible time. Transport of lightly wounded soldiers to the rear depletes the strength of the fighting force by increasing the number of man-days lost and by lessening their motivation for return to combat.

Proposition V. The farther a wounded soldier is evacuated from the combat zone, the greater will be the number of noneffective man-days and the less will be his motivation for return to combat duty.

On the other hand, the logistic burden imposed by medical service on a military undertaking is increased by the holding of noneffectives at the far end of a line of communications if they cannot be returned to duty and if transport is available to evacuate them to the base. Food, supplies, and maintenance of the personnel occupied with their care compete for cargo space with ammunition, troop rations, and other materiel in transit to the combat zone.

It is the purpose of the evacuation policy to control the size of this logistic burden. An evacuation policy is established or changed by order and is derived from logistic calculations and strategic planning unknown to the wound surgeon in a unit organization.

Proposition VI. After decision is made that a wounded soldier is transportable, there is immediate need to decide whether his injury is such that he can be returned to active duty within the limit of the evacuation policy then in force. If not, he is evacuated.

The decision that a wounded soldier is to be held in the area for return to combat duty oftentimes conflicts with the humanitarian instincts of the doctor, schooled by his profession in solicitude for the individual patient. Complete objectivity is required, as the summation of a number of these decisions may well determine the success or failure of the military undertaking. Even if an unlimited number of replacements is assumed, the evacuation of a casualty to a remote base and the forward transport of a replacement is a logistic burden far greater than that imposed by holding the casualty in the area in accord with the terms of a sound evacuation policy.

No decision is required or permitted regarding the future disposition of the casualty in the zone to which he is being evacuated. If a soldier is told that he is being sent to the base and from there will be returned to the Zone of Interior, all efforts of the surgeons at the base to return him to duty may be frustrated. A surgeon in the forward zone is uninformed regarding the evacuation policy of the base and also may be completely unaware of the pressing need to utilize some of the wounded as service troops even though they have residual disabilities.

Certain military considerations may diminish the degree of selection that can be introduced into evacuation. Those most commonly encountered are (1) a limited number of hospital beds; (2) restrictions on the movement or placement of hospitals imposed by the terrain or tactical situation; and (3) limited availability of transport. When the element of selection is diminished the surgeon is challenged to greater efforts in his task of saving life and limb, and there is greater decimation of the combat force by the movement of the lightly wounded to the rear. Under these circumstances, greater flexibility rather than rigidity is required in the evacuation policy established in an area. It must rise and fall with the ebb and flow of casualties. Only by adjusting the evacuation policy to the number of impending casualties can a severe drain on the manpower resources of the combat force be minimized. This requires close co-ordination between surgeon and tactical command. Statistical tabulations measured against actual logistic situations are available to illustrate the great practical importance of this concept.

Selection is based on a sorting of casualties, or *triage*. Normally, this begins with the aid man in the field and continues at every medical installation. The divisional medical service provides the first screening. Any situation that disturbs or destroys the *organization* of divisional medical service results in less efficient triage. For example, a rapidly moving offensive or an amphibious invasion results in a dilution of the stream of evacuees by soldiers with minor injuries who normally would not be evacuated out of the division and this tends to lower mortality rates for WIA seen in hospitals to the rear of the division. Similarly, during intensive combat there may be left on the field of battle, to be classified as KIA, men who would otherwise be carried to aid stations and, dying soon thereafter, appear in the count of DOW. This phenomenon tends to reduce the mortality rate calculated for all the WIA. Similar paradoxical happenings in military surgery are quite common and oftentimes lead to generalizations that have no true basis. They may be associated in the mind of the doctor with the introduction of some new therapeutic procedures or otherwise serve as the basis of false assumptions.

Proposition VII. The degree of selection possible in evacuation is profoundly affected by the military situation and may paradoxically affect the "results" shown by statistical data.

Surgical Considerations in Evacuation

Depending on the conditions of combat, individual and oftentimes heroic efforts may be instituted in the forward area to rush the desperately wounded patient to a hospital. Normally, the first organized triage point of the divisional medical service is the clearing station. When the station is supported by a mobile surgical hospital in close proximity (litter carry), casualties of immediate urgency are evacuated to this unit. Others of less urgency are evacuated to mobile evacuation hospitals sited at a greater distance. Still others are held at the clearing station for return to duty from that point.

In a typical deployment of a combat force the placement of formal surgical facilities *forward* of the divisional clearing station would be of little avail, as evacuation lines within the division first converge at this point.

At the divisional clearing station triage of the wounded who require operation is based primarily on the urgency of the wound. Receiving as it does a selected group of nontransportable casualties, the task of the forward surgical hospital is to save life by methods that will make patients transportable in the shortest possible time. Neither the treatment of transportable wounded nor the treatment of lightly wounded for early return to duty is normally a function of the surgical hospital. Its holding facilities are small, the logistic burden it imposes is great, and to clog its activities with poorly sorted casualties would destroy its usefulness. It cannot function effectively *forward* of an efficient triage point.

After this initial selection based on the urgency of the wound, the military surgeon is faced by two tasks: (1) the return of the lightly wounded to duty under terms of the evacuation policy then in force; and (2) making transportable, casualties who must be transported farther to the rear. Surgical procedures not essential to wound management at that time may make a transportable patient nontransportable and are avoided. Splinting is designed for support during transport and not for definitive correction of deformity. It is called "transportation splinting." Sutures placed in a wound (primary or delayed) lead to wound breakdown and infection as a result of transport; they are avoided except under specific indications. Forward surgery as performed on the wounded who must be evacuated subsequently is not complete surgery; it is the *initial* effort required to save life and limb, prevent infection, and render the patient transportable. It has been called "initial surgery."

Surgery at a base assumes a different character and, contingent on the number of fixed beds, is usually conducted under a longer evacuation policy than that permitted in the forward area. Extensive experience with overseas base surgery in two wars has shown that the manpower salvage among battle casualties as measured by the numbers returned to duty status in an overseas threater is almost negligible if more than 90 days' hospitalization is required.* Expansion of bed capacity beyond the needs to carry a 90-day evacuation policy cannot be justified on the grounds of returning more wounded to duty. If transport to the Zone of Interior is intermittent, as with hospital ships, or if the number of casualties that may be received by the base may fluctuate greatly, then the fixed-bed capacity is adjusted to the needs for holding and for the reception of peak loads.

The hospitals of the base carry the heavy surgical work load identified in World War II as *reparative* surgery. The initial wound surgery of the forward area, having been left incomplete because of the anticipated transport of the patient, is completed at the base. Transportation splinting is removed and therapeutic splinting substituted therefor. Battle fractures are reduced to final alignment and apposition of fragments. Wounds left open are closed by reparative suture. An intensive and vigorously conducted program of reparative surgery, made possible by antibiotics and the liberal use of whole blood transfusion, increases the number of battle casualties returned to duty and minimizes the disability resulting from the wound in those casualties evacuated to the Zone of Interior.

To attain the benefit of reparative surgery that resides in an increased number of wounded returned to duty, two things are necessary: (1) the initial surgery must be well performed and the patient must reach a hospital for reparative wound revision and closure by the fourth or fifth day after wounding; (2) the patient must be held in that hospital for approximately 15 days. In other words, after reparative suture he must be regarded as nontransportable not because transport would endanger life but because it will seriously jeopardize the wound healing necessary for prompt return to duty or prevent it altogether.

*Editors' note: Army logistic principles generally dictate an evacuation policy of 120-days, exceptions being made only under unusual circumstances. As may be seen from Appendix IV, after 90 days 62.32 percent of WIA admissions will have been returned to duty. At the end of 120 days this figure is 70.18.

— G.W.B. and M.E. De B.

Proposition VIII. If combat soldiers with simple though extensive wounds can receive adequate and prompt initial surgery and then be evacuated to fixed beds where they may remain approximately fifteen days, a high percentage can be returned to duty status.

The biologic processes of wound infection and wound healing do not compromise with faulty medical administration and are beyond the reach of command decision. Biologic determinants, not the wound surgeon, establish the necessity for (1) the shortest possible time-lag between wounding and initial excisional surgery; (2) adherence to the planned delay between excisional surgery and reparative wound revision and closure; and (3) the provision of suitable holding periods in hospital coincident with wound treatment. Military planning must accede to a reasonably precise time schedule of wound surgery, unless grim necessity demands the permanent sacrifice of large numbers of combat troops temporarily evacuated for simple wounds. To disregard such a schedule means an acceptance of an over-all increase in mortality, disability, and deformity. The losses in life and in combat troop strength that will accrue are as real as those caused by direct enemy action.

The margins of safety in the schedule of evacuation and necessary holding periods are not the same for all types of wounds but depend on the structure or structures that are injured. Approximate schedules for sample categories of wounds are given below. In these schedules it is assumed that the combat force is closely supported by its own mobile hospitals and that transport to a base requires from 12 to 24 hours.

A. Wounds Involving Muscle

1. Wounding to clearing station		0 - 6 hours
2. Clearing station to initial excisional surgery		0 - 6 hours
3. Initial surgery to reparative wound revision and closure:		
a. Holding	12 - 48 hours	
b. Evacuation	12 - 24 hours	
c. Holding	24-60 hours	
TOTAL		4 - 8 days

4. Holding before return to duty or transport 7 - 15 days

B. Battle Fractures of Femur
   1. Wounding to clearing station 0 - 6 hours
   2. Clearing station to initial excisional surgery 0 - 6 hours
   3. Initial surgery to reparative wound revision and skeletal traction:
      a. Holding 12 - 36 hours
      b. Evacuation 12 - 24 hours
      c. Holding 24 - 60 hours
      TOTAL 4 - 8 days
   4. Holding in skeletal traction before transport in plaster 6 - 8 weeks

C. Abdominal Wounds
   1. Wounding to clearing station 0 - 6 hours
   2. Clearing station to emergency operation in forward surgical hospital* 0 - 5 hours
   3. Holding before transport 7 - 10 days
   4. Evacuation to base 12 - 24 hours
   5. Holding before transport 3 - 15 days

Schedules such as these can be accomplished only by minimizing the movement of patients between fixed hospitals and not using these installations as a "chain" of evacuation. The mission of a fixed hospital is the *treatment* of casualties, and it is equipped and staffed for that purpose. This mission cannot be accomplished when a fixed hospital is regarded as though it were a collecting or clearing station in a busy line of evacuation. Under these circumstances patients are held for treatment only if complications of the wound render them nontransportable. Others are rushed along, perhaps pausing at each of four or five fixed hospitals for a day or so, *but not remaining at any one for a long enough time to receive the necessary reparative wound surgery.* Septic complications of

*Of 3,310 high-priority cases with abdominal and thoracic wounds 68.2 percent received emergency surgery 0-11 hours after wounding, and 21.4 percent 0-5 hours after wounding (cf. Table 31, page 100).

wounds are thereby increased, the numbers returned to duty decreased, and the total fixed-bed requirement expanded. The beneficial results of military surgery are found in correctly timed *treatment,* not in temporary custodial care and evacuation.

To attain the potential benefits of reparative surgery that reside in reduction of wound sepsis and other complications among those casualties who must be returned to the Zone of Interior, the same hospitalization policies outlined for the lightly wounded must apply, namely, a holding period in a base hospital. For many types of injury, a period of 15 days is all that is required to close the soft-part wound and secure firm healing. If battle fractures requiring skeletal traction are to remain in the base at all, then the period during which they must be regarded as nontransportable may extend to 10 or 12 weeks. The holding period thus depends on the nature of the wound.

Methods of Transport and their Bearing on the Military and Surgical Aspects of Evacuation

Evacuation of the wounded calls for transport in one direction —combat zone to base to Zone of Interior. This contrasts with the transport requirements of supply services such as Ordnance or Quartermaster for a heavy forward-moving cargo load. While greatest efficiency might be found in the joint utilization of shuttle transportation, this is practical on a large scale only with air transport. First, transport of the wounded requires specialized accommodations. Second, the rules of the Geneva Convention do not afford protection to a carrier utilized for the transport of war materiel in one direction and of wounded in the other. Transport marked with the red cross and moving from the base toward the combat zone can carry only medical supplies and noncombat health personnel, a cargo that is not in balance with the much greater return load of casualties.

Irrespective of the advantage of any immunity from enemy attack afforded by the red cross, the evacuation of the wounded on the backhaul of nonmedical transport threatens the selectivity of evacuation because the timing and capacity of such transport is determined primarily by nonmedical requirements.

Proposition IX. The more closely the evacuation of casualties is integrated with the transport of combat personnel or war ma-

teriel, the more difficult it is for the Medical Department to maintain the selective evacuation required to return sick and wounded to duty status.

With such integration the number of wounded evacuated tends to be determined by the timing and availability of the transport moving toward the rear. Under such circumstances, a medical installation receives an order to have a specified number of transportable casualties ready for evacuation at a specified hour. Unless the hospital is holding a backlog of casualties selected on the basis that they cannot be returned to duty under the terms of the existing evacuation policy, casualties who might be returned to duty will be evacuated *in order to make up a full backhaul cargo load.*

Proposition X. When orders are issued to a hospital to have a specified number of transportable casualties ready for evacuation at a specified time, and that number has been determined by the capacity of the transport rather than the existing evacuation policy, soldiers who might be returned to duty will be subjected to retrograde movement. Their number will be inversely proportional to the distance of the hospital from the front (unless the hospital is receiving selected casualties).

It is instructive to review the implications of the above statements as they apply to the common means of transport.

Ambulance. Under control of the medical service and utilized for short hauls with small cargo load per vehicle, the ambulance provides a flexible and responsive method of litter evacuation in those zones where selectivity in evacuation and distribution is most essential. The ambulance is supplemented by the use of trucks to lift a larger number of lightly wounded "sitters." The chief limitation of motor transport is found with a restricted road network on which combat-loaded convoys have been assigned priority of movement.

Rail. Aerial bombing that selects the rail network as a major target of enemy action has made the hospital train moving between railhead and base almost obsolete as a means of transport.

Ship. The use of the hospital ship as a means of transport is to be distinguished from its utilization as an offshore hospital for the treatment of casualties, particularly in amphibious or beachhead operations. In World War II the Army hospital ship was essentially an ambulance for the transport of treated casualties, whereas the Navy hospital ship was equipped and staffed to act as a surgical hospital. When used as a *mobile hospital* close to a combat zone, it is necessary for the ship to unload casualties who can be returned to duty before proceeding as a *transport* to a remote base.

As a transport, the usefulness of the hospital ship has been reduced by the heavy demands of supply services on the limited docking facilities of bombed ports. Its large capacity and limited loading time at infrequent intervals make the movement of casualties between well-established bases its prime function, if indeed it is to be used at all.

Improvised transport of fresh casualties from far to near shore in amphibious operations may be accomplished on returning combat vessels.

Air Evacuation. Air evacuation is logistically efficient insofar as the backhaul of an air lift shuttle is utilized for the transport of casualties. It has repeatedly demonstrated its usefulness as the only feasible means of transport to bridge great distances between combat force and base. It is safe, quick, and comfortable for the wounded. Nevertheless, the manner in which evacuation of the wounded by air is used and the extent to which air transport may modify the conventional patterns of logistic support raise problems that may be solved only by recasting certain accepted procedures of the wound surgeon.

As used extensively in World War II for transport of casualties between well-established bases and between such bases and the Zone of Interior, air evacuation raised no problem. The plane simply replaced the hospital train or hospital ship. With a large fixed-bed capacity, a base can supply a steady flow of evacuees carefully reviewed in disposition board proceedings and selected with an eye to the optimum time for interruption of continuity in surgical management. Because of the smaller cargo load per unit carrier, air evacuation is more flexible than ship evacuation.

Air evacuation was invaluable in World War II for transport of the wounded between combat zone and closely supporting base, although many lightly wounded who might have been returned to duty without leaving the combat zone were evacuated to the base. With a large fixed-bed capacity in close support of a combat force, the experienced base medical service returned the lightly wounded to duty after required hospital treatment. By this means it was possible to keep the number of mobile beds in the combat zone at a minimum and to keep them cleared to receive fresh casualties. The loss of effective man-days and a certain attrition of strength that resulted from evacuation of lightly wounded to a base were accepted by command.

The use of air evacuation to the Zone of Interior *as a substitute for the building up of fixed hospital beds in a base closely supporting a combat force* will present an entirely new problem. Such a procedure can be expected to deplete combat strength at a rapid rate unless the force itself takes over the salvage function and provides a number of mobile beds adequate to maintain a reasonable evacuation policy. Under such circumstances, the procedures of the wound surgeon developed for the typical situations that existed in World War II may be completely changed. The simple wounds of those casualties who can be returned to duty might well be closed by *primary suture* and the patients held in the combat zone. The complex wounds that preclude return to duty might be treated by initial surgery and these casualties evacuated from an air strip in the combat zone directly to some remote base or to the Zone of Interior for reparative procedures.

Proposition XI. As changing means of transport modify the methods of providing logistic support to a combat force, the conventional relations between overseas base and combat force may well undergo radical changes. Because of new weapons, many old concepts of echelons of hospitals may be altered. The wound surgeon must stand ready to adapt his methods to meet new circumstances; administrative officers must consider the conditions essential to sound wound management; and a high degree of selectivity must be introduced into evacuation procedures.

Distribution of the Wounded

Selective distribution of the wounded so that they may receive competent surgical treatment without delay is a vital part of the evacuation plan. The distribution of the urgent nontransportable cases to the surgical hospital adjacent to the divisional clearing station has been noted. The distribution of transportable patients to evacuation hospitals is largely a problem of adjusting numbers to prevent any one unit from building up a backlog of unoperated cases. The distribution of casualties as they arrive at an overseas base is both a matter of numbers and of securing the specialist treatment required.

(a) Combat Zone. When evacuation hospitals are supporting a combat force, the proper utilization of these hospitals to provide surgical treatment as soon as possible after injury centers on the distribution of casualties among them. Distribution based on the relative number of empty beds available in the hospitals, or distribution according to the shortest direct haul from a divisional clearing station, ignores the fact that the wounded are being evacuated *to receive wound surgery*. Once this seemingly obvious assumption is granted, the *surgical lag* in the hospital units, which is the time expressed in hours required for a hospital to complete the required surgery, becomes the key to distribution.

As a basic assumption it may be stated that:

Proposition XII. The average moderately to severely wounded patient may be held unoperated upon without complication or retardation of recovery only from zero to six hours after clearance from the divisional clearing station.

To bring every casualty to surgery in less than six hours' time requires a system of evacuation control based on frequent (four hours or less) estimates from each hospital regarding the surgical lag then existing in that unit. This lag in turn is based on examination of the casualties already received and remaining unoperated, and an estimate of the work-load potential of the operating teams for the next period. Casualties are then distributed so that they will receive surgical treatment at the earliest possible time.

Vacant beds have no bearing upon whether a patient will live or die or return to his unit at an early date. Distribution by rotating the hospital destination of successive ambulance convoys is equally fallacious, as there is great variation in the length of time that must be expended on different casualties and also considerable variation in the number of casualties that can be handled by the operating teams of a hospital. The illness of a key surgeon or radiologist may unexpectedly reduce the case turnover of a hospital.

(b) **Base** (Communications Zone or Zone of Interior). When a large number of casualties arrive in Base by any method of transport, the same principle of surgical lag is applicable to equalize their distribution among the fixed hospitals of the area. Careful and immediate appraisal of each casualty admitted is made possible. The surgical work load is heavy. Wound complications must be identified, casts changed, x-ray examinations secured, and patients prepared for early wound revision and reparative closure.

In addition to distribution by number, the selective hospitalization of certain casualties who require the skills of surgical specialists is necessary to promote expeditious and competent surgical treatment. As a practical matter, the unloading of a large number of unsorted battle casualties on a hospital in which specialty services are inadequately staffed reduces the quality of wound surgery and delays the ultimate discharge of these patients from the hospital. Decisions are delayed, unskilled measures result in complications, priorities in management are likely to be faulty, and the ultimate results of wound surgery will be substandard.

A triage distribution center at the air strip or airport, or if hospital centers are established, triage at a common receiving point, provides the necessary sorting.

Hospitalization in Base for wounded prisoners-of-war may make sudden and unexpected demands on a limited fixed-bed capacity and specialist personnel. As a rule, P.O.W. wounded present a higher incidence of serious wound complications and sequelae, and in addition the need for an enclosure and the provision of guards may require selective hospitalization under the direction of the Provost Marshall.

The establishment of a large system of specialized general hospitals in the Zone of Interior during World War II necessitated a mechanism for the distribution of patients in accord with specialty requirements. Other factors, such as geographic residence of the casualty, were also determinants. A central operational agency in control of all bed credits directed the movement and distribution of patients from the debarkation hospitals. A uniform system of diagnostic coding that might have brought the diagnoses of overseas disposition boards into conformity with the specialty structure established in the Zone of Interior would have been advantageous. The same need for tagging certain patients for distribution to specialty centers developed in evacuation from Army to Base in overseas theaters, and this need was met by attaching an appropriate sticker to the envelope of the Field Medical Record.

Proposition XIII. Identification of the specialty requirements of a casualty in advance of his arrival at a distribution center speeds the turnover at that center and reduces the factor of error.

Summary

Insofar as selective evacuation and distribution of casualties can be maintained, the potential benefits of wound surgery will be achieved. Wound surgery returns wounded combat personnel to duty status and reduces the disability among those who cannot fight again. Nonselective evacuation of battle casualties undertaken for bed clearance, measured by transport capacity, timed by transport availability, and followed by distribution to hospitals based on bed credits, invites wound complications, retards recovery, and prevents return to duty.

APPENDIX I

Patients Remaining in Hospital (Overseas and ZI) by Type, Based on January-June 1943 Admissions in North African Theater of Operations

Hospital Days*	Disease	Injury	Wounded
1	10,000	10,000	10,000
2	9,746	9,502	9,843
3	9,212	8,774	9,647
4	8,452	8,084	9,429
5	7,584	7,446	9,233
6	6,838	6,889	8,993
7	6,199	6,387	8,833
8	5,635	5,975	8,643
9	5,162	5,629	8,498
10	4,740	5,346	8,342
11	4,367	5,095	8,216
12	4,046	4,884	8,084
13	3,760	4,674	7,980
14	3,542	4,482	7,875
15	3,350	4,326	7,770
16	3,150	4,167	7,663
17	2,951	4,033	7,581
18	2,803	3,908	7,491
19	2,652	3,804	7,398
20	2,525	3,694	7,318
21	2,376	3,587	7,224
22	2,262	3,497	7,130
23	2,154	3,406	7,041
24	2,068	3,327	6,961
25	1,993	3,254	6,861
26	1,913	3,180	6,782
27	1,840	3,105	6,711
28	1,775	3,036	6,625
29	1,709	2,959	6,534
30	1,645	2,888	6,454
31	1,594	2,830	6,381
32	1,546	2,773	6,309
33	1,503	2,719	6,240
34	1,462	2,667	6,174
35	1,424	2,617	6,109
36	1,388	2,568	6,046
37	1,355	2,520	5,984
38	1,323	2,474	5,924
39	1,293	2,429	5,866
40	1,264	2,385	5,808
41	1,240	2,346	5,748
42	1,217	2,308	5,688
43	1,196	2,272	5,628
44	1,176	2,237	5,569

*Complete days.

APPENDIX I (Cont.)

Patients Remaining in Hospital (Overseas and ZI) by Type, Based on January-June 1943 Admissions in North African Theater of Operations

Hospital Days*	Disease	Injury	Wounded
45	1,156	2,203	5,510
46	1,138	2,170	5,451
47	1,120	2,138	5,393
48	1,103	2,107	5,334
49	1,086	2,077	5,276
50	1,070	2,048	5,219
51	1,054	2,019	5,163
52	1,039	1,991	5,108
53	1,023	1,963	5,054
54	1,008	1,936	5,000
55	993	1,909	4,947
56	978	1,883	4,895
57	964	1,857	4,844
58	949	1,831	4,793
59	935	1,806	4,744
60	921	1,782	4,695
65	866	1,672	4,477
70	820	1,573	4,278
75	775	1,480	4,063
80	730	1,393	3,850
85	682	1,311	3,682
90	632	1,235	3,540
95	585	1,167	3,381
100	541	1,107	3,216
105	497	1,054	3,068
110	454	1,005	2,931
115	413	955	2,792
120	374	905	2,658
130	298	822	2,436
140	250	740	2,243
150	205	677	2,041
160	158	615	1,885
170	126	545	1,714
180	93	485	1,579

*Complete days.

The distributions here are carried to 180 days, well beyond the range of field army problems considered in the text, for whatever reference value they may have for those concerned with hospitalization and evacuation at the theater level.

APPENDIX II

Cumulative Hospital Days (Overseas and ZI) from Admission Through Day Shown per 10,000 Admissions by Type of Patient, Based on January-June 1943 Admissions in North African Theater of Operations

Hospital Days*	Disease	Injury	Wounded
1	10,000	10,000	10,000
2	19,746	19,502	19,843
3	28,958	28,276	29,490
4	37,410	36,360	38,919
5	44,994	43,806	48,152
6	51,832	50,695	57,145
7	58,031	57,082	65,978
8	63,666	63,057	74,621
9	68,828	68,686	83,119
10	73,568	74,032	91,461
11	77,935	79,127	99,677
12	81,981	84,011	107,761
13	85,741	88,685	115,741
14	89,283	93,167	123,616
15	92,633	97,493	131,386
16	95,783	101,660	139,049
17	98,734	105,693	146,630
18	101,537	109,601	154,121
19	104,189	113,405	161,519
20	106,714	117,099	168,837
21	109,090	120,686	176,061
22	111,352	124,183	183,191
23	113,506	127,589	190,232
24	115,574	130,916	197,193
25	117,567	134,170	204,054
26	119,480	137,350	210,836
27	121,320	140,455	217,547
28	123,095	143,491	224,172
29	124,804	146,450	230,706
30	126,449	149,338	237,160
31	128,043	152,168	243,541
32	129,589	154,941	249,850
33	131,092	157,660	256,090
34	132.554	160,327	262,264
35	133,978	162,944	268,373
36	135,366	165,512	274,419
37	136,721	168,032	280,403
38	138,044	170,506	286,327
39	139,337	172,935	292,193
40	140,601	175,320	298,001
41	141,841	177,666	303,749
42	143,058	179,974	309,437
43	144,254	182,246	315,065

*Complete days.

APPENDIX II (Cont.)

Cumulative Hospital Days (Overseas and ZI) from Admission Through Day Shown per 10,000 Admissions by Type of Patient, Based on January-June 1943 Admissions in North African Theater of Operations

Hospital Days*	Disease	Injury	Wounded
44	145,430	184,483	320,634
45	146,586	186,686	326,144
46	147,724	188,856	331,595
47	148,844	190,994	336,988
48	149,947	193,101	342,322
49	151,033	195,178	347,598
50	152,103	197,226	352,817
51	153,157	199,245	357,980
52	154,196	201,236	363,088
53	155,219	203,199	368,142
54	156,227	205,135	373,142
55	157,220	207,044	378,089
56	158,198	208,927	382,984
57	159,162	210,784	387,828
58	160,111	212,615	392,621
59	161,046	214,421	397,365
60	161,967	216,203	402,060
65	166,403	224,777	424,870
70	170,593	232,835	446,653
75	174,558	240,419	467,401
80	178,298	247,556	487,074
85	181,805	254,273	505,808
90	185,065	260,598	523,785
95	188,084	266,566	541,010
100	190,876	272,218	557,420
105	193,448	277,591	573,053
110	195,803	282,713	587,979
115	197,949	287,588	602,216
120	199,896	292,213	615,772
130	203,208	300,794	641,088
140	205,904	308,560	664,376
150	208,159	315,599	685,694
160	209,948	322,032	705,214
170	211,340	327,800	723,132
180	212,419	332,913	739,501

*Complete days.

APPENDIX III

PATIENTS RETURNED TO DUTY (OVERSEAS AND ZI) PER 10,000 ADMISSIONS, BY TYPE, BASED ON JANUARY-JUNE 1943 ADMISSIONS IN NORTH AFRICAN THEATER OF OPERATIONS

Hospital Days*	Disease	Injury	Wounded
1	252	484	135
2	534	695	158
3	756	678	192
4	866	631	181
5	744	550	233
6	638	495	158
7	561	408	187
8	472	342	141
9	420	280	152
10	367	242	121
11	320	211	126
12	285	211	98
13	218	188	100
14	188	155	107
15	199	156	102
16	198	132	81
17	147	123	84
18	150	102	87
19	129	114	80
20	149	105	91
21	114	88	94
22	108	89	89
23	86	78	81
24	70	76	96
25	80	73	77
26	72	74	70
27	65	75	84
28	66	75	90
29	64	65	79
30	51	57	73
31	47	56	70
32	43	53	68
33	40	52	66
34	38	50	63
35	35	49	62
36	34	47	61
37	31	47	58
38	30	44	58
39	28	44	56
40	24	39	59
41	22	38	58
42	21	36	58
43	20	35	58
44	19	34	58

*Complete days.

APPENDIX III (*Cont.*)

Patients Returned to Duty (Overseas and ZI) per 10,000 Admissions, by Type, Based on January-June 1943 Admissions in North African Theater of Operations

Hospital Days*	Disease	Injury	Wounded
45	18	33	57
46	17	32	57
47	17	31	56
48	16	30	56
49	16	29	56
50	15	29	54
51	15	28	54
52	14	27	52
53	14	27	53
54	13	27	51
55	14	26	51
56	13	25	50
57	13	25	49
58	13	25	48
59	12	24	47
60	11	23	45
65	9	20	40
70	7	19	41
75	6	18	42
80	6	16	34
85	6	16	29
90	5	14	30
95	5	13	31
100	4	9	28
105	3	9	24
110	3	9	24
115	1	9	23
120	2	8	21

*Complete days.

APPENDIX IV

Cumulative Returns to Duty (Overseas and ZI) per 10,000 Admissions, by Type of Patient, Based on January-June 1943 Admissions in North African Theater of Operations

Hospital Days*	Disease	Injury	Wounded
1	252	484	135
2	786	1,179	293
3	1,542	1,857	485
4	2,408	2,488	666
5	3,152	3,038	899
6	3,790	3,533	1,057
7	4,351	3,941	1,244
8	4,823	4,283	1,385
9	5,243	4,563	1,537
10	5,610	4,805	1,658
11	5,930	5,016	1,784
12	6,215	5,227	1,882
13	6,433	5,415	1,982
14	6,621	5,570	2,089
15	6,820	5,726	2,191
16	7,018	5,858	2,272
17	7,165	5,981	2,356
18	7,315	6,083	2,443
19	7,444	6,197	2,523
20	7,593	6,302	2,614
21	7,707	6,390	2,708
22	7,815	6,479	2,797
23	7,901	6,557	2,878
24	7,971	6,633	2,974
25	8,051	6,706	3,051
26	8,123	6,780	3,121
27	8,188	6,855	3,205
28	8,254	6,930	3,295
29	8,318	6,995	3,374
30	8,369	7,053	3,447
31	8,416	7,109	3,517
32	8,459	7,162	3,585
33	8,499	7,214	3,651
34	8,537	7,264	3,714
35	8,572	7,313	3,776
36	8,606	7,360	3,837
37	8,637	7,407	3,895
38	8,667	7,451	3,953
39	8,695	7,495	4,009
40	8,719	7,534	4,068
41	8,741	7,572	4,126
42	8,762	7,608	4,184
43	8,782	7,643	4,242
44	8,801	7,677	4,300

*Complete days.

APPENDIX IV (Cont.)

Cumulative Returns to Duty (Overseas and ZI) per 10,000 Admissions, by Type of Patient, Based on January-June 1943 Admissions in North African Theater of Operations

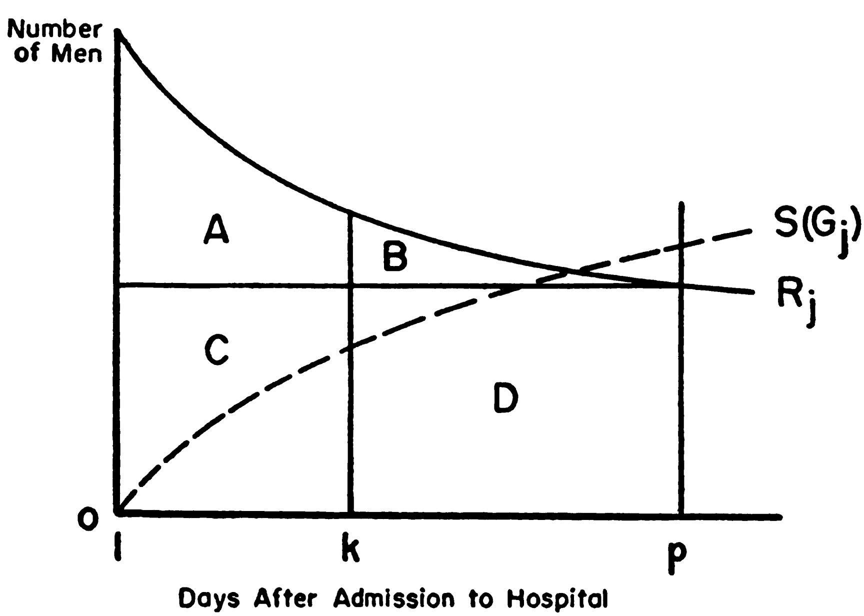
Hospital Days*	Disease	Injury	Wounded
45	8,819	7,710	4,357
46	8,836	7,742	4,414
47	8,853	7,773	4,470
48	8,869	7,803	4,526
49	8,885	7,832	4,582
50	8,900	7,861	4,636
51	8,915	7,889	4,690
52	8,929	7,916	4,742
53	8,943	7,943	4,795
54	8,956	7,970	4,846
55	8,970	7,996	4,897
56	8,983	8,021	4,947
57	8,996	8,046	4,996
58	9,009	8,071	5,044
59	9,021	8,095	5,091
60	9,032	8,118	5,136
65	9,078	8,225	5,345
70	9,115	8,322	5,541
75	9,148	8,412	5,749
80	9,178	8,495	5,944
85	9,208	8,574	6,096
90	9,237	8,646	6,232
95	9,262	8,710	6,385
100	9,283	8,764	6,539
105	9,301	8,814	6,668
110	9,316	8,858	6,786
115	9,327	8,904	6,905
120	9,338	8,947	7,018
130	9,364	9,015	7,202
140	9,383	9,076	7,336
150	9,399	9,117	7,476
160	9,414	9,153	7,568
170	9,421	9,180	7,653
179	9,427	9,197	7,701

*Complete days.

APPENDIX V

Methods of Calculation Employed in Analysis of Patients Remaining in Hospital and Returned to Duty

The system generated by a set of admissions to hospital is outlined in pages 216-217. In general the hospital-days required for their care may be found by summation of the daily series given in graphic form by the remaining curve. This process may be extended to various portions of the area under the remaining curve, portions which correspond to the hospital-days of particular groups of patients before and after various points in time established by administrative decisions governing evacuation of patients. All the problems considered in the section of Chapter VI dealing with forward areas are concerned with hospitalization and return to duty prior to the date set by the army evacuation policy, however it may be set.



In order to compute hospital-days the area under the remaining curve bounded by the ordinate erected at the day fixed by the evacuation policy has been divided into four parts, A, B, C, and D as shown in the accompanying diagram. The cumulative curve of returns to duty is also shown there. These areas differ slightly from those exhibited in

Figures 27 and 30 in that, in order to simplify the calculations, the evacuation of patients does not extend over a period of many days but is accomplished instantaneously. The physical meaning of these areas may be described as follows:

A. The hospital-days, through day k, of all patients disposed of in the army area by death or return to duty before day p.
B. The hospital-days, after day k, of all patients disposed of in the army area by death or return to duty before day p.
C. The hospital-days, through day k, of all patients evacuated from the army area before day p.
D. The hospital-days, after day k, and before day p, of all patients evacuated from the army area.

Day k is thus the last day in hospital in the army area for those evacuated under the policy set by day p. It may be noted that the first day is day 1, and that as the evacuation policy is defined here day $p-1$ is the last day in hospital allowed in the army area, not day p. Patients still held in army hospitals on day $p-1$, of course, are those scheduled to return to duty on day $p-1$.

For purposes of computation it is convenient to label the remaining curve as made up of the succession of points R_j, where j is the day of hospitalization. Similarly, if G_j represents the number returning to duty on day j then the returned-to-duty curve in the diagram represents $S(G_j)$ where S stands for the operation of summation from day 1 through day j, however chosen. As defined here, R_j includes G_j; that is, the returns to duty on any day are charged against hospital beds for that last day. Then it is obvious that the total area of interest

$$A + B + C + D = \overset{p-1}{\underset{j=1}{S}}(R_j). \tag{1}$$

Similarly, hospital costs through the last day before evacuation begins are defined as

$$A + C = \overset{k}{\underset{j=1}{S}}(R_j). \tag{2}$$

These areas are found directly from Appendix II, Cumulative Hospital Days, once the limits of summation are defined. It should be remarked, however, that Appendix II provides these areas for patients in each of the three major diagnostic groups and that its utilization for problems involving more than one of these groups requires, in addition, a set of weights specifying the proportionate distribution of admissions by type.

Area C may itself be found as

$$C = R_p \cdot k \tag{3}$$

and

$$D = R_p(p-k-1). \tag{4}$$

Then the area A + B + C, used frequently in the problems of Chapter VI, has been found as

$$A + B + C = \overset{p-1}{\underset{j=1}{S}} (R_j) - R_p(p-k-1). \qquad (5)$$

Since the problems of Chapter VI concern principally all admissions in the army area, regardless of type, for computational purposes (5) has been used in the form of a double-summation over the three types of admission; that is

$$A + B + C = \overset{3}{\underset{i=1}{S}} \overset{p-1}{\underset{j=1}{S}} (w_i R_{ij}) - \overset{3}{\underset{i=1}{S}} (w_i R_{ip}) \; (p - k_i - 1) \qquad (6)$$

where the w's are the proportionate weights given the three types of admission (disease, injury, and wounded) and the same value of p is employed for each type of patient. It will be observed that k also varies by type of patient.

In the computations underlying Figures 35 and 37, for example, (6) was employed and the assumptions stated in the text led to a series of numerical values for the left-hand side of the equation, representing bed-days available in the army area, and the solution consisted in finding the value of p corresponding to each percentage bed-reserve or ratio of beds to admissions. In deriving the data for Figure 36 and for the effect of varying weights applied to types of admission, (6) was also used. In these problems the left-hand side of the equation was constant and the problem was to find p for the various combinations of values for the k's in the first instance and for the different sets of w's in the other. In each case, once p had been found it was a simple matter to convert it to the percentage of all admissions returned to duty. For any single type of patient these percentages appear in Appendix IV; for all admissions a similar table was constructed on the basis of the weights accorded the several types of admission in the problem under consideration.

GLOSSARY OF MILITARY TERMS AND ABBREVIATIONS

Admission. Statistical unit employed in determining incidence of disease, nonbattle injury, and battle wound or injury. Basically, admissions include all cases admitted for medical care and not returned to duty on the same calendar day as that on which first seen, but they also include certain other cases treated on an outpatient (duty) status, designated as carded for record only (CRO). Prior to December 1944, all carded for record only cases except KIA are counted as admissions. Subsequent to that date only the following CRO's are included: deaths (except KIA) of personnel not currently under Army medical care; medical discharges, on Certificate of Disability for Discharge (CDD) under the provisions of AR 615-361, of personnel not currently patients excused from duty; and venereal disease cases, not previously treated for the same current condition by any Army medical installation as an Army case, which are treated on an outpatient (duty) status.

A.E.F. American Expeditionary Forces in World War I.

AFPAC. Army Forces, Pacific Area Command.

AG. TAG. The Adjutant General, or the Adjutant General's Department. The AG is charged with the administration of all matters relating to correspondence, records, administrative directions, publications, decorations, etc.

AGF. Army Ground Forces, one of the three major subdivisions of the Army in World War II, comprising all the ground combat branches of the Army. The other major subdivisions were the Army Air Forces and the Army Service Forces.

AGO. Adjutant General's Office. See AG.

ASF. Army Service Forces, one of the three major subdivisions of the Army, providing general administration, transportation, supply, evacuation, and other services.

Battle Casualty. Includes personnel killed in action, wounded or injured in action, and captured, interned or missing in action, unless otherwise noted.

CBI. China-Burma-India Theater.

DOW. Died of wounds, includes deaths from battle wounds and/or battle injuries, except that it does not include the killed in action (KIA). The KIA died before, and the DOW after, admission to some medical installation.

ETMD. Essential Technical Medical Data. A recurring report established in World War II to provide higher headquarters with basic medical facts in subordinate commands.

ETO. European Theater of Operations.

Forward Area. Equivalent to the army area as used here, the geographical area under the control of a field army.

Hospital. Medical installation equipped for more than first aid and triage. Aid stations and clearing stations are excluded. Two main types are fixed, or stationary (general, station, and sometimes field), and mobile (portable surgical, sometimes field, evacuation, and army convalescent).

Hospital Admissions. Refers to patients admitted to medical installations operating as hospitals.

Hit. A term used for the sum of two categories of battle casualties, wounded or injured in action, and killed in action. It thus differs from the total battle casualty count in excluding missing, captured, etc.

KIA. Killed in action. Dead on field of battle without ever having been admitted to a medical installation alive; may have been seen alive after wounding.

MD. Medical Department.

MIA. Missing in action. A sub-category of battle casualties which initially includes those persons missing from their units under circumstances indicating that their missing status is a result of enemy action. Most of those initially reported as MIA were subsequently reported to be captured or interned, or declared dead (not KIA), or returned to duty; these are the major subdivisions of the MIA group. Many KIA were first erroneously reported as MIA and such reports later corrected to exclude them from MIA totals. The MIA data used here are thus of two kinds: (1) initial unit reports which may differ considerably from final counts; and (2) preliminary AG consolidations in 1946 by which time presumably most of the changes had been made.

MOS. Military occupational specialty, a job in the Army system of classification, e.g. gunner, rifleman, cook. Each MOS has a number, its SSN or specification serial number.

MTO. Mediterranean Theater of Operations, formerly North African Theater of Operations.

Nonbattle Injury. A category of admission, paralleling disease and battle wound or injury. Refers to all admissions caused by external agents except admissions classifiable as battle casualties.

Noneffectives. Personnel unable to perform duty because of disease, nonbattle injury, or wounds. The non-effective rate is the ratio of the number of such personnel to the available strength, usually in thousands.

NRC. National Research Council of the National Academy of Sciences.

POA. Pacific Ocean Areas, comprising the South Pacific Area and Central Pacific Area, later combined with SWPA into AFPAC.

Quarters Admission. Used here to denote an admission in which the patient, although unable to perform duty, is not hospitalized, but remains in his quarters or in a bed at dispensary, aid station, or other echelon below the hospital level.

SGO. The Surgeon General's Office.

SSN. Specification serial number for an MOS. See MOS.

SWPA. Southwest Pacific Area.

TAG. See AG.

T/O. Table of organization. Table for a unit, showing number, ranks, and duties of authorized personnel. When shown as T/O & E, Table of Organization and Equipment also shows prescribed weapons and equipment.

WD. War Department, after World War II changed to Department of the Army.

WIA. Wounded or injured in action. As used here, persons wounded or injured due to enemy action including those injured while going to, or returning from, a combat mission whether or not directly due to enemy action. It does not include men injured on purely training flights or missions. The definition of this term is currently being revised by the Army.

Wounded. See WIA.

Z/I. Zone of Interior; the continental U. S. in World War II.

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This Book

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