The US Army's Center for Strategy and Force Evaluation

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PERSONNEL ATTRITION RATES IN HISTORICAL LAND COMBAT OPERATIONS: AN ANNOTATED BIBLIOGRAPHY

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JUNE 1993

PREPARED BY
OFFICE, SPECIAL ASSISTANT FOR MODEL VALIDATION

US ARMY CONCEPTS ANALYSIS AGENCY
8120 WOODMONT AVENUE
BETHESDA, MARYLAND 20814-2797

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Director
US Army Concepts Analysis Agency
ATTN: CSCA-MV
8120 Woodmont Avenue
Bethesda, MD 20814-2797

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This annotated bibliography is intended to provide a guide to the literature on personnel attrition rates in historical land combat operations. It should be useful to all who need to consider historical attrition rates for the purpose of modeling, wargaming, studies, and analysis. Since it includes well over 200 titles, several aids are provided to facilitate its use. First, all documents are given a short title that consists of the principal author's last name and its date of publication. For example, Hartley-1989c refers to a work by Hartley published in 1989. The added later, c, indicates that the document referred to is the third publication in 1989 by this author. These short titles serve as the key document identifiers. Second, Appendix A gives a list of the full document titles in order by these short titles. Third, Appendix B gives a short subject index to the documents, classified by selected subject categories. Fourth, Appendix C gives a key word index to the full titles arranged alphabetically by the key words they contain. The annotated bibliography itself is in Appendix D, arranged in order by the short titles described above.

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June 1993

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Prepared by

Dr. Robert L. Helmbold
OFFICE, SPECIAL ASSISTANT FOR MODEL VALIDATION

US Army Concepts Analysis Agency
8120 Woodmont Avenue
Bethesda, Maryland 20814-2797

PREFACE

The Personnel Attrition Rates (PAR) Study is limited to studying personnel strengths and battle casualties in historical land combat operations. Other types of attrition (nonbattle losses, losses to equipment, casualties to other services, and so forth) are outside PAR's scope, as are personnel losses in models, simulations, wargames, field experiments, or training exercises (like those of the National Training Center).

Phase 1, or PAR-P1, is devoted to assembling the available data and past studies on personnel strengths and attrition rates in land combat operations, preparing a comprehensive bibliography of it, and planning the approach to subsequent phases. Its specific objectives are to:

- Collect as many as possible of the available tabulated data and data-based studies of attrition rates in historical land combat operations,
- Prepare a comprehensive bibliography of such data and studies, and
- Outline an approach to accomplishing the subsequent phases of the PAR Study as a whole.

The collection of data and data-based studies consists of the files of pertinent documents maintained at the U.S. Army Concepts Analysis Agency. Subsequent phases of the PAR Study may convert some of their most important data to electronic form to facilitate its independent analysis.

This annotated bibliography is intended to provide a guide to the literature on personnel attrition rates in historical land combat operations. It should be useful to all who need to consider historical attrition rates for the purposes of modeling, wargaming, studies, and analysis. Since it includes well over 200 titles, the following aids are provided to facilitate its use. First, all documents are given a short title that consists of the principal author's last name and its date of publication. For example, Hartley-1989c refers to a work by Hartley published in 1989. The added letter, c, indicates that the document referred to is the third publication in 1989 by this author. These short titles serve as the key document identifiers. Second, Appendix A gives a list of the full document titles in order by these short titles. Third, Appendix B gives a short subject index to the documents, classified by selected subject categories. Fourth, Appendix C gives a key word index to the full titles arranged alphabetically by the kev words they contain. The annotated bibliography itself is in Appendix D, arranged in order by the short titles described above.

Despite our efforts to be comprehensive, it seems hardly likely that our bibliography actually includes all of the pertinent documents. We apologize to the authors of important works that have been omitted, and urge readers who know of additional works that should be included to send us a detailed description of them (preferably in the same format as the existing entries in Appendix D), as it may be possible to include them in a revised and expanded version if enough material is received to warrant it, or else in a short supplement.

DEPARTMENT OF THE ARMY
US ARMY CONCEPTS ANALYSIS AGENCY
8120 WOODMONT AVENUE
BETHESDA, MARYLAND 20814-2797

REPLY TO
ATTENTION OF:

19 AUG 1993

CSCA-MVM

MEMORANDUM FOR Deputy Under Secretary Of The Army (OR), Headquarters, Department Of The Army, Washington, DC 20310

SUBJECT: Personnel Attrition Rates in Historical Land Combat Operations: An Annotated Bibliography

1. The U. S. Army Concepts Analysis Agency (CAA) is pleased to publish this Research Paper by Dr. Robert L. Helmbold. Its annotated bibliography will give U. S. Army operations analysts a well-organized guide to the literature on personnel casualties and attrition rates in historical land combat operations. Properly used, this information can be used to improve U. S. Army treatment of personnel attrition in models, wargames, studies, and analyses. Wide dissemination will make this work available to others for further use in their work.

2. Questions or inquiries should be directed to the Office of Special Assistant for Model Validation, U. S. Army Concepts Analysis Agency (CSCA-MV), 8120 Woodmont Avenue, Bethesda, MD 20814-2797, (301) 295-1611 or DSN 295-1611.

E. B. VANDIVER III
Director

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CAA	**PERSONNEL ATTRITION RATES IN HISTORICAL LAND COMBAT OPERATIONS: AN ANNOTATED BIBLIOGRAPHY**	**SUMMARY CAA-RP-93-2**

THE REASON FOR PERFORMING THIS STUDY was that there is an internal need for a comprehensive catalog of the works collected in support of the U.S. Army Concepts Analysis Agency's (CAA) Personnel Attrition Rates (PAR) Study. Because the resultant bibliography provides an excellent guide to the literature, it is being provided for others to use.

THE STUDY SPONSOR was the Director, U.S. Army Concepts Analysis Agency.

THE STUDY OBJECTIVE was to provide the Army with a comprehensive bibliography of works on personnel attrition rates in historical land combat operations.

THE SCOPE OF THE STUDY includes works on the personnel strengths and battle casualties of land combat forces. Other types of attrition (nonbattle losses, losses to equipment, casualties to other services, and so forth) are outside PAR's scope. PAR is concerned only with historical data on actual combat operations; it does *not* deal with personnel losses in models, simulations, wargames, field experiments, or training exercises (like those of the National Training Center). PAR is focused mainly on original or translated works in English, although a few important works in other languages are included. Studies of personnel attrition are also included, provided they contain cogent analyses of a publicly available, nonproprietary body of tabulated data on attrition in actual combat operations. Since trends in attrition over long periods of time are of interest, data on ancient as well as recent battles are included. However, as no contract support was available and in-house resources were limited, no systematic effort has been made to extract data from the archives or primary source materials, and no original historical research was undertaken. Thus, PAR relies almost exclusively on secondary works that contain data in readily usable tabulated form. All works received prior to the cutoff date of 31 May 1993 are included.

THE MAIN ASSUMPTION of this paper is that the bulk of the pertinent works have been collected and are on file at CAA.

THE BASIC APPROACH used in this study was to obtain the pertinent documents through extensive personal visits, correspondence, and phone calls.

THE PRINCIPAL FINDINGS of the work reported herein are that a great deal of relevant work is available. However, for a given purpose, only a properly chosen part of it is useful. Sometimes none of it applies. Also, there is no terminological standardization of strength or loss nomenclature among nations, among services within a given nation, among theaters even for a given service, and sometimes not even among arms within a given service in a particular theater. Moreover, the nomenclature is continually being refined or redefined. Furthermore, any supposed terminological standardization is commonly ignored in the heat of battle. Since it is impractical to convert differences in terminology and classification schemes to a common basis, comparisons among strength and loss reports can be seriously misleading.

THE STUDY EFFORT was directed by Dr. Robert L. Helmbold, Scenarios and Model Validation Division.

COMMENTS AND SUGGESTIONS may be sent to the Director, U.S. Army Concepts Analysis Agency, ATTN: CSCA-MV, 8120 Woodmont Avenue, Bethesda, Maryland, 20814-2797.

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CONTENTS

PREFACE

CHAPTER — Page

1 EXECUTIVE SUMMARY 1-1
Background 1-1
Objective 1-1
Scope 1-1
Assumptions 1-1
Approach 1-1
Findings and Other Observations 1-2

2 INTRODUCTION TO THE ANNOTATED BIBLIOGRAPHY 2-1
Introduction 2-1
Short Titles 2-1
List of Titles 2-1
Key Word Index to Titles 2-1
Index to Selected Subjects 2-1
Annotated Bibliography 2-2
Other Sources of Information 2-2

3 SOME OBSERVATIONS 3-1
Introduction 3-1
Data Base Problems 3-1
Frequently Rediscovered Facts 3-2
Failure to Deal With Both Sides 3-4
Lack of Preparations for Collecting Attrition Data 3-4
Lack of Attention to Civilian Casualties 3-4
Expense of Archival Research 3-5
Some Suggested Research Topics 3-5

APPENDIX

A List of Titles A-1
B Key Word Index to Titles B-1
C Index to Selected Subjects C-1
D Annotated Bibliography D-1
E Distribution E-1

GLOSSARY Glossary-1

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CHAPTER 1

EXECUTIVE SUMMARY

1-1. BACKGROUND. In April 1992, the U.S. Army Concepts Analysis Agency (CAA) started a three-phased study of Personnel Attrition Rates (PAR). The present document covers only Phase 1, which focusses on collecting and preparing a comprehensive bibliography of the available data and past studies on personnel strengths and attrition rates in historical land combat operations. Phase 2 is intended to survey and review the data and past studies, and put the data into readily analyzable electronic form. Phase 3 is intended to perform some original analyses of the assembled data.

1-2. OBJECTIVE. The main reason for performing this study was that the anticipated later phases of the PAR Study will require a comprehensive catalog of the works collected during Phase 1. Because the resultant bibliography provides an excellent guide to the literature, it is being provided for others to use. As such, it provides the Army with a fairly comprehensive bibliography of the works on personnel attrition rates in historical land combat operations.

1-3. SCOPE. PAR is limited to studying personnel strengths and battle casualties of land combat forces. Other types of attrition (nonbattle losses, losses to equipment, casualties to other services, and so forth) are outside PAR's scope. PAR is concerned only with historical data on actual combat operations: it will *not* deal with personnel losses in models, simulations, wargames, field experiments, or training exercises (like those of the National Training Center). PAR focuses mainly on either original or translated works in English, although some important work in other languages may be included. Studies of personnel attrition are also included, provided they contain cogent analyses of a publicly available, nonproprietary body of tabulated data on attrition in actual combat operations. Since trends in attrition over long periods of time are of interest, data on ancient as well as recent battles are solicited. However, as no contract support is anticipated and in-house resources are limited, no systematic effort is made to extract data from the archives or primary source materials, and no original historical research is envisioned. Thus, PAR relies almost exclusively on secondary works that contain data in readily usable tabulated form. All works received prior to the cutoff date of 31 May 1993 are included.

1-4. ASSUMPTIONS. The main assumption of this paper is that the bulk of the pertinent works have been collected and are on file at CAA.

1-5. APPROACH. The basic approach used in this study was to obtain the pertinent documents through extensive personal visits, correspondence, and phone calls.

1-6. FINDINGS AND OTHER OBSERVATIONS. The principal findings of the work reported herein are that a great deal of relevant work is available. However, for a given purpose, only a properly chosen part of it is useful. Sometimes none of it applies. Also, there is no terminological standardization of strength or loss nomenclature among nations, among services within a given nation, among theaters even for a given service, and sometimes not even among arms within a given service in a particular theater. Moreover, the nomenclature is continually being refined or redefined. Furthermore, any supposed terminological standardization is commonly ignored in the heat of battle. Since it is impractical to convert different terminological and classification schemes to a common basis, comparisons among strength and loss reports can be seriously misleading.

CHAPTER 2

INTRODUCTION TO THE ANNOTATED BIBLIOGRAPHY

2-1. INTRODUCTION. This chapter describes what the bibliography includes and excludes and provides other material helpful in understanding and using it.

2-2. SHORT TITLES. Every work included in the bibliography is given a short title that serves as the primary key to the work and facilitates its identification. Normally, a work is referred to by its short title, rather than by its full title. These short titles are composed of the last name of the work's principal author and its date of publication. They are expressed in the form Name-yyyy, where Name is the author's last name and yyyy the year of publication. For example, Lanchester-1916 refers to the work by Lanchester that was published in the year 1916. If more than one work is associated with a given author and year, then lower case Latin letters are assigned to distinguish them. Thus, if there had been two works by Lanchester published in 1916, they would be referred to as Lanchester-1916a and Lanchester-1916b, respectively.

2-3. LIST OF TITLES. Appendix A lists the full titles of the works included in the bibliography, arranged in order by their short titles. Thus, it also provides a list of the works by their principal author's last name. Thus, if the principal author of a work is known, its short and full title can readily be found by consulting the list of titles in Appendix A. Every work included in the annotated bibliography is listed once (and only once) in Appendix A.

2-4. KEY WORD INDEX TO TITLES. Appendix B lists the short and full titles of the works included in the bibliography, arranged in order by the key words in their full title. For example, if all that is known of a work is that the word "civil" appeared in its full title, its short and full titles can readily be found by consulting the entries under that key word in Appendix B. Since the full title normally contains several key words, each work included in the bibliography may be listed several times in Appendix B (once under each of its key words).

2-5. INDEX TO SELECTED SUBJECTS. Appendix C lists the short titles of the works included in the bibliography, arranged by selected subject headings. The subject headings used are admittedly somewhat arbitrary—nevertheless they will often be found very useful. For example, if a reader wants to consider the variation of attrition rates over a long period of historical time, one could turn to the works listed under "Variation With Historical Epoch" in Appendix C. There the reader will find several works that

contain material related to that topic. Every work included in the bibliography is listed at least once in Appendix C. Normally, a work is listed several times in Appendix C, once for each of the selected subjects it addresses in a significant way.

2-6. ANNOTATED BIBLIOGRAPHY. Appendix D contains the annotated bibliographies, arranged in order by their short titles. It is the heart of this paper. In general, more information is given on works that are obscure or rare, and so may be difficult to acquire, than on works that are widely available through the usual sources. Each work is described using the following arrangement:

a. **Document Description.** Author, full title, parent organization, date, pagination, classification, availabilty (*i.e.*, where a copy of the work can be found).

b. **Objectives and Scope.** Taken from the document itself, or given the obvious interpretation if the document does not explicitly state its purpose.

c. **Populations Included.** Characterizes the population the work considers to have been at risk of becoming a casualty.

d. **Timeframes Included.** States the wars or span of years included in the document's scope.

e. **Casualty Types Included.** States how the work characterizes the casualty types it considers.

f. **Time Intervals Included As.** Gives the specific time intervals for which the work provides casualty data (*e.g.*, daily, from start to end of a battle, from start to end of a war, and so forth).

g. **Situational Descriptors Defined As.** Lists the major situational descriptors the work uses to characterize the kind of environment that prevailed at the time the casualties were incurred.

h. **Data Sources Used.** Lists the major data sources the work uses.

i. **Other and Miscellaneous.** Offers any pertinent explanation, clarification, or information.

j. **Summary of Findings Regarding Battle Casualties.** Summarizes the work's findings regarding attrition rates.

k. **Comments and Critique.** Gives the present author's personal observations and views on the work being reviewed.

2-7. OTHER SOURCES OF INFORMATION. The reader should be aware of the following additional sources of information on losses.

a. **DTIC.** Many of the works included in the bibliography are available from the Defense Technical Information Center (DTIC). Your librarian should know how to use the DTIC document accession number (the so-called AD-number, given in Appendix D as part of the document's availability

description) to obtain documents from DTIC. If needed, further information on DTIC may be obtained from:

Defense Logistics Agency
Defense Technical Information Center (DTIC)
Bldg 5, Cameron Station
5010 Duke Street, Alexandria, VA 22314-6145
Document Information, 703-274-7633.
Answering Service for User Requests, 703-274-6811.

b. **NTIS.** Those who have no access to DTIC can usually obtain unclassified AD documents from the National Technical Information Service (NTIS). For information on that procedure, contact:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22151
Document Sales Desk, 703-487-4650.
General Information, 703-487-4600.
Computer Products, 703-487-4763.
Customer Services, 703-487-4660.

c. **PASBA.** Various organizations are tasked with the responsibility for collecting, processing, analyzing, and disseminating selected types of casualty data. One of these is PASBA:

U.S. Army
Patient Administration Systems and Biostatistics Activity (PASBA)
Fort Sam Houston, Texas 78234-6070.

Its mission is to "implement policy and provide guidance on patient administration and operate a worldwide medical data collection system in support of United States Army Health Services Command." As of late 1992, it consisted of approximately 92 military and civilian personnel with the following organization and functions.

(1) **Office of the Commander.** Provides consultative service to the Office of the Army Surgeon General; HQ 7th Medical Command, Europe; HQ 18th Medical Command, Korea; and Department of Army pertaining to patient administration.

(2) **Chief Statistician.** Develops organizational statistical policy and provides guidance on statistical methodology. Monitors biostatistical projects for the activity. Reviews all studies which have statistical analyses prior to release. Performs liaison duties with Department of Army, federal, state, and private agencies for development of programs and exchange of data. Serves as staff advisor to commander on matters pertaining to statistical methods and policy.

(3) **Medical Records Consultant.** Implements policy and provides guidance on medical records administration. Provides consultation services to U.S. Army Health Services Command (HSC) staff elements and its hospitals on medical records administration to include technical assistance and

staff visitation regarding functional organization, chart analysis, diagnostic coding, standard nomenclature, preparation of coding transcripts, file management, medical records research, development of medical records forms, standardization of equipment for medical records forms, standardization of equipment for medical records activities, requirements of various national health and accrediting agencies, and Joint Commission for Accreditation of Healthcare Organizations (JCAHO). Develops policies and procedures to improve the efficiency of inpatient, outpatient, and health records administration and related systems, and monitors their implementation within HSC.

(4) **Administration Division.** Provides administration, logistical, and information management support to the activity's technical divisions.

(5) **Biostatistics Division.** Provides statistical analysis in support of the Army Medical Department (AMEDD). Receives, interprets, and provides medical statistical data for varied users. Data is used by the AMEDD in making personnel and financial resourcing decisions. The information is also utilized for clinical research and statistical studies. The division maintains a computerized data base for patients treated in Army hospitals. And, as such, plays a key role in the development of statistical models and automation systems.

(6) **Patient Administration Systems Division.** Operates the Individual Patient Data System (IPDS) and the central registry for the Army Family Advocacy Program System (AFAPS). The IPDS is an automated worldwide medical data collection system. Data received is screened for completeness and validity before being made available for the AMEDD and Department of Army users. The division also maintains the automated worldwide AFAPS central registry containing data on child and spouse abuse.

(7) **Patient Administration Operations Division.** Implements policies and provides guidance to Army medical treatment facilities (MTFs) on patient administration. The division provides technical guidance, training, and assistance on matters pertaining to patient administration management in such areas as: medical eligibility, entitlements, business office operations, casualty reporting, decedent affairs, medical disability, procurement of civilian medical services, and sharing of facilities with other federal medical facilities.

(8) Commercial phone numbers are of the form 512-212-####; DSN numbers of the form 471-####. Points of contact with the phone digits ####, as of late 1992, were as follows:

Office of the Commander (HSHI-QZ)	1102
Administration Division (HSHI-QA)	0780
Biostatistics Division (HSHI-QB)	0688
Patient Administration Systems Division (HSHI-QP)	0797
Patient Administration Operations Division (HSHI-QR)	2978
Chief Statistician (HSHI-QZ)	0471
Medical Records Consultant (HSHI-QZ)	0471

d. SURVIAC. Another organization tasked with the responsibility for collecting, processing, analyzing, and disseminating selected types of loss data is SURVIAC:

U.S. Department of Defense
Survivability/Vulnerability Information Analysis Center (SURVIAC)
WL/FIVS/SURVIAC
Wright-Patterson AFB, Ohio 45433-6553

Its mission is to provide an information center on nonnuclear survivability and lethality issues, focused chiefly on aircraft and other vehicle losses. It maintains computerized data bases and computer-indexed referenced libraries. In addition to its own holdings, it can access other existing data bases such as DTIC, the NASA Scientific and Technical Information Library, Lessons Learned Program, and the Chemical Defense Data Base. As a full-service information analysis center, SURVIAC identifies, reviews, evaluates and stores relevant scientific and technical data on all aspects of nonnuclear survivability and lethality. SURVIAC determines and responds to user community needs and provides technical advice and support in such areas as survivability design, key technologies, survivability assessments, applied methodologies, and munitions effectiveness analysis. Technical areas of interest extend to:

- Weapon system, subsystem, and component physical and functional descriptions and characteristics.
- Vulnerability, vulnerability reduction, susceptibility, and susceptibility reduction assessments.
- Live fire test data and analyses.
- Survivability, lethality, and munitions effectiveness assessments.
- Combat systems operations, damage, and repair.
- System signatures, target detection, acquisition, and tracking.
- Threat launch, flyout, and fuzing characteristics.
- Countermeasures, counter-countermeasures, and threat effects.

SURVIAC's major reference libraries include:

- Survivability/Vulnerability Reference Library (Reports, studies, analyses, and raw data).
- Laser Reference Library (test, resarch and development, and directed energy weapons).
- Aircraft Battle Damage Repair Library (reports and data on aircraft battle damage repair).
- Vehicle Signatures Library (reports and data on vehicle signatures).
- Combat Evaluation Library (reports, studies, and analyses from U.S. Army experience in Southeast Asia).

SURVIAC's data base services include:

- ACFTDAB (Southeast Asia fixed wing aircraft).
- HELODAB (Southeast Asia rotary wing aircraft).
- GNVEHSEADB (Southeast Asia ground vehicle).
- LASERDAB (laser shots against a variety of materials).
- RAM TEAM (rapid area maintenance team data base).
- Yom Kippur (Arab-Israeli tank and personnel carrier; fixed wing aircraft).

- JUST CAUSE (battle damage repair from 1989 Panama incident).
- Pk/h Matrix (critical component and supporting test data requirements matrix).

SURVIAC's central office can be reached on DSN 785-7840 or commercial 513-255-4840. Its Washington, DC area satellite office is located at Booz-Allen & Hamilton, Inc., 4001 N. Fairfax Drive, Suite 650, Arlington, VA 22203 and can be reached on 703-528-8080.

CHAPTER 3

SOME OBSERVATIONS

3-1. INTRODUCTION. The scope of Phase 1 does not include drawing any general conclusions regarding battle casualties or attrition rates in land combat operations. Nor are the following remarks a comprehensive critical analysis of the current state of the art on those topics. However, we here offer a few general observations and thoughts that occurred to us while compiling the annotated bibliography.

3-2. DATA BASE PROBLEMS. Clearly, many works have addressed one aspect or another of personnel casualties and attrition in land combat operations, and there is a wealth of material on that subject. Nevertheless, the coverage tends to be spotty, in the sense that a given document may deal only with a restricted aspect of that subject. It is usually the case that only a carefully-selected subset of the available work is relevant to a given problem—indeed, it may be that none of the existing work is particularly relevant or helpful.

The problem of applicability is complicated by the lack of terminological standardization in strength or loss nomenclature and classification systems among nations, among services within a given nation, among theaters even for a given service, and sometimes even among arms or units within a given service in a particular theater. Moreover, terminology is continually being refined or redefined. Furthermore, any terminological standardization is commonly ignored in the heat of battle. Consequently, comparisons among strength and loss reports can be seriously misleading, particularly since it is not possible to convert from one terminology and classification system to another. As Smith-1969 says, "Another major problem for the historian—and for those engaged in operations research as well—entails inconsistency of data categories, by war, by period during a single war, by service, by agency, and by data objectives. ...[in official compilations of statistics] all the basic data-gathering problems are hidden behind the solid facade of the final totals. These totals, in turn, represent the end product of many more manhours of work than the historian can hope to spend upon a data-gathering problem. ... we still lack sufficient numbers of trained and competent statisticians and data-processing personnel to assure that the data being spewed forth is both accurate and complete."

For example, the reported strength may be the initial strength only, the total strength committed during the course of the battle, the average strength over the course of the battle, the strength actually engaged or committed, the strength "present" on or near the battlefield (whether engaged or not), may include various categories of support and staff elements or be that of the combat arms only, and so

forth. Combat losses may or may not lump the died of wounds (DOW) in with the killed in action (KIA). Definitions of what constitutes a "wound" have changed from time to time, from nation to nation, from service to service, and even within a given service may differ from one arm or branch to another. For example, some World War II casualty accounts distinguish between the "slightly" and the "seriously" wounded, while others list only the most seriously wounded and others include almost all injuries—even relatively minor ones.

Accordingly, there are significant data base problems in analyzing the strength and loss data. Many other kinds of data base problems are discussed in such works as Anonymous-1953b, Beebe-1952, Carey-1987, Datel-1979, HERO-1967a, Jacob-1984, Morgenstern-1963, Rosenau-1976, Russet-1972, Wainstein-1973a, Wainstein-1973b, and Williams-1978. The problem with discrepancies in classification schemes and terminology is not trivial, as pointed out by Datel-1979. It can be illustrated by the following tabulation in Reister-1975 exhibiting irreconcilable differences between the U.S. Army Surgeon General and Adjutant General accounts of World War II casualties, and attributed to differences in their classification schemes:

Type casualty	The Adjutant General's Report	The Surgeon General's Report
WIA	592,170	723,560
Total deaths (KIA + DOW)	216,005	213,030
-KIA	189,696	192,220
-DOW	26,309	20,810
Other battle deaths†	18,869	16,793

† Missing in Action (MIA) later declared dead, prisoners of war (POW) who died in enemy hands, etc.

In the future, we can expect to be faced with similar or worse discrepancies between counts assembled and provided by various agencies, since (as noted by Schmidt-1963, Smith-1969, and Uhorchak-1992) there is at present no designated organization or explicit requirement either to collect, process, and disseminate during combat operations any data on casualties or attrition, or to resolve the discrepancies among various reporting agencies. For example, The Surgeon General concentrates on personnel who are admitted to hospitals for treatment, while The Adjutant General also reports on personnel who are KIA, MIA, captured, or otherwise lost from their assigned unit.

3-3. FREQUENTLY REDISCOVERED FACTS. Some facts about strengths and losses—or about their influence on other characteristics of combat—are rediscovered again and again. All of them can be considered as readily apparent, in the sense that no capable investigator who takes the trouble to look for patterns in the numbers could miss them. At the same time, they are sufficiently subtle as to pass largely unnoticed by historians searching for unique features distinguishing one battle from another. A few of these frequently rediscovered facts are listed below, most of which can be found somewhere in

either Berndt-1897 or Bodart-1908. Since they are at least that old, they can surely be considered part of the classical knowledge. They are not listed in any particular order.

a. The distribution of wound sites over the body has been relatively stable for many years.

b. The ratio of WIA to KIA has been relatively constant for many years.

c. Officers take higher casualties in proportion to their number than enlisted men.

d. Infantry suffers far more casualties, on the average, than any of the other service branches.

e. Fratricide incidents are common.

f. Too much combat stress will drive you crazy.

g. Combat tends to be episodic in nature (sometimes expressed as "Hours of boredom punctuated by moments of sheer terror.").

h. Lack of proper sanitation and standards of personal care result in heavy losses to disease.

i. It takes a heap of ammo to cause a casualty, because weapon effectiveness in battle is on the order of two or three orders of magnitude lower than on the firing range.

j. Casualty rates have tended to remain stable or decline for the last 300 or 400 years, despite the advances in weapons technology.

k. Personnel force ratios have little or nothing to do with which side wins, who advances, or how many losses are suffered in battles or wars (expressed in one way or another, this has also been noted by Dupuy-1977, Fain-1977, Goad-1973, Helmbold-1969, Helmbold-1986, Helmbold-1990, and Kirkpatrick-1985, among others).

l. The loser suffers proportionately higher losses than the winner (expressed in one way or another, this has also been noted by Best-1952b, CAA-1985, Hammerman-1982, Hartley-1990, Hartley-1991a, Helmbold-1961, Helmbold-1964a, Helmbold-1986, Helmbold-1990, Klingberg-1966, Schmieman-1967, Weiss-1966a, and Willard-1962, among others).

m. Smaller units tend to take higher percentage casualties than larger ones.

n. Battles that last longer tend to have lower average attrition rates than short ones, although their fraction of casualties tends to be about the same.

o. Loss numbers, percentages, and rates vary widely from time to time and from one unit to another.

3-4. FAILURE TO DEAL WITH BOTH SIDES. There have been several studies and many collections of statistics on losses that consider only one side's casualty experience. All such studies and statistical collections are fundamentally flawed because they ignore entirely the side that is *causing* those casualties. Thus, it is unsurprising that no one-sided casualty analyses have found any clear or consistent relationship between casualties and such important matters as victory, rate of advance, morale, unit cohesion, or "breakpoint." At best they find that there is some connection between casualty rates and the general "intensity" of combat—but, of course, those periods of high intensity are precisely those times when the interactions *between* forces are most important and influential, and thus the least to be disregarded. Clark-1954 expresses this very forcefully in her final conclusion: "The very wide individual differences in the ability of infantry battalions to carry out a given mission cannot be accounted for in terms of casualties alone, no matter how the data are presented. Of the other interacting variables it is believed that failures and breakdowns in leadership, fire support and reinforcement, and communications are the most frequent and powerful influences." In this regard, see also Helmbold-1971b, Summers-1970, Wainstein-1973b, Wainstein-1986.

3-5. LACK OF PREPARATIONS FOR COLLECTING ATTRITION DATA. Most armies (specifically including those of the United States) have in times of peace failed to devise and implement adequate procedures, organizations, and trained personnel for collecting, processing, analyzing, and disseminating the lessons learned from their wartime casualty and loss experience (in this regard, see Datel-1979, Schmidt-1963, Smith-1969, Uhorchak-1992, HERO-1967a, and Wainstein-1973a). We also note that there is little evidence that modern technological advances in operational research, statistics (such as experimental design, sampling methods, census bureau-type population statistics, or actuarial sciences of the sort that deal with life tables), or data management technologies have been or are being systematically applied to this area.

3-6. LACK OF ATTENTION TO CIVILIAN CASUALTIES. Little or no systematic information on casualties to noncombatants (be they friendly, enemy, or neutral civilians) is available. Most of what little information we have has been gathered and published by nonmilitary organizations (official civil government agencies, private and semi-official charitable organizations, private nonprofit organizations, and concerned individuals). There seems to be growing concern throughout the world over the fate of noncombatants and the burdens imposed on them by military action. In this connection, we note the popular outcry against what are viewed as excessive civilian casualties caused by U.S. military operations during the Vietnamese War and in Panama (Operation JUST CAUSE), or by others such as Iraq and Iran during the Iraq-Iran Wars, by Iraq against the Kurds, and by Serbs against the Muslim enclaves in Bosnia-Herzegovina.

With the increasing likelihood of U.S. military involvement in peacekeeping or "police action" operations, this worldwide concern over civilian casualties could assume greater importance. Accordingly,

serious thought should be given to increasing U.S. capability to accurately and credibly measure and record collateral damage from military operations conducted by itself or other parties.

3-7. EXPENSE OF ARCHIVAL RESEARCH. Most operations analysts have no idea of how voluminous are the military records stored by the U.S. National Archives and Records Administration. Nor do most of them have a proper appreciation for how time-consuming and labor-intensive (and therefore expensive) it is to extract quantitative information from them. For information on what can and cannot be done with such records, and an account of some of the problems involved, consult Campbell-1969, Compton-1984, HERO-1967a, and Smith-1969.

3-8. SOME SUGGESTED RESEARCH TOPICS. Some open or controversial issues that may be particularly suited to future research are listed below, though not in any particular order.

a. What is the effect of national character on victory and losses in battle? Some analysts claim that its influence is consistent, pervasive, and of major importance. On the other hand, some found little or no evidence for that.

b. What is the correct theory of attrition in battle? It seems that the currently available data do not suffice to determine the scope of applicability to real combat of any of the innumerable equations or other models that have been proposed to account for attrition in battle.

c. How is the attrition rate affected by various environmental or tactical factors (such as weather; terrain; fortifications; state of training, morale, unit cohesion; combat experience, and so forth; nature and effectiveness of the command, control, intelligence, and communications system; type of tactical disposition or maneuver of forces; and so forth)? No very satisfactory analysis of this is available. Case studies of the type that argue "They did this, *and won*!" are unconvincing because they do not answer the obvious question—"Well, yes. But how frequently would the same action have brought home a victory? A loss? A draw?"

d. Attrition rates on each side are roughly proportional to the attrition rate on the other side.

e. Attrition rate of the winner is independent of whether he was attacking or defending.

f. Attrition rates have steadily and steeply declined with the passage of time since about 1600 AD.

g. Attrition rates are independent of environmental factors such as weather, temperature, visibility, the degree of cover and concealment provided by the natural terrain, and like factors.

h. Attrition rates decline as the severity of environmental factors increases.

i. Attrition rates are higher on both sides when they are evenly matched.

j. Attrition rates decline as speed of movement increases.

k. Attrition rates increase as the opportunity for the losing side to break contact diminishes.

l. Attrition rates increase as weapon lethality (effective range, rate of fire, accuracy, and terminal effectiveness) increases.

m. Attrition rates decline with calendar date.

n. Attrition rates decline with time into a war (or into a battle, or into a campaign).

o. The "personal equation" effect, well-known in astronomical circles, also affects historical data.

p. Attrition causes units to "break." Breakpoints occur at definite values of the casualty level, casualty rate, casualty fraction, attrition rate, casualty exchange ratio, fractional exchange ratio, force ratio, etc.

q. Daily attrition rates are distributed (normally, exponentially, log-normally, Weibull, Gamma, etc.).

r. The loser's casualty fraction is about twice the winner's.

s. Attrition rates vary seasonally, increasing in the "good weather" seasons, and decreasing in the "bad weather" seasons.

t. How does the casualty fraction or attrition rate depend on:

(1) Posture (attack/defense).

(2) Success (win/lose/draw).

(3) Opposing force ratio.

(4) Size of force.

(5) Battle duration.

(6) Opposing casualty exchange ratio.

(7) Opposing fractional exchange ratio.

(8) Opposing attrition rate.

(9) Amount or quality of fire support (air and ground).

u. Attrition rates are strongly affected by "national characteristics."

v. The following hypotheses are adapted from Dupuy-1990 (especially Chapter 6, Attrition Verities):

(1) In the average modern battle, the attacker's numerical strength is about double the defender's.

(2) In the average modern battle, the attacker is more often successful than the defender.

(3) Casualty rates of winners are lower than those of losers.

(4) Small force casualty rates are higher than those of large forces. (The smaller the force, the higher its casualty fraction.)

(5) More effective forces inflict casualties at a higher rate than less effective opponents.

(6) There is no direct relationship between force ratios and attrition rates.

(7) In most modern battles, the numerical losses of attacker and defender have been similar.

(8) Casualty rates for defenders vary inversely with strength of fortifications. (The stronger the fortifications, the lower the defender's casualty rate.)

(9) Casualty rates of a surprising force are lower than those of a surprised force.

(10) In the average modern battle, attacker casualty rates are somewhat lower than defender casualty rates.

(11) In bad weather, casualty rates for both sides decline markedly.

(12) In difficult terrain, casualty rates for both sides decline markedly.

(13) The casualty-inflicting capability of a force declines after each successive day in combat.

(14) Casualty rates are lower at night than in the daytime.

(15) Casualty rates are higher in summer than in winter.

(16) The faster the front moves, the lower the casualty rates for both sides.

(17) Casualty rates seem to decline during river crossings.

(18) An "all-out" effort by one side raises casualty rates for both sides.

(19) A force with greater overall combat power inflicts casualties at a greater rate than the opponent.

(20) The distribution of killed and wounded casualties in 20th century warfare is constant. (About 20 percent of the battle casualties are killed immediately. This corresponds to a wounded to killed ratio of about 4.)

(21) Average World War II division engagement casualty rates in Western Europe were 1 percent to 3 percent per day.

(22) Attrition rates in the 1973 October War were comparable to those of World War II.

(23) Casualty rates for major power forces in minor hostilities after 1945 are about half those

experienced in World War II.

(24) Materiel loss rates are related to personnel casualty rates.

(25) Tank loss rates are five to seven times higher than personnel casualty rates.

(26) Attacker tank loss rates are generally higher than defender tank loss rates. (This is in relation to personnel casualty rates on the opposing sides. If the attacker's tank loss rate is about seven times that of the attacking personnel casualty rate, the defender's tank loss rate will probably be closer to five times (or even less) the defender's [personnel] casualty rate.)

(27) Artillery materiel loss rates are generally about one-tenth personnel casualty rates.

(28) Self-propelled artillery loss rates are two to three times greater than for towed guns.

(29) The loss rates of light, to medium, to heavy artillery weapons are in the proportion: 2.2/1.8/1.0.

APPENDIX A

LIST OF TITLES

A-1. INTRODUCTION. This appendix lists the titles of the documents which were reviewed and deemed sufficiently pertinent to annotate in Appendix D. They are arranged in alphabetical order according to the short title composed of the last name of their principal author and their year of publication. Each document is given a short title consisting of its principal author's last name and its date of publication. For example, Hartley-1989c refers to a work by Hartley published in 1989. The added letter, c, indicates that the document referred to is the third publication in 1989 by this author. These short titles are used throughout this paper as the key document identifiers. The annotated bibliography in Appendix D gives the full bibliographic citation for each of the listed titles.

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APPENDIX B

KEY WORD INDEX TO TITLES

B-1. INTRODUCTION. This appendix provides an index to the document titles listed by short title in Appendix A. Here they are arranged alphabetically by the key words contained in their titles. For example, all titles with the word "Allied" are listed under that entry. Documents may be listed several times, once for each key word in their long title. No authors' names are included in the key words, since Appendix A already provides a listing by principal author.

B-2. INDEX

ABOARD
Blood-1992, Analyses of Battle Casualties by Weapon Type Aboard US Navy Warships.

ACCOMPLISHMENT
Summers-1970, Combat Casualties and Mission Accomplishment.

ACCURACY
Morgenstern-1963, On the Accuracy of Economic Observations.

ACROSS
Bredeson-1991, Technical Notes on Comparison of Battle Outcomes Across Nationality.
Datel-1981, On Studying Morbidity Across All Three Armed Services.

ACSDB
CAA-1990, The Ardennes Campaign Simulation Data Base (ACSDB).

ACTION
Beebe-1957, Influence of Type of Ground Action on the Wounded in Action, US Divisions in Second World War.
Mareth-1985, Combat Stress Reaction: A Concept in Evolution.
Maughan-1970, An Inquiry Into the Nature of Wounds Resulting in Killed in Action in Vietnam.
Reister-1969, Effects of Type of Operation and Tactical Action on Major Unit Casualty and Morbidity Experience--Korean War.

ACTIVE
DoD-1991, Worldwide US Active Duty Military Personnel Casualties--Oct 1, 1979 Through Dec 1, 1991.

ACTS
Holmes-1985, Acts of War: The Behavior of Men in Battle.

ACTUAL
Schmidt-1963, The Necessity for Objective Data from Actual Combat Engagements While Current.

ADEQUATELY
Kirkpatrick-1985, Do Lanchester's Equations Adequately Model Real Battles?

ADOLPHUS
Dodge-1895, Gustavus Adolphus.

ADVANCE
Gould-1952, An Analysis of Infantry Rates of Advance in Battle.
Helmbold-1990, Rates of Advance in Historical Land Combat Operations.
Pearsall-1972, Casualty Rates and Opposed Advance.
Wainstein-1973b, Rates of Advance in Infantry Division Attacks in the Normandy-Northern France and Siegfried Line Campaigns.

AFTERMATH
Stouffer-1949, The American Soldier: Combat and Its Aftermath.

AGENT
Burt-1965, Distribution of Combat Casualties by Causative Agent.
Naisawald-1953a, The Causative Agents of Battle Casualties, Second World War.

AID
Bellamy-1987, Death on the Battlefield and the Role of First Aid.

AIR
Helmbold-1971a, Air Battles and Ground Battles--A Common Pattern?
Kelley-1977, Quality-Quantity Tradeoffs: A Historical Analysis of Air Combat.
Lanchester-1916, Aircraft in Warfare: The Dawn of the Fourth Arm.

AIRCRAFT
Lanchester-1916, Aircraft in Warfare: The Dawn of the Fourth Arm.

ALEXANDER
Dodge-1890, Alexander the Great.

ALLIED
Coox-1951, Survey of Allied Tank Casualties in Second World War.
Engel-1963, Combat Effectiveness of Allied and German Troops in the Second World War Invasion of Crete.
Wainstein-1973a, Some Allied and German Casualty Rates in the European Theater of Operations.

ALTERNATIVES
Pride-1989, Technological Alternatives to the Direct Fire Fratricide Problem.

AMERICA
Barnett-1992, America's Vietnam Casualties: Victims of a Class War?
Fox-1889, Regimental Losses in the American Civil War, 1861-1865.
Livermore-1900, Numbers and Losses in the Civil War in America 1861-1865.
Peckham-1974, The Toll of Independence: Engagements and Battle Casualties of the American Revolution.
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AMICIDE
Shrader-1982, Amicide: The Problem of Friendly Fire in Modern War.

AMMUNITION
Anonymous-1945, Artillery Ammunition Expenditures as Related to Infantry Casualties.
Anonymous-1953a, The Relationship of Casualties to Tactics and Ammunition Expenditure: 2d US Infantry Division, Korea, 1 Feb 1953--31 Mar 1953.
Naisawald-1953b, The Cost in Ammunition of Inflicting a Casualty.

AMPUTATION
Traverso-1981, Combat Casualties in Northern Thailand: Emphasis on Land Mine Injuries and Levels of Amputation.

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Blood-1992, Analyses of Battle Casualties by Weapon Type Aboard US Navy Warships.
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Johnson-1981a, Analytical Survey of Personnel Replacement Systems in Modern War.

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Dupuy-1977, Analyzing Trends in Ground Combat.

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Campbell-1969, The National Archives and Military Records.

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CAA-1990, The Ardennes Campaign Simulation Data Base (ACSDB).

AREA
Ember-1987, Human Relations Area Files (HRAF).
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Karis-1988, Of Blue Badges and Purple Cloth: The Impact of Battle Death in a Cohesive Unit.

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Beyer-1962, Wound Ballistics.

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Clark-1954, Casualties as a Measure of Loss of Effectiveness of an Infantry Battalion.

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Holmes-1985, Acts of War: The Behavior of Men in Battle.
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Thornton-1975, BDM/CARAF Feasibility Investigation of Computerized Simulation Models to Estimate Personnel Loss Rates.

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Mellor-1972, Casualties and Medical Statistics.

Melsom-1975, Battle Casualties.

Mitchell-1931, Casualties and Medical Statistics of the Great War.

Naisawald-1953a, The Causative Agents of Battle Casualties, Second World War.

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Parker-1965, Survey of Casualties, Republic of Vietnam Military Forces, 1962.

Peckham-1974, The Toll of Independence: Engagements and Battle Casualties of the American Revolution.

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Traverso-1981, Combat Casualties in Northern Thailand: Emphasis on Land Mine Injuries and Levels of Amputation.
Vagts-1945, Battle and Other Combatant Casualties in the Second World War.
Vandivier-1990, Battle Casualties as a Function of Environmental Factors.

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Arebalo-1990, Variation of Historical Casualty Rates With Battle Dates.
Bellamy-1983, The Causes of Death in Conventional Land Warfare: Implications for Combat Casualty Care Research.
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Boyd-1964, Casualty Predictions for Medical Workloads from Conventional Weapons, 1965-1970.
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Goad-1973, Prediction of Opposed Movement and Casualty Rates.
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Kuhn-1989, Ground Forces Battle Casualty Rate Patterns: The Empirical Evidence.
Kuhn-1990, Ground Forces Battle Casualty Rate Patterns: Current Rate Projections Compared to the Empirical Evidence.
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Naisawald-1953b, The Cost in Ammunition of Inflicting a Casualty.
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Robinson-1965, Casualty Predictions for Medical Workloads from Conventional Weapons.
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Burt-1965, Distribution of Combat Casualties by Causative Agent.
Naisawald-1953a, The Causative Agents of Battle Casualties, Second World War.

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Bellamy-1983, The Causes of Death in Conventional Land Warfare: Implications for Combat Casualty Care Research.
Dumas-1923, Losses of Life Caused by War.
McBride-1991, Report and Medical Analyses of Personnel Injury from Operation "JUST CAUSE".

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Dumas-1923, Losses of Life Caused by War.

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Fain-1988, Forced Changes in Combat Posture.
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COMPANY
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Gilchrist-1928, A Comparative Study of World War Casualties from Gas and Other Weapons.
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COMPARED
Kuhn-1990, Ground Forces Battle Casualty Rate Patterns: Current Rate Projections Compared to the Empirical Evidence.

COMPARISON
Benn-1952, Tank Effectiveness: A Comparison of the Theoretical Measure With Observed Battle Performance and a Further Note on Rate of Fire.
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COMPUTER
CAA-1985, Integrated Warfare--Representing the Decision Processes Within Computer Simulations of Combat.
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Hartley-1991a, Confirming the Lanchestrian Linear-Logarithmic Model of Attrition.

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HERO-1967b, Comparative Analysis of Armored Conflict Experience.
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Richardson-1970, An Analysis of Recent Conflicts.

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Johnson-1981b, Medical Consequences of the Various Weapons Systems Used in Combat in Thailand.

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APPENDIX C

INDEX TO SELECTED SUBJECTS

C-1. INTRODUCTION. This appendix provides a short subject index to the documents deemed sufficiently pertinent to annotate in Appendix D. The documents are referred to by their short titles, which are described in Appendix A. Many subject categories could be used, but we contented ourselves with the following.

C-2. SUBJECT INDEX

[For Causative Agents and Ammunition Per Hit] Anonymous-1953a, Beebe-1952, Berndt-1897, Best-1952a, Best-1952b, Best-1966, Beyer-1962, Burt-1965, Blood-1992, Cleaver-1956, Coben-1986, Cochrane-1959, Connerat-1971, Coox-1951, Dougherty-1990, Dupuy-1986, Dupuy-1990, Eisner-1964, Gilchrist-1928, HERO-1979, Holmes-1985, Johnson-1981b, JTCG-1970, Letterman-1866, Love-1925, Love-1932, MacDonald-1951, MacLean-1990, MACV-1968, McBride-1991, McQuie-1968, Melsom-1975, Mitchell-1931, Naisawald-1953a, Naisawald-1953b, Neel-1973, Otis-1883, Page-1954, Palinkas-1985a, Parker-1965, Preston-1954, Reister-1969, Reister-1975, Reister-1986, Rich-1968, Robinson-1965, Shephard-1991, Thayer-1985, Traverso-1981, Uhorchak-1992, Walker-1991.

[For Data Base Usage, Problems, and Fallacies] Bellamy-1987, Best-1952a, Best-1952b, Best-1966, Busse-1968, Bzik-1984, CAA-1991, Campbell-1969, Carey-1987, Compton-1984, Datel-1979, Datel-1981, Delbruck-1913, Dumas-1923, Dunn-1971, Dupuy-1977, Fox-1889, Hartley-1989a, Heidenrich-1993, Helmbold-1993, HERO-1967a, HERO-1975, HERO-1979, Hutzler-1989, Love-1925, Jacob-1984, Miller-1978, Morgenstern-1963, Naisawald-1953a, Osipov-1915, Otis-1883, Palinkas-1985a, Peckham-1974, Reister-1969, Rosenau-1976, Ross-1992, Russset-1972, Schmidt-1963, Smith-1969, Thayer-1985, Thornton-1975, Uhorchak-1992, Vagts-1945, Wainstein-1973a, Williams-1978, Woodward-1875.

[Dictionaries of Battles and/or Wars] Berndt-1897, Bodart-1908, CAA-1990, CAA-1991, Chandler-1988, Eggenberger-1967, Harbottle-1905, Kohn-1987, Laffin-1986, Peckham-1974, Sweetman-1985, Young-1977.

See also Statistical Tabulations.

[For Field Experiments] Anderson-1961, CALL-1988, CALL-1992, Davis-1953, Goldsmith-1986, Hamza-1987, Kuhn-1989, Rowland-1987.

[For Form of Attrition Relationships, and Associated Matters] Best-1966, Boyd-1964, Busse-1968, Cockrell-1974, Dunn-1971, Engel-1954, Engel-1963, Fain-1970, Fain-1977, Goad-1973, Goad-1974, Hartley-1989a, Hartley-1989b, Hartley-1989c, Hartley-1990, Hartley-1991a, Hartley-1991b, Hartley-1991d, Helmbold-1961, Helmbold-1964a, Helmbold-1965, Helmbold-1994, Kelley-1977, Kingsley-1968, Kirkpatrick-1985, Lanchester-1916, Love-1931, Osipov-1915, Overholt-1970, Pearsall-1972, Peterson-1967, Rowland-1987, Sams-1972, Scales-1992, Schaefer-1977, Schmieman-1967, Voevodsky-1969, Voevodsky-1972, Willard-1962, Weiss-1966a.

[For Friendly Fire, Fratricide, Amicide, and Collateral Damage] Bryan-1976, Beyer-1962, CALL-1988, CALL-1992, Dumas-1923, Goldsmith-1986, Hamza-1987, MACV-1968, Pride-1989, Reister-1969, Reister-1986, Shrader-1982, Thayer-1985, Vagts-1945.

[For Influence on Breakpoints, Victory, Rate of Advance, etc.] Berndt-1897, Best-1952a, Best-1952b, Best-1966, Bodart-1908, CAA-1975, CAA-1985, Clark-1954, Cockrell-1974, Drea-1983, Dunn-1971, Dupuy-1977, Etheridge-1981, Fain-1988, Goad-1973, Goad-1974, Goodman-1989, Gould-1952, Hammerman-1982, Hartley-1989a, Hartley-1989b, Hartley-1989c, Hartley-1990, Hartley-1991a, Hartley-1991b, Hartley-1991d, Helmbold-1961, Helmbold-1964a, Helmbold-1964b, Helmbold-1967, Helmbold-1969, Helmbold-1971a, Helmbold-1971b, Helmbold-1986, Helmbold-19[illegible]bold-1990, Helmbold-1994, HERO-1979, Karis-1988, Klingberg-1966, McQuie-1968, Overho[illegible]earsall-1972, Preston-1954, Russet-1972, Schaefer-1977, Schmieman-1967, Singer-1972, Small-1982, Summers-1970, Voevodsky-1969, Voevodsky-1972, Wainstein-1973b, Wainstein-1986, Weiss-1963, Weiss-1966a, Yengst-1982.

[For Psychiatric Casualties] Anonymous-1926, Belenky-1983, Best-1966, Chernol-1983, Clark-1954, Cochrane-1959, Copp-1990, Davis-1953, Davis-1954, Drea-1983, Holmes-1985, Love-1932, Mareth-1985, Mitchell-1931, Mellor-1972, Neel-1973, Otis-1883, Palinkas-1985b, Preston-1954, Reister-1986, Stouffer-1949, Vineberg-1965, Wiltse-1965.

[For Small Unit Operations] Best-1952a, Best-1966, Brinkerhoff-1985, Clark-1954, Cockrell-1974, Compton-1983, Davis-1954, Fox-1889, Gould-1952, Heitman-1903, Karis-1988, Kremer-1906, Love-1925, Page-1954, Reister-1986, Ross-1992, Rowland-1987, Schaeffer-1977, Summers-1970.

[For Statistical Analyses] Best-1966, Boyd-1964, Burt-1965, CAA-1975, CAA-1985, Cleaver-1956, Cockrell-1974, Connerat-1971, Dunn-1971, Fain-1970, Fain-1977, Goad-1973, Goad-1974, Hartley-1989a, Hartley-1989b, Hartley-1989c, Hartley-1989a, Hartley-1990, Hartley-1991a, Hartley-1991c, Hartley-1991d, Helmbold-1961, Helmbold-1964a, Helmbold-1964b, Helmbold-1967, Helmbold-1969, Helmbold-1971a, Helmbold-1971b, Helmbold-1986, Helmbold-1987, Helmbold-1990, Klingberg-1966, Kuhn-1989, McQuie-1968, Osipov-1915, Overholt-1970, Pearsall-1972, Peterson-1967, Richardson-1960, Richardson-1970, Robinson-1965, Rowland-1987, Schaefer-1977, Schmieman-1967, Singer-1972, Small-1982.

Vandivier-1990, Vineberg-1965, Voevodsky-1969, Voevodsky-1972, Walker-1991, Weiss-1963, Weiss-1966a, Weiss-1966b, Willard-1962.
See also Statistical Tabulations.

[For Statistical Tabulations] Anderson-1988, Best-1966, Beyer-1962, Bodart-1916, Boyd-1964, Brinkerhoff-1985, Burt-1965, CAA-1975, CAA-1990, CAA-1991, Cleaver-1956, Cockrell-1974, Connerat-1971, DoD-1991, Dodge-1890, Dodge-1891, Dodge-1891, Dodge-1895, Dodge-1900, Dodge-1904, Dumas-1923, Dunn-1971, Dupuy-1970, Eisner-1964, Ember-1987, Fain-1970, Fain-1977, Fox-1889, Goldich-1973, Heitman-1903, Helmbold-1961, Helmbold-1964a, Helmbold-1990, HERO-1967a, HERO-1967b, HERO-1975, HERO-1979, Johnson-1981a, JTCG-1970, Kelley-1977, Kremer-1906, Kuhn-1989, Larcher-1934, Livermore-1900, Love-1932, MacDonald-1951, Maughan-1970, McBride-1991, McQuie-1988, Mellor-1972, Mitchell-1931, Mottelay-1893, Naisawald-1953a, Naisawald-1953b, Melsom-1975, Neel-1973, Osipov-1915, Otis-1883, Palinkas-1985a, Palinkas-1985b, Parker-1965, Preston-1954, Peckham-1974, Reister-1969, Reister-1975, Reister-1986, Rich-1968, Richardson-1960, Robinson-1965, Ross-1992, Shephard-1001, Singer-1972, Small-1982, Smith-1955, Summers-1970, Thayer-1985, Traverso-1981, Uhorchak-1992, Vineberg-1965, Wainstein-1973a, Wainstein-1973b, Walker-1991, Woodward-1875, Wright-1942.
See also Statistical Analyses, Dictionaries of Battles and/or Wars, and specific wars.

[For Variation With Historical Epoch] Arcbalo-1990, Berndt-1897, Bodart-1908, Bodart-1916, CAA-1985, Carey-1987, Dumas-1923, Dupuy-1977, Dupuy-1986, Dupuy-1990, Gilchrist-1928, Hartley-1991a, Helmbold-1961, Helmbold-1964a, Helmbold-1964b, Helmbold-1967, Helmbold-1969, Helmbold-1971a, Helmbold-1971b, Helmbold-1986, Helmbold-1987, Helmbold-1990, Hoeffler-1981, Kuhn-1989, McConnell-1987, Melsom-1975, Naisawald-1953a, Neel-1973, Otis-1883, P..ker-1965, Reid-1975, Robinson-1965, Rowland-1987, Voevodsky-1969, Voevodsky-1972.

[For Variation With Nationality or National Character] Bodart-1908, Bredeson-1991, Dumas-1923, Dupuy-1986, Dupuy-1990, Hartley-1991a, Hartley-1991c, Hartley-1991d, Helmbold-1961, Helmboid-1964a, Kuhn-1989, Love-1932, Naisawald-1953a, Otis-1883, Rowland-1987, Vagts-1945, Wainstein-1973a.

[For Variation With Rank, Branch of Service, and/or MOS] Anonymous-1953b, Beebe-1952, Bellamy-1983, Bellamy-1987, Berndt-1897, Best-1966, Bodart-1908, Bodart-1916, Boyd-1964, Bzik-1984, Blood-1990, CALL-1988, Carey-1987, Cleaver-1956, Coben-1986, Cochrane-1959, Compton-1983, DoD-1991, Dumas-1923, Fox-1889, Holmes-1985, Kremer-1906, Larcher-1934, Love-1925, MacLean-1990, McConnell-1987, Palinkas-1985a, Palinkas-1985b, Parker-1965, Shephard-1991, Summers-1970, Thayer-1985, Uhorchak-1992, Vineberg-1965, Walker-1991.

[For Variation With Tactical Situation] Anonymous-1945, Anonymous-1953a, Beebe-1957, Best-1952a, Best-1952b, Best-1966, Blood-1990, Bodart-1908, Boyd-1964, Brinkerhoff-1985, CAA-1975, CAA-1985, Cleaver-1956, Cockrell-1974, Compton-1983, Connerat-1971, Davis-1953, Dupuy-1986, Dupuy-1990, Eisner-1964, FM-1987, Goad-1973, Goad-1974, Hartley-1989a, Hartley-1991d, Helmbold-1961, Helmbold-1964a, Helmbold-1964b, Helmbold-1967, Helmbold-1969, Helmbold-1971a, Helmbold-1971b, Helmbold-1986, Helmbold-1987, Helmbold-1990, Johnson-1981a, Kuhn-1989, Kuhn-1990, Kuhn-1991, Larcher-1934, Love-1932, McConnell-1987, Mitchell-1931, Overholt-1970, Parker-1965, Pearsall-1972, Reister-1969, Reister-1986, Robinson-1965, Scales-1992, Schaefer-1977, Shrader-1982, Shephard-1991, Traverso-1981, Vandivier-1990, Vineberg-1965, Wainstein-1973a, Wainstein-1973b, Walker-1991, Weiss-1966a.

[For Variation With Site of Wound] Beebe-1952, Bellamy-1983, Beyer-1962, Boyd-1964, Eisner-1964, Johnson-1981b, JTCG-1970, Letterman-1866, Love-1925, Love-1932, Maughan-1970, McBride-1991, Meggitt-1977, Mitchell-1931, Neel-1973, Otis-1883, Palinkas-1985a, Parker-1965, Reister-1969, Resiter-1975, Reister-1986, Rich-1968, Robinson-1965, Uhorchak-1992, Walker-1991.

[For Variation With Unit Size] Brinkerhoff-1985, Berndt-1897, Best-1966, CAA-1985, Dodge-1890, Dodge-1891, Dodge, 1895, Dodge-1900, Dodge-1904, Dupuy-1986, Dupuy-1990, FM-1987, Hartley-1989a, Hartley-1989b, Hartley-1989c, Hartley-1990, Hartley-1991a, Hartley-1991b, Hartley-1991d, Helmbold-1961, Helmbold-1964a, Helmbold-1964b, Helmbold-1967, Helmbold-1969, Helmbold-1971a, Helmbold-1971b, Helmbold-1986, Helmbold-1987, Helmbold-1990, Kelley-1977, Kuhn-1989, Kuhn-1990, Kuhn-1991, Love-1931, Pearsall-1972, Reister-1969, Reister-1986, Schaefer-1977.

[For Vehicle, Equipment, and Crew Losses] Benn-1952, Connerat-1971, Coox-1951, Dost-1972, Dougherty-1990, Dupuy-1977, Dupuy-1986, Dupuy-1990, Hartley-1991b, Hartley-1991d, HERO-1967b, HERO-1979, MacDonald-1951, McCrea-1954, Page-1954, Schaefer-1977, Shephard-1991, Uhorchak-1992, Wainstein-1986, Walker-1991.

[For War in General or General Information] Bellamy-1986, Bellamy-1987, Berndt-1897, Best-1966, Bodart-1908, Bodart-1916, Bowen-1988, CAA-1991, Connerat-1971, Cordesman-1990, Datel-1981, Davis-1953, Delbruck-1913, Denton-1969, DoD-1991, Dodge-1890, Dodge-1891, Dodge-1895, Dodge-1900, Dodge-1904, Dumas-1923, Dupuy-1970, Dupuy-1977, Dupuy-1986, Dupuy-1990, Ember-1987, FM-1987, FM-1991, Giddings-1955, Hampton-1987, Heitman-1903, Helmbold-1987, Holmes-1985, Hutzler-1989, Johnson-1981a, JTCG-1970, Karis-1988, Klingberg-1966, Love-1931, McQuie-1968, Meggitt-1977, Miller-1978, Preston-1954, Reid-1975, Richardson-1960, Richardson-1970, Rosenau-1976, Ross-1992, Russet-1972, Singer-1972, Small-1982, Thornton-1975, Traverso-1081, Vagts-1945, Vineberg-1965, Voevodsky-1969, Voevodsky-1972, Wainstein-1986, Weiss-1963, Weiss-1966b, Wiltse-1965,Wright-1942, WSEG-1975, Yengst-1982.

[For War, American Civil] CAA-1991, Dumas-1923, Fox-1889, Goldich-1973, Heitman-1903, Kremer-1906, Letterman-1866, Livermore-1900, Mottelay-1893, Otis-1883, Voevodsky-1969, Voevodsky-1972, Weiss-1966a, Woodward-1875.

[For War, Mideast] Cordesman-1990, Belenky-1983, CAA-1991, Dupuy-1977, Heidenrich-1993, Kuhn-1989, WSEG-1975.

[For War, Falklands] Cordesman-1990, Wainstein-1986.

[For War, Iran-Iraq] Cordesman-1990.

[For War, Korea] Anonymous-1953a, Best-1952a, Best-1952b, Beyer-1962, Boyd-1964, Burt-1965, Busse-1968, Carey-1987, Cleaver-1956, Davis-1953, Davis-1954, Fain-1970, Goldich-1973, Hartley-1989a, HERO-1967a, Hoeffler-1981, Johnson-1981a, Kelley-1977, MacDonald-1951, McCrea-1954, Miller-1978, Overholt-1970, Page-1954, Preston-1954, Reister-1969, Reister-1986, Robinson-1965, Voevodsky-1969, Voevodsky-1972, Weiss-1966b.

[For War, Vietnam] Barnett-1992, Bellamy-1986, Bzik-1984, Carey-1987, Coben-1986, Connerat-1971, Dost-1972, Dougherty-1990, Eisner-1964, Goldich-1973, Hoeffler-1981, Johnson-1981a, JTCG-1970, Kelley-1977, MACV-1968, Maughan-1970, Neel-1973, Palinkas-1985a, Palinkas-1985b, Parker-1965, Rich-1968, Shrader-1982, Thayer-1985, Voevodsky-1969, Walker-1991.

[For War, World War I] Anonymous-1926, Ayres-1923, Boyd-1964, CAA-1991, Cochrane-1959, Dumas-1923, Gilchrist-1928, Goldich-1973, Hoeffler-1981, Kohn-1932, Larcher-1934, Love-1925, Love-1932, Miller-1978, Mitchell-1931, Robinson-1965, Voevodsky-1969, Voevodsky-1972, Weiss-1966b.

[For War, World War II] Anonymous-1953b, Arebalo-1990, Beebe-1952, Beebe-1957, Benn-1952, Best-1966, Beyer-1962, Blood-1990, Blood-1992, Boyd-1964, Burt-1965, CAA-1975, CAA-1990, CAA-1991, CALL-1988, Carey-1987, Clark-1954, Cockrell-1974, Compton-1983, Coox-1951, Copp-1990, Dougherty-1990, Dupuy-1982, Engel-1954, Engel-1963, Giddings-1955, Goad-1973, Goad-1974, Goldich-1973, Gould-1952, HERO-1967a, HERO-1967b, HERO-1975, HERO-1979, Hoeffler-1981, Johnson-1981a, Keilig-1956, Kuhn-1989, MacLean-1990, Mellor-1972, Miller-1978, Naisawald-1953a, Naisawald-1953b, Pearsall-1972, Reister-1975, Robinson-1965, Schaefer-1977, Shephard-1991, Shrader-1982, Stouffer-1949, Summers-1970, Vagts-1945, Vineberg-1965, Voevodsky-1969, Voevodsky-1972, Wainstein-1973a, Wainstein-1973b, Wainstein-1986, Weiss-1966b, Wiltse-1965.

See also Dictionaries of Battles and/or Wars, and Statistical Tabulations.

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APPENDIX D

ANNOTATED BIBLIOGRAPHY

D-1. INTRODUCTION. This appendix contains the annotated bibliographies, arranged in order by their short title as explained in Appendix A. Those short titles provide the key to the documents, and are used consistently throughout the rest of this paper.

D-2. EXPLANATORY REMARKS.

a. See the Glossary for definitions of terms and abbreviations.

b. Occasionally, some related documents are specifically cited in the annotated bibliography. The chief purpose of such citations is to note important considerations significantly affecting the validity or scope of applicability of the primary document's findings. A secondary pupose is to call the reader's attention to other intimately related documents. However, in general we do not cite other documents on the same subject, or those that merely confirm or refine the primary document's findings, since they can easily be found by using either the key word index in Appendix B or the index to selected subjects in Appendix C.

c. Text included in square brackets, [like this] are clarifications or comments interpolated by the compiler of this bibliography, and are not part of the original text.

d. In general, more information is given on documents that are little known, rare, or difficult to access. Nevertheless, we can only indicate a document's general nature—the annotated bibliographies are guides to the originals, not substitutes for them.

e. We have included a few documents that, technically, are outside PAR's scope. To give a few examples, we have in mind documents such as Anderson-1961 (deals with a field experiment), Bryan-1976 (does not contain tabulated data on casualties or attrition), or Coben-1986 (does not deal with land combat forces). These and similar works came to our attention by chance while compiling the bibliography and it seemed silly to omit them. However, we hereby put the reader on notice that we made no attempt to seek out such distantly related documents and that there must be many other such works that did not happen to come to our attention.

ANDERSON-1961

1. Document Description. Anderson, Marilyn, *et al.*, "Data Histories of Casualties Occurring in the Fall 1959 USA-CDEC Field Experiment," Stanford Research Institute, Menlo Park, CA. Prepared for the US Army Combat Development Group, US Medical Service, Brooke Army Medical Center, Fort Sam Houston, Texas under Contract No. DA-49-193-MD-2169, October 1961, 64 pp. UNCLASSIFIED. Available from DTIC as AD-294 729.

2. Objectives and Scope. To document the data histories of the casualties that occurred during the fall 1959 field experiment. This is part of SRI Project No. ESU-3694 (Contract No. DA-49-193-MD-2169), which is to summarize and analyze data collected in two medical field experiments performed at the US Army Combat Developments Experimentation Center.

3. Populations Included. Casualties that occurred in the field experiment.

4. Timeframes Included. 1959.

5. Casualty Types Included. Killed, emergency litter (litter casualty with an average life expectancy of 6 hours without medical treatment), delayed litter (litter casualty with an average life expectancy of 12 hours without medical treatment), delayed ambulatory (ambulatory casualty with an average life expectancy of 12 hours without medical treatment).

6. Time Intervals Included As. Not relevant.

7. Situational Descriptors Defined As. Several situational descriptors are included. However, these focus on the medical environment in which the casualty is treated.

8. Data Sources Used. Field experimentation records.

9. Other and Miscellaneous. Table I provides data on the occurrence of all casualties that were recorded in the field experiment. Table II repeats the occurrence data for those casualties that were processed by the medical system and gives additional data that were recorded during the subsequent processing.

10. Summary of Findings Regarding Battle Casualties. No summary statement of findings is included in the document, which contains only data.

11. Comments and Critique. Contains only field experimentation data.

ANDERSON-1988

1. Document Description. Anderson, Richard C., "New Engagement Data for the Breakpoints Data Base," Historical Evaluation and Research Organization (HERO). Prepared for the US Army Concepts Analysis Agency as part of the Study of Forced Changes of Combat Posture under Contract No. MDA903-87-C-0807, 30 September 1988, 80 pp. UNCLASSIFIED, available from DTIC as AD-A201 404.

2. Objectives and Scope. To augment the DMSI/CAA data base of battles and engagements with 24 additional items, thus documenting a part of the historical research done under the contract cited above.

3. Populations Included. Each side in the selected battle or engagement.

4. Timeframes Included. 1943 to 1944.

5. Casualty Types Included. Total Losses.

6. Time Intervals Included As. Duration of the battle or engagement.

7. Situational Descriptors Defined As. Several situational descriptors are included. These are in the form of those used in CAA-1991, *q.v.*

8. Data Sources Used. Primarily US National Archives.

9. Other and Miscellaneous. Data are given on the total strengths, total losses, and situational descriptors of the following battles or engagements: 1943–Sidi Bou Zid I, Sidi Bou Zid II, Kasserine Pass; 1944–Rapido North I, Rapido North II, Rapido South I, Rapido South II, Bowling Alley I, Bowling Alley II, Bowling Alley III, Mortain I, Mortain II, Schmidt I, Schmidt II, Schmidt III, Wahlerscheid, Krinkelt-Rocherath I, Krinkelt-Rocherath II, Schnee Eifel Center, Schnee Eifel South, Schnee Eifel North I, Schnee Eifel North II, Our River Center, Our River North.

10. Summary of Findings Regarding Battle Casualties. No summary statement of findings is included in the document, which contains only data. The data were used in Fain-1988.

11. Comments and Critique

a. A brief narrative of the action is included for each battle or engagement.

b. It is not easy to tell what total force and total losses actually represent or include.

c. This provides a useful update and revision of CAA-1991.

ANONYMOUS-1926

1. Document Description. Anonymous, "Report of the Secretary of War to the President, 1926 [for the Fiscal Year ended June 30, 1926]," Prepared by the Office, US Secretary of War, 1926, 272 pp [of which only pages 191 to 240 are related to battle casualties]. UNCLASSIFIED. Available from the Pentagon Library (UA24.A1 1925/27).

2. Objectives and Scope. To document the results of a check on reports of wounds received by the US Expeditionary Forces during World War I.

3. Populations Included. US Expeditionary Forces, distinguishing officers and enlisted.

4. Timeframes Included. The whole of World War I.

5. Casualty Types Included. KIA, WIA, and DOW.

6. Time Intervals Included As. Not used.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. As described below under Other and Miscellaneous.

9. Other and Miscellaneous. From the description given in the document "During the fiscal year the task of rechecking all authorization and credits for wounds incurred by members of the American Expeditionary Forces was completed. The recheck included an inquiry into the degree of the wound, whether the wound was the result of an act of the enemy or an accident, the organization of which the individual was a member at the time, the military operation in which the individual was participating at the time, the rank or grade held, the State from which the individual entered the service, and the branch of service and component force in which commissioned or enlisted. A similar recheck was made in the cases of all individuals who were killed in action or died of wounds. Since this information will also be of value to students of military operations and to historians a compilation in the form of tables, which appear on pages 193 to 240, inclusive, show, respectively, the following.

"Table G. American Expeditionary Forces in Europe, showing, by divisions, regiments, and nondivisional units, total number of battle casualties, including killed in action, died of wounds, and wounds.

"Table H. American Expeditionary Forces in Europe, showing, by arm of service and grade, total number of battle casualties among commissioned officers, including killed in action, died of wounds, and wounds.

"Table I. American Expeditionary Forces in Europe, showing, by component forces, total number of battle casualties, including killed in action, died of wounds, and wounds, commissioned officers being classified by grades.

"Table J. American Expeditionary Forces in Europe, showing, by States, total number of battle casualties among, including killed in action, died of wounds, and wounds, also the number of individuals wounded.

"Table K. American Expeditionary Forces in Europe, showing, by major operations and defensive sectors, number of battle casualties, including killed in action, died of wounds, and wounds, commissioned officers being classified by grades.

"Table L. American Expeditionary Forces in Europe, showing, by major operations and defensive sectors, battle casualties of divisions and nondivisional units.

"Table M. American Expeditionary Forces in Europe, showing total number of wounds, number of first wounds (which represents the number of individuals wounded), number of second wounds, and number of third wounds, all by type and degree of wound, commissioned officers being classified by grades. Number of fourth wounds shown in footnote.

"Table N. American forces in Siberia, showing, by organizations (officers and enlisted men separately), total number of battle casualties, including killed in action, died of wounds, and wounds.

"Table O. Troops at sea, showing, by vessels (officers and enlisted men separately), number of battle casualties, including killed in action, died of wounds, and wounds.

"Table P. Aggregate figures, showing aggregate figures on battle casualties of the American Expeditionary Forces in Europe, the American forces in Siberia, and troops at sea.

"Battle casualties suffered during the World War by the personnel of the United States Army only, including commissioned officers, Army nurses, field clerks, and enlisted men, who served at some time during the period beginning April 6, 1917, and ending November 11, 1918, with the American Expeditionary Forces in Europe and Siberia, were considered in compiling these statistics, except that, in the cases of members of the American forces in northern Russia, the period of service is extended to August 25, 1919, and to April 1, 1920, in the cases of members of the American forces in Siberia. Battle casualties among personnel of the United States Navy and the United States Marine Corps are not included, not even in the cases of members of those services who were wounded or killed while serving with the Army. Figures on killed in action are, of course, limited to the period of active hostilities. This also applies to wounds. In cases of deaths from wounds received in action, the figures include all deaths occurring prior to January 1, 1921, attributable to wounds received in action, provided the deceased was still in the military service at time of death. The figures on casualties in Europe include those which occurred in northern Russia among Army personnel during the operations there.

"The following definitions were applied.

- Killed in action. Killed in combat with the enemy on the field of battle or died before reaching an aid station or hospital of wounds inflicted by the enemy.

- Died of wounds received in action. Died as a result of wounds received in action against the enemy, of treatment therefore, or of complications resulting therefrom, after having reached an aid station or hospital.

- Wounded in action. Wounded by primary or secondary missile, or by gas, set in motion by a hostile act of the enemy, the wound having required treatment by a medical officer.

"Accidental wounds, received while in action or otherwise, and shell shock (including psychoneurosis and concussion) are not included in the tables as wounds. In the cases of many individuals who suffered shell shock, the symptoms did not appear until some time afterwards and consequently medical treatment was not administered at the time the shock was incurred. The number of shell-shock cases, as shown by the records, is 5,016.

"Self-inflicted injuries are not regarded as wounds and are not included in the tables."

10. Summary of Findings Regarding Battle Casualties. No summary findings stated.

11. Comments and Critique. Provides numbers of casualties only. In order to derive rates, they must be combined with strengths obtained from other sources.

ANONYMOUS-1945

1. Document Description. Anonymous, "Artillery Ammunition Expenditures As Related to Infantry Casualties," US Army, XII Corps Artillery, 28 July 1945, 41 pp. UNCLASSIFIED. Available from US Military History Institute, Carlisle Barracks, PA (D797.U7 A77 1945). Document is in the form of an official memorandum prepared under the direction of Commanding General XII Corps Artillery, and signed for him by MAJ Mack A. Braly, Field Artillery, Adjutant, addressed to Artillery Officer, Third US Army. There are attachments to the memo.

2. Objectives and Scope. To respond to a request from the Artillery Officer, Third US Army, for data on the relationship between artillery ammunition expenditures and infantry casualties.

3. Populations Included. US XII Corps.

4. Timeframes Included. 1 September 1944 to 8 May 1945.

5. Casualty Types Included. US casualties (sum of killed, wounded, and missing) and German prisoners of war.

6. Time Intervals Included As. Variable.

7. Situational Descriptors Defined As. Brief statement of the action, *e.g.*, "4th Armored Division, 5th, 76th, & 80th Infantry Divisions. *Consolidation of positions*—preparation for attack across Sauer and Our River."

8. Data Sources Used. Not stated, but presumably XII Corps operational records.

9. Other and Miscellaneous. The Attachments to the basic memo include: Report on operations by periods; Cumulative report; 5th Infantry Division Comments; 26th Infantry Division Comments; 35th Infantry Division Comments; 80th Infantry Division Comments; 4th Armored Division Comments; 6th Armored Division Comments; and 11th Armored Division Comments.

10. Summary of Findings Regarding Battle Casualties. Selected and paraphrased from the memorandum of transmittal:

a. A compilation of US casualties (killed, wounded, and missing), US artillery rounds expended, and German prisoners of war captured by us is attached as Inclosure #1. A study of Inclosure #1, which is arranged by time periods covering certain operations, shows little if any consistency in various types of operation.

b. When arranged in an overall cumulative way, however, some consistency becomes apparent. During the approach to the Moselle and through the Lorraine, both US casualties and the number of German prisoners taken tended to increase with increasing artillery expenditure. However, this is attributed to the general tempo or intensity of combat.

c. There is no way to list German casualties.

d. Artillery expenditures during the Luxembourg campaign were much higher than in the earlier operations cited above. In the Luxembourg campaign, average friendly casualties decreased substantially (from 253 to 175 per day) while average German prisoners captured increased. This may indicate lower morale on the part of the Germans.

e. Near the end there was a breakthrough and collapse of the German Army. This period is characterized by less ammunition, fewer casualties, and large numbers of prisoners taken.

11. Comments and Critique. Not much information of direct use to the PAR studies.

ANONYMOUS-1953a

1. Document Description. Anonymous (but by a member of the Wound Ballistics Research Team on temporary duty assignment to Japan and Korea), "The Relationship of Casualties to Tactics and Ammunition Expenditure, 2d US Infantry Division, Korea, 1 Feb 1953-31 Mar 1953," Wound Ballistics and Research Team, Unnumbered, undated but presumably circa 1953, 132 pp. UNCLASSIFIED. Available from the US Army Military History Institute, Carlisle Barracks, PA (UL 504.3 R46 1953).

2. Objectives and Scope. From the Preface: "During the course of the Wound Ballistics and Body Armor studies in Korea, it was necessary for the research teams to be as close to the main line of resistance as possible in order to (a) determine the over-all value of body armor and (b) to accurately record wound ballistics data close to the field of combat. The base of operations for this team was the Surgeon's office of the 2d United States Infantry Division. This afforded an excellent source of information as to the daily operations of the entire division and the proximity of the fighting enabled the research team to reach any point of the division area in a relatively short time.

"With the tactics confined to aggressive patrolling and defending this line of the United States Army front it was possible for the team to visit frequently every unit engaged in the defense of this line. This freedom of movement within the Division sector permitted almost daily contact with platoon, company, battalion, and regimental commanders. Also members of the team were permitted to attend the daily briefings conducted at division headquarters for the Commanding General and his staff.

"In addition to the wound ballistics and body armor projects, a study of the relationship of casualties to tactics and ammunition expenditure was carried out for the period 1 February to 31 March 1953. This study was a day by day account of the activities of each unit participating in the actual combat. Information on casualties sustained, including killed, wounded, and missing in action was recorded as well as the total number of rounds of ammunition expended within the various calibers for each day. Data on enemy casualties, both counted and estimated were secured directly from the participating units as well as the number of incoming rounds of enemy artillery and mortar ammunition. The battle action reports from each unit were utilized in securing information on disposition of enemy forces and their over-all capabilities."

3. Populations Included. US 2d Infantry Division, Korea, 1 Feb to 31 Mar 1953.

4. Timeframes Included. 1953.

5. Casualty Types Included. Killed, wounded and missing.

6. Time Intervals Included As. Daily.

7. Situational Descriptors Defined As. Weather, enemy operations, enemy capabilities, incoming artillery and mortar fire, air activity, friendly ammunition expenditure, enemy casualties, friendly casualties.

8. Data Sources Used. Official records and personal observation.

9. Other and Miscellaneous.

a. Table of Contents includes the following items. Preface, Introduction, Friendly Ammunition Expenditures, Comparison of Casualties, Gas Casualty Data (World War I), Tactical Operations, Enemy Forces, Hostile Artillery, Day by Day Battle Actions, Cost of Ammunition per Casualty, Enemy Materiel and Positions Destroyed or Damaged.

b. The document refers (in its Introduction) to "A previous and more detailed report concerning the relationship of casualties to tactics and ammunition expenditure" that was published in October 1952, but which covered only a five day period.

10. Summary of Findings Regarding Battle Casualties.

a. Estimates that, in defensive situations of the sort experienced by the 2d Infantry Division during the course of this study, about 675 pounds of artillery and mortar ammunition plus about 366 pounds of bombs are required to produce one enemy casualty. However, this is based on the official estimates of enemy casualties, which were thought by many to be unrealistically high. If a more modest estimate of enemy casualties is used, then it is estimated that 2000 rounds of artillery and mortar, 1,000 rounds of 30 and 50 caliber ammunition, and 1,000 pounds of airborne munitions are required to produce one enemy casualty.

b. Based on the incoming artillery and mortar fire, about 821 rounds were required to produce one friendly casualty. No estimate of enemy small arms fire or grenades could be ascertained.

c. The author quotes World War I figures taken from the book *Chemicals in Warfare*, by A. M. Prentice and published by McGraw-Hill, to estimate that in World War I either 190 pounds of chemical agent, 500 pounds of high explosive, or 5,000 rounds of small arms or machinegun fire were required to produce one enemy casualty.

11. Comments and Critique.

a. The document appears to be an unpublished typewritten manuscript. Nevertheless, it seems to provide information not readily available elsewhere.

ANONYMOUS-1953b

1. Document Description. Anonymous, "Army Battle Casualties and Nonbattle Deaths in World War II. Final Report, 7 December 1941—31 December 1946," Prepared by the Statistical and Accounting Branch, Office of the Adjutant General, under the direction of the Program Review and Analysis Division, Office of the Comptroller of the Army, Office Chief of Staff, Reports Control Symbol CSCAP (OT) 87, 1 June 1953, 118 pp. UNCLASSIFIED. Available from the files of the US Army Engineer Strategic Studies Center, Casey Building, Fort Belvoir, VA 22060.

2. Objectives and Scope. To present the final statistical record of battle casualties and nonbattle deaths incurred during World War II by United States Army military personnel.

3. Populations Included. US Army military personnel, including members of the Army Air Forces.

4. Timeframes Included. 7 December 1941 through 31 December 1946. The latter date was selected because it was the day hostilities were declared terminated by Presidential Proclamation No. 2714. The Japanese accepted Allied peace terms on 14 August 1945, and signed the surrender agreement on 2 September 1945.

5. Casualty Types Included. Battle casualties are shown in various ways such as by type and disposition, theater, month of occurrence, duty branch, grade in which serving, component, place of occurrence, organization, campaign, and area of residence. Death statistics include classifications by type of death, theater, month of death, duty branch, grade in which serving, type of personnel and area of residence.

6. Time Intervals Included As. Various.

7. Situational Descriptors Defined As. Various.

8. Data Sources Used. The statistics presented in this document include all changes processed in the card files records of the Adjutant General's Office through 31 December 1949. Processing after 31 December 1946 consisted primarily of revisions from declared dead to other reportable death categories.

9. Other and Miscellaneous. This document notes that, starting with Circular no. 21, dated 24 January 1942, many War Department circulars were issued which explained and progressively clarified, expanded, and restated the approved battle casualty categories and their reporting procedures. However, the major categories (killed in action, died of wounds and injuries received in action, *etc.*) were not stated definitively in World War II reporting instructions. The document states that "This undoubtedly resulted in differences in interpretations among the various overseas theaters," even though those interpretations were generally consistent.

10. Summary of Findings Regarding Battle Casualties. A summary of battle casualties reveals the following:

Type of battle casualty	Air Corps	Infantry	Field Artillery	Engineers	All other	Total (excluding Air Corps)
KIA	45,520	118,376	6,979	5,920	16,003	147,278
WIA	18,364	471,376	29,068	20,006	53,356	573,806
DOW	1,140	19,799	1,701	1,149	2,973	25,622

These values can be summarized roughly as follows. There are about 4 WIA for every KIA, and there are about 20 WIA for every DOW.

11. Comments and Critique. This document apparently served as the basis for US Army Field Manuals for several years following World War II. However, it actually provides only the *number* of casualties, not their *rates*.

AREBALO-1990

1. Document Description. Arebalo, Cathy J., "Variation of Historical Casualty Rates With Battle Dates," US Army Soldier Support Center, Fort Benjamin Harrison, Indiana 46216-5700, December 1990, 30 pp. UNCLASSIFIED. Available from DTIC as AD-A235 876.

2. Objectives and Scope. To determine if technological advances have a significant effect on casualty rates by examining historical casualty rates over time for the period 1937 to 1983.

3. Populations Included. Those recorded in the data base of battles and engagements used in this study, which was the same as used in McQuie-1988, *q.v.*

4. Timeframes Included. March 1938 to June 1982.

5. Casualty Types Included. Total casualties to the attacker and to the defender.

6. Time Intervals Included As. Whole number of days a battle lasted.

7. Situational Descriptors Defined As. General locale (*e.g.*, Italy) and the nation whose forces were on the attack or defense (*e.g.*, US versus Japan).

8. Data Sources Used. The so-called "benchmarks" data base used by McQuie-1988, *q.v.*

9. Other and Miscellaneous. Scope is limited to conventional land battles only, and to the relationship between casualty rates and the dates of historical land battles.

10. Summary of Findings Regarding Battle Casualties.

a. Although the evidence is not overwhelming, it is strong enough to support the belief that casualty rates have not risen despite technological advances. Hence historical casualty rates are relevant to future casualty estimation.

b. Inconclusive and conflicting results were obtained from attempts to compare casualty rates by decade and by war.

11. Comments and Critique.

a. A more extensive data base should have been used. The one selected contains a very high percentage of World War II battles.

b. Some of the data in the data base has been questioned as being inaccurate.

c. It is quite possible that casualty rates decrease for large units and longer periods of time. Thus, several of the World War II battles would be expected to have lower casualty rates than many of the later battles, since they involved larger forces and/or lasted for longer times. This effect was not taken into account in this statistical analysis.

d. The findings are not particularly new. Many others have commented on the apparent stability of casualty rates in conventional land combat battles.

AYRES-1923

1. Document Description. Ayres, Leonard P., "The War With Germany. A Statistical Summary: The Official Record of the United States' Part in The Great War," Statistics Branch of the General Staff, undated but apparently 1923, 310 pp plus four maps. UNCLASSIFIED. Available from Georgetown University (D570.A4 O48 1923).

2. Objectives and Scope. The purpose was to summarize selected statistical data on World War I.

3. Populations Included. American Expeditionary Force.

4. Timeframes Included. 6 April 1917 to 11 November 1918.

5. Casualty Types Included. KIA, WIA-Slightly, WIA-Seriously, DOW, MIA, POW, DNBI.

6. Time Intervals Included As. A few monthly time series for the total force are given.

7. Situational Descriptors Defined As. None.

8. Data Sources Used. Primarily from the US National Archives.

9. Other and Miscellaneous.

a. Diagram 54 shows US disease and battle deaths for the Mexican War, Civil War, Spanish War, and World War I.

b. Table of Contents includes the following: Four Million Men; Six Months Training; Transporting 10,000 Men a Day; Food, Clothing and Equipment; Springfields, Enfields, and Brownings; Two Thousand Guns on the Firing Line; Airplanes, Motors, and Balloons; Two Hundred Days of Battle; Health and Casualties; A Million Dollars an Hour; General Information in Regard to the Congressional Medal of Honor and Distinguished Service Cross, With Notes and Explanations; Awards of the Congressional Medal of Honor; Awards of the Distinguished Service Cross; Awards of the Distinguished Service Medal; and Bibliography of the Great War.

10. Summary of Findings Regarding Battle Casualties.

a. Of every 100 American soldiers and sailors, who served in the war with Germany, two were killed or died of disease during the period of hostilities.

b. The total battle deaths of all nations in this war were greater than all the deaths in all the wars in the previous 100 years.

c. Russian battle deaths were 34 times as heavy as those of the United States; those of Germany 32 times a great; the French 28 times; and the British 18 times as large.

d. The number of American lives lost was 125,500, of which about 10,000 were in the Navy, and the rest in the Army and the Marines attached to it.

e. In the American Army the casualty rate in the Infantry was higher than in any other service, and that for officers was higher than for men.

f. For every man killed in battle, six were wounded.

g. Five out of every six men sent to hospitals on account of wounds were cured and returned to duty.

h. In the expeditionary forces battle losses were twice as large as deaths from disease.

i. In this war the death rate from disease was lower, and the death rate from battle was higher, than in any other previous American war.

j. Inoculation, clean camps, and safe drinking water practically eliminated typhoid fever among our troops in this war.

k. Pneumonia killed more soldiers than were killed in battle. Meningitis was the next most serious disease.

l. Of each 100 cases of venereal disease recorded in the United States, 96 were contracted before entering the Army, and only 4 afterwards.

m. During the entire war available hospital facilities in the American Expeditionary Forces have been in excess of needs.

11. Comments and Critique. Practically all of the statistics are for very high echelon units, for example, the entire American Expeditionary Force. The work contains many graphical exhibits.

BARNETT-1992

1. Document Description. Barnett, Arnold; Stanley, Timothy; and Shore, Michael, "America's Vietnam Casualties: Victims of a Class War?", Journal of the Operations Research Society of America, Vol 40, No 5, September-October 1992, 856-866 pp. UNCLASSIFIED.

2. Objectives and Scope. To analyze claims that deaths in Vietnam fell inequitably on the poorer segments of the population.

3. Populations Included. Vietnam war dead.

4. Timeframes Included. Whole Vietnam War.

5. Casualty Types Included. Dead.

6. Time Intervals Included As. Not used.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. US National Archives and the Vietnam Veterans Memorial Directory.

9. Other and Miscellaneous. Several different approaches to the issue are taken. It is admitted that each has its limitations and shortcomings, but the hope is that they will be strongly indicative when taken all together.

10. Summary of Findings Regarding Battle Casualties. From the abstract: "Analysis of data about the 58,000 Americans killed in Vietnam implies that affluent communities had only marginally lower casualty rates than the nation as a whole. Poor communities had only marginally higher rates. Data about the residential addresses of war casualties suggest that, within both large heterogeneous cities and wealthy suburbs, there was little relationship between neighborhood incomes and per capita Vietnam death rates. Such outcomes call into question a widespread belief that continues to influence US policy discussions, namely, that American war deaths in Vietnam were overwhelmingly concentrated among the poor and working class.

11. Comments and Critique. Information is not applicable to battle casualty rates.

BEEBE-1952

1. Document Description. Beebe, Gilbert W.; and De Bakey, Michael E., "Battle Casualties: Incidence, Mortality, and Logistic Considerations," Charles C. Thomas (publisher), 1952, 277 pp. UNCLASSIFIED. Available from libraries. Published simultaneously in the British Commonwealth of Nations by Blackwell Scientific Publications, Ltd., Oxford, England, and in Canada by The Ryerson Press, Toronto.

2. Objectives and Scope. From the 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, US 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. ... 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."

3. Populations Included. Primarily US Army, with occasional allusion to US Army Air Forces and to US Marine Corps.

4. Timeframes Included. World War II.

5. Casualty Types Included. KIA, WIA, DOW, MIA, DNBI.

6. Time Intervals Included As. Attention is paid to the calendar times at which casualties occurred.

7. Situational Descriptors Defined As. Usually by theater of operation, but in some cases by major campaign or tactical operation.

8. Data Sources Used. From the front matter: "This volume is based on data contained in official records of the Army Medical Service, US Army. Assistance in assembling these data and in producing the manuscript for the volume was provided to the authors by the Historical Division, Army Medical Library, and the Medical Statistics Division, Office of the Surgeon General. The opinions and views set

forth, however, are those of the authors and should not be construed as reflecting the official policies of the Department of the Army."

9. Other and Miscellaneous. The document includes over 100 tables and 37 figures. The table of contents includes the following:

a. Incidence of hits and wounds: Relative incidence of battle and nonbattle casualties; Correlation between battle and nonbattle admissions; Variation in proportion of wounded among all admissions; and Incidence of battle casualties.

b. Death from wounding: Historical trend; Variation among theaters; Multiple and single wounds; Body region; Echelon of treatment; Surgical lag-time; Specific organs and tissues involved; Causative agent; and Mechanism of death.

c. Effectiveness of weapons: General principles; Field data on lethality of weapons; and Bougainville study.

d. Location of hits and wounds: Surface area and position of the body; Differences among weapons; Environmental protection and body armor; Distribution of hits and wounds in World War I: Peripheral nerve injuries; Arterial injuries; Amputations; and Burns.

e. Logistic problems of personnel, hospitalization, and evacuation in forward areas: Need for surgical specialists in Army area; Hospitalization and evacuation of battle casualties; Surgical implications of the evacuation and distribution of battle casualties; Distribution of the wounded; and Summary.

f. Appendixes.

10. Summary of Findings Regarding Battle Casualties. The findings are too numerous to summarize here.

11. Comments and Critique. This is a major work of primary importance in the study of battle casualties and attrition rates, and a well-known classic. It is one of the most important references in its field.

BEEBE-1957

1. Document Description. Beebe, Gilbert W.; Leith, Carroll I., Jr.; and Reister, Frank A., "Influence of Type of Ground Action on the Wounded in Action, US Divisions in World War II," Military Medicine, Vol 121, no 6, December 1957, 361-370 pp. UNCLASSIFIED. A much more thorough and detailed analysis is provided for the Korean War data in Reister-1969, *q.v.*

2. Objectives and Scope. To augment the description in Beebe-1952 (*q.v.*) of the relationship of wounded and injured in action to the type of military operation being conducted.

3. Populations Included. US Army and Marine Corps Divisions.

4. Timeframes Included. World War II.

5. Casualty Types Included. Various.

6. Time Intervals Included As. Those for selected operations such as: Tarawa, Saipan, Iwo Jima, Normandy, Salerno, Leyte, Okinawa, Anzio, Cisterna, St. Lô, Po Valley, St. Malo, Lanuvio, Cherbourg, Brest, Metz, Cassino, Aachen, Manila, Nuremburg, Machinato Line, Gustav Line, Shuri Line, Hurtgen Forest, Gothic Line, Yamashita Line, Siegfried Line, Rapido, Volturno (1st, 2d, and 3rd crossing), Roer, Rhine, Moselle, Mortain, Bougainville, and Ardennes (1st and 2nd phases).

7. Situational Descriptors Defined As. The type of military operation is classified as one of the following six types: (i) beachhead (*e.g.*, Normandy), (ii) offensive breakthrough (*e.g.*, St. Lô), (iii) reduction of ports or towns (*e.g.*, Cassino), (iv) assaults on fortified lines (*e.g.*, Siegfried Line), (v) river crossings (*e.g.*, Rhine), and (vi) defense (against strong enemy counter attack—*e.g.*, Ardennes).

8. Data Sources Used. Material assembled during the preparation of Beebe-1952.

9. Other and Miscellaneous. Contains tables showing, for each of the operations selected, its calendar period, number of divisions, number of division-days, mean division strength, number of WIA, and rate of WIA (per 1,000 per day).

10. Summary of Findings Regarding Battle Casualties. No attempt was made to evolve a classification of all ground casualties, or to go beyond US experience in Word War II. Despite the great variation found among the wounded rates for individual operations, some slight measure of uniformity is introduced by the six classifications employed here. Summary tables and figures give the average and distribution of WIA rates for each of the six major classes of tactical operations examined.

11. Comments and Critique. Gives a good discussion of many of the key difficulties and pitfalls of using historical information.

BELENKY-1983

1. Document Description. Belenky, Gregory Lucas; Tyner, C. Frederick; and Sodetz, Frank J., "Israeli Battle Shock Casualties: 1973 and 1982," Walter Reed Army Institute of Research, Division of Neuropsychiatry, Washington, DC 20307, Report WRAIR NP-83-4, August 1983, 38 pp. UNCLASSIFIED. The document carries the following disclaimer: "The contents of this report are the author's personal opinions and not those of the US Army or the Walter Reed Army Institute of Research. Approved for public release, distribution unlimited." Available from DTIC (AD-A133 359).

2. Objectives and Scope. To document the information gained from contact with the Israelis.

3. Populations Included. Israeli Defence Forces.

4. Timeframes Included. The 1973 Arab-Israeli War and the 1982 war in Lebanon.

5. Casualty Types Included. Battle shock, as related to wounded in action.

6. Time Intervals Included As. Not used.

7. Situational Descriptors Defined As. Various.

8. Data Sources Used. This report is based on four visits to Israel: June 1978, June 1982, January 1983, and April 1983. The material is taken from presentations by the Israelis during the Second and Third International Conferences on Psychological Stress and Adjustment in Time of War and Peace (1978, 1983), and from discussions with psychologists and psychiatrists of the Israeli Defense Forces.

9. Other and Miscellaneous. Contains tables showing the number WIA and KIA for Israeli Forces in Lebanon during June-December 1982, incidence of psychiatric casualties to Israeli Forces in Lebanon (and their ratio to WIA), and the relation of the incidence of psychiatric casualties to various "predictors" such as the incidence of physical casualties (KIA and WIA) and morale.

10. Summary of Findings Regarding Battle Casualties. Psychiatric casualties were a significant source of manpower loss for the Israeli Defence Forces in the 1973 Arab-Israeli War and in the 1982 war in Lebanon (adding about 20 percent to the WIA numbers). They exhibited symptoms similar to those of battle shock casualties observed in allied armies in World War I, World War II, and the Korean War. Experience indicates that a psychiatric casualty treated within the division is much more likely to return to duty than one evacuated beyond the division.

11. Comments and Critique. Adds important information to that given by Stouffer-1949 (*q.v.*).

BELLAMY-1983

1. Document Description. Bellamy, Ronald F., "The Causes of Death in Conventional Land Warfare: Implications for Combat Casualty Care Research," Letterman Army Institute of Research, Presidio of San Francisco, CA 94129, Institute Report No. 142, March 1983, 20 pp. UNCLASSIFIED. The document carries the following disclaimer: "This material has been reviewed by Letterman Army Institute of Research and there is no objection to its presentation and/or publication. The opinions or assertions contained herein are the private views of the author(s) and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense." Available from Letterman Army Institute. Also published in Military Medicine, February 1984, vol 149, no 2, pp 55-62.

2. Objectives and Scope. To analyze the existing data in a different manner than heretofore used, in order to estimate mortality as a function of time after wounding. These estimates are then used to weigh alternative casualty handling policies and procedures.

3. Populations Included. US soldiers.

4. Timeframes Included. World War II, the Korean War, Vietnam War.

5. Casualty Types Included. KIA, WIA, DOW.

6. Time Intervals Included As. Not used.

7. Situational Descriptors Defined As. Limited to bullet and penetrating fragment effects.

8. Data Sources Used. Primarily Reister-1973, Reister-1975, and Beebe-1952, plus miscellaneous other sources.

9. Other and Miscellaneous. Gives, among others, tables showing the estimated probability of being killed in action by a given wound (characterized by location of the wound, *i.e.*, head, face, neck, thorax, abdomen, upper extremity, lower extremity, multiple locations) and the estimated mortality of such wounds within specified time periods (*i.e.*, 1 hour, 6 hours, 24 hours, and 7 days).

10. Summary of Findings Regarding Battle Casualties. The majority of combat deaths occur on the battlefield before evacuation to a medical treatment facility occurs. To bring about a significant improvement in the salvage of casualties, there must be a renewed emphasis on field medical care. First and foremost, there is a need to improve the field management of hemorrhage. Second, because craniocerebral trauma is the most important cause of mortality in the definitive care setting, there is a need to determine whether or not the salvage amongst these casualties can (or perhaps should) be improved. Third, not only is there a need to improve the management of sepsis in the combat support hospital setting, but there is a need to know whether or not the appalling toll taken by sepsis whenever definitive care is delayed can be ameliorated by steps that are within the capability of those rendering

treatment on the battlefield. Finally, there is a need to keep an open mind toward unorthodox and even outlandishly futuristic proposals for combat casualty care.

11. Comments and Critique. Provides an important critical analysis of the value of alternative battlefield casualty care systems, and emphasizes the key role played by combat medics and battalion surgeons. Compare this with Bellamy-1986 and Bellamy-1987.

BELLAMY-1986

1. Document Description. Bellamy, Ronald F.; Maningas, Peter A.; and Vayer, Joshua S., "Epidemiology of Trauma: Military Experience," Annals of Emergency Medicine, vol 15, no 12, December 1986, pp 1384-1388. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. As stated in the article, "The purpose of this article is to show that the epidemiologies of military and civilian trauma differ in important respects."

3. Populations Included. US soldiers and civilian trauma victims.

4. Timeframes Included. Not used (but banks heavily on the US experience in Vietnam).

5. Casualty Types Included. KIA, WIA, DOW, non-battle casualties.

6. Time Intervals Included As. Not used.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Primarily the records of the Wound Data and Munitions Effectiveness Team (WDMET)—*see* JTCG-1970—and records of civilian trauma cases in San Francisco during 1977.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. From the abstract: "Battle injuries sustained in conventional war are are more likely to be lethal than are injuries sustained by civilians. Depending on the tactical situation, mortality may range from 20 percent to more than 80 percent of all casualties. The American experience indicates that about 90 percent of the total mortality occurs on the battlefield. Such casualties, those classified as killed in action, die before reaching medical care. More than 90 percent of all battle injuries (morbidity) are caused by penetrating missiles. Exsanguination from wounds of the heart/great vessels and penetrating/perforating wounds of the skull cause the majority of battle field deaths. The frequency distribution of injury severity appears to be bimodal. A large peak occurs at low injury severity and indicates a population of casualties with relatively benign soft tissue wounds. A smaller peak at high injury severity represents those killed in action." The greater lethality of combat trauma is later explained as due mainly to (i) the conventional battle field being more lethal than an urban street and (ii) the military system for prehospital care is less effective.

11. Comments and Critique. This provides a well-taken caution against extrapolating civilian trauma experience to the military setting. It also provides an analysis of the "bimodal" character of combat injuries.

BELLAMY-1987

1. Document Description. Bellamy, Ronald F., "Death on the Battlefield and the Role of First Aid," Military Medicine, Vol 152, no 12, 1987, 634-635 pp. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To examine what can realistically be achieved by battlefield first aid.

3. Populations Included. US soldiers.

4. Timeframes Included. Not used.

5. Casualty Types Included. KIA, WIA, DOW.

6. Time Intervals Included As. Not used.

7. Situational Descriptors Defined As. Limited to bullet and penetrating fragment effects.

8. Data Sources Used. Primarily the records of the Wound Data and Munitions Effectiveness Team (WDMET)—*see* JTCG-1970.

9. Other and Miscellaneous. An example incident from the Vietnam War is used to illustrate the author's point. The author notes that it is a historical fact that the overwhelming majority of recent American combat deaths have occurred on the battlefield (*i.e.*, are KIA), and cites the following figures: World War II—88 percent, Korea—91 percent, Vietnam—88 percent.

10. Summary of Findings Regarding Battle Casualties. The previous assessment (*cf.* Bellamy-1983) indicated that 15 percent to 20 percent of those killed in action might be saved by first aid, but a 5 percent to 10 percent reduction is probably more realistic when all factors are considered (specifically including cases where the casualty is unreachable due to enemy action).

11. Comments and Critique. Emphasizes the key role played by combat medics.

BENN-1952

1. Document Description. Benn, E; and Shephard, R. W., "Tank Effectiveness: A Comparison of the Theoretical Measure With Observed Battle Performance and a Further Note on Rate of Fire," Army Operational Research Group [United Kingdom], Report Number 6/52, 1952, 17 pp. UNCLASSIFIED. Approved for public release; distribution unlimited. Available from DTIC as AD-A955 920.

2. Objectives and Scope. To validate a theoretical measure of the effectiveness of tanks in combat against historical data on British-German tank engagements in Europe during World War II.

3. Populations Included. British versus German tank engagements.

4. Timeframes Included. World War II.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. Unspecified.

7. Situational Descriptors Defined As. Tank versus tank engagements.

8. Data Sources Used. From the document's section on Data: "A considerable amount of information on tank v. tank actions of the last war has been derived from an analysis of Allied war diaries. Full details of this information are given in MORU [Military Operational Research Unit] Report No. 33: 'Tank Battle Analysis' and in an AORG [Army Operational Research Group] Memorandum: 'A Survey of the Tank Warfare in Europe' (to be published shortly). For about 100 of the actions recorded, the details are sufficient to indicate the types of tank involved, the initial allied and enemy strengths, and the casualties suffered by each side. Some 20 of these actions are 1-versus-1 battles, and the data for these must, by the very nature of the source of information, constitute a biased sample; this group of actions has not therefore been considered here. Details of the remaining 79 actions, which form the basis of the present analysis, are given in Table 1 below."

9. Other and Miscellaneous. Includes 17 tables and 0 figures. The major section headings include: Introduction; Data on British and German Tanks; Comparison of theoretical predictions with battle performance; Discussion; Summary.

10. Summary of Findings Regarding Battle Casualties. From the document's Abstract: "Although the data available have been too limited to allow a complete validation of the theory to be made, the comparisons that are presented are sufficient to show that the general trends and levels of performance predicted by the measure of effectiveness are well indicative of what can be expected in battle; there is as yet no reason to suspect that any major modifications in the concept will be needed. ... It is concluded that the measure of effectiveness may now be used to give a good general indication of the relative merits of opposing tanks in battle. Confidence in future predictions of values for Effectiveness may

perhaps now be considered to be limited primarily by the possible inaccuracies in the data for enemy equipments."

11. Comments and Critique. The document's Table 1 groups the 79 engagements into 6 categories according to the types of tank involved, *e.g.*, Pz Kw V v. Sherman [Panzer Kampfwagen V versus Sherman]. For each of the six categories used, this table gives the number of tanks committed on each side, and the number of tanks surviving on each side. It would have been helpful to have provided, in addition, a complete tabulation of the committed and surviving tanks on each side in each of the 79 engagements.

BERNDT-1897

1. Document Description. Berndt, Otto (Captain in the Austrian General Staff), "Die Zahl im Kriege: Statistiche Daten aus der Neueren Kriegsgeshichte in Graphischer Darstellung [Number in War: Statistical Data from Modern Military History in Graphical Form], G. Freytag & Berndt, Vienna, 1897, 169 pp. UNCLASSIFIED. Available from US Army Command and General Staff College Library (355.09 B524z).

2. Objectives and Scope. In the first part, to present in graphical form statistical data for the major European wars and land and sea battles of the 1800s. In the second part, to offer a some thoughts and conclusions based on those numerical data.

3. Populations Included. Participants in battles.

4. Timeframes Included. Napoleonic Wars, Franco-Prussian War, Austria-Hungarian War, Russo-Turkish War, and a selection of battles from the wars of Frederick the Great.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. Normally from the start to end of a battle.

7. Situational Descriptors Defined As. Not specified.

8. Data Sources Used. Unspecified.

9. Other and Miscellaneous. Table of Contents includes:

a. War and peace in the 19th Century (*i.e.*, years of war and of peace, with the times various nations became involved in war).

b. Strengths of the armies in the major campaigns of the 19th Century.

c. Strengths and losses in the most important battles and engagements, followed by the sieges and investments or fortresses. This includes the following land battles. 1741–Mollwitz; 1745–Hohenfriedberg; 1757–Prague, Koln, Rossbach, Breslau, Leuthen; 1758–Zorndorf, Hochkirk; 1759–Kunersdorf; 1760–Liegnitz, Torgau; 1800–Marengo, Hohenlinden; 1805–Caldiero, Austerlitz; 1806–Jena and Auerstadt; 1807–Eylau, Friedland; 1809–Eckmuhl, Talavera, Aspern, Wagram; 1812–Smolensk, Borodino, Salamanca; 1813–Vittoria, Lutzen, Bautzen, Dresden, Kulm, Katzbach, Gross-Beeren, Dennewitz, Leipzig; 1814–La Rothiere, Laon; 1815–Ligny, Waterloo; 1829–Kulewtscha; 1831–Grochow-Bialolenka, Ostrolenka; 1848–St. Lucia, Custozza; 1849–Mortara, Novara, Komorn, Temesvar; 1854–Alma, Inkerman; 1855–Tschernaya; 1859–Magenta, Solferino; 1864–Doppler Schanzen; 1866–Custozza, Langensalza, Wysokow, Trautenau, Skalitz, Jicin, Koniggratz; 1870–Worth, Spichern, Colombey-Borny, Mars-la-Tour, Gravellotte, Beaumont, Noisseville, Sedan, Beaune la Roland, Orleans; 1871–Belfort; 1877–Plevna; 1866–Koniggratz (cavalry); 1870–Ville sur Yron (cavalry). It also includes the following

sea battles. 1798–Abukir; 1805–Trafalgar; 1827–Navarin; 1866–Lissa. It also includes the following sieges and investments. 1800–Genoa; 1807–Colberg, Danzig; 1808/09–Saragossa; 1813–Danzig; 1828–Braila, Varna; 1829–Silistria; 1854/55–Sevastopol; 1870–Strassburg, Metz; 1870/71–Belfort, Paris.

d. Space and time.

10. Summary of Findings Regarding Battle Casualties.

a. Losses from illness and hardship far exceed those taken in battle.

b. Superiority in numbers, especially when it is considerable, has made itself felt in the majority of battles (or engagements). However, many battles have been won by the weaker side.

c. Regarding the duration of battles it is to be remarked that they were nearly always concluded in 1 battle day; only a few lasted longer, and none over 3 days.

d. The striking observation is that on the average the duration of a battle is increasing with the passage of time, although one might have expected the opposite, considering the extraordinary improvements in weaponry and their corresponding vastly increased destructive action.

e. It is evident that not only the total losses but also the bloody losses have diminished, and we remark that in the later major wars they amounted to only half of that shown for the battles of the Seven Year's War. Therefore battles have become less productive of losses, less lethal in the course of time.

f. Based on historical considerations the author anticipates claim that in the major battles of a future war the average bloody loss to both sides will certainly not exceed 15 percent and even the bitterest ones fought will only with difficulty exceed 20 percent on both sides.

g. The percentage losses are the same on both sides only in individual rare cases, and as a rule are higher on one side and lower on the other. It is then of interest to observe that the highest loss of an army in the major battles of recent times never exceeded a fourth of their strength. (Germans at Mars-la-Tour 22 percent, French at Worth 16 percent, at Sedan 19 percent, Austrians at Koniggratz 11 percent, Russians at Plevna III 17 percent.)

h. The individual units of an army suffer very differently, according to the role that falls to them in the battle. While many army corps and divisions have very few losses or even none at all, others who find themselves in critical engagements leave a great number of their men on the field of battle. However, since particularly lethal collisions do not engage the whole battle line, but only a greater or lesser part of it, extraordinarily high losses occur to only a part of it. They can be of various significance, according to how small the unit is for which one computes the loss percent. For example, an army corps cannot lose as high a percent of its manpower as may a regiment, battalion, or company, for the devastating action of enemy fire lies unequally over the units of the corps. Of course, losses in individual

small units can often reach a horrifyingly high level. In the heat of battle individual regiments, and even brigades, have lost up to half of their strength from the action of enemy weapons; individual companies were nearly annihilated.

i. In the last columns of these tables the average number of losses for the winner and loser are computed. When one compares these numbers with the corresponding total losses, one sees that in the battles of nearly every war, the earlier as well as the later ones, the loser has suffered double the winner's losses.

j. The bloody losses stand in a different relation. It seems justifiable to conclude that in today's wars the winner will on the average lose at least as many people as the loser to the effects of weapons.

k. Current battles are conducted on the principle that at its conclusion one of the opponents has endured so many losses that it is unable to put up further resistance—or until it believes it can no longer resist—at which point it gives up the fight and abandons the field. Accordingly we set forth the theoretical conclusion that the beaten side must be the one that suffers the relatively greater losses. If by losses one means total losses, then this rule finds its confirmation through the fact, ascertained earlier, that in the great majority of cases the loser has about double the winner's losses. However, the total losses are not really the cause of winning and losing, but the result thereof, since the losses in prisoners, missing, stragglers, *etc.* as a rule impinge in greater number on the defeated, but only after the outcome has already been decided. Therefore the total losses could not have decided the outcome. Accordingly the bloody losses must indeed be decisive. However, we then have to admit that in general these are so equal, that they alone would not tip the balance to the victor. How does one then explain the indisputably persistent influence of bloody losses on battle outcomes? The action of these losses becomes clear immediately when one lets not only the lifeless numbers speak but takes into account the morale effect, which losses exert on each side.

l. Proportionately, losses to officers are even higher than to men. ... on the average 4-6 officers are killed or wounded out of every 100. However, since on the average engaged units have only 2 officers for every 100 men, it follows that proportionately about 2 or 3 times as many officers fall as men; a ratio which apparently has stayed the same in the course of time.

m. In major battles the most losses always occur to the infantry; significantly fewer to the artillery and as a rule the least to the Cavalry. Only when it comes to massive cavalry attacks are cavalry losses very considerable, particularly when the cavalry is also subject to enemy infantry fire. Thus the French Cavalry lost 34 percent at Worth, the Germans 17 percent at Mars-la-Tour (Cuirassier Regiment No 7 37 percent), the Austrian 3d Reserve Cavalry Division at Koniggratz 22 percent (Cuirassier Regiment No. 8 46 percent).

n. The ratio of dead to wounded is evidently nearly constant, despite the improvements in weaponry in the course of time; as a rule one-fourth of those hit by enemy weapons are killed. Only for sides in fortifications does the percentage of defenders killed rise, since their hits are naturally more 'ethal (due to being shot in the head).

o. The old saw, that not every round strikes home, gains more and more significance. It takes a blizzard of shots to achieve a hit. According to Plonnies, during the campaign of 1859 an average of 140 shots were needed to get a hit; in the campaigns of 1864 and 1866 just for the Prussian side about 70 shots were needed. In the battle of Gravelotte-St. Privat the Saxon Corps got only one hit in 400 shots and at Mars-la-Tour needed 452 shots (according to Honig). Also Wolozkoi, an expert of the first rank, concludes on the basis of his studies that in future battles on the average about 400 shots will be needed to get a hit. Therefore, one need have no hope or fear that improvements in weapons—by the time they have become common goods—will produce a greater result or higher losses; the implacable facts of history speak against it.

11. Comments and Critique. Provides an excellent alternative source of information on the major European wars and battles of the 1800s.

BEST-1952a

1. Document Description. Best, Robert J., "Analysis of Personnel Casualties in the 25th Infantry Division 26-31 July 1950," Operations Research Office, ORO Technical Memorandum ORO-T-22(FEC), 14 April 1952, 37 pp. UNCLASSIFIED. Available from DTIC as ATI-171 207.

2. Objectives and Scope. From the Summary "The problem is to determine the extent to which data available through regular channels can serve to describe: (i) the extent of battle casualties; (ii) their causes; (iii) the circumstances in which they are sustained; and, (iv) their effect on the tactical outcome. ... As primarily a test of the quality and usefulness of available data, this study has in general been limited to the combat experience of the 24th and 27th regiments, 25th Infantry Division, for 26-31 July 1950 and 27-28 July 1950 respectively."

3. Populations Included. 24th and 27th Regiments, 25th US Infantry Division.

4. Timeframes Included. Korean War.

5. Casualty Types Included. KIA, DOW, slightly WIA, slightly injured in action, seriously WIA, seriously injured in action, MIA.

6. Time Intervals Included As. 26-31 July 1950.

7. Situational Descriptors Defined As. A table showing location of troops when rendered a casualty uses the following "location" descriptors: unknown, advancing on enemy, holding position under attack, withdrawing, behind front line (not under attack).

8. Data Sources Used. From the Summary: "The Strength Accounting Branch, AG Section, GHQ, FEC [Far East Command], keeps verified and corrected machine records for all individuals who become casualties. These records can supply the name and organizational affiliation of all men who become casualties, the date of the casualty, and the type of casualty.

"In the individual casualty files of the AG Casualty Branch, data of varying completeness and reliability are available as to the hour of the casualty, the cause (weapon) of the casualty, the situation of the individual when rendered a casualty, and the part of the body affected. No use is ordinarily made of these data.

"Detailed narratives of tactical actions are sometimes available. They vary in the form of presentation and are of varying completeness and reliability. The unit histories in which they are embodied are submitted many months after the period of action covered, if they are submitted at all."

9. Other and Miscellaneous. The table of contents includes the following: Summary; Withdrawal in the face of a numerically superior enemy; The extent of battle casualties; The causes of battle casualties; Location of troops when rendered a casualty; Effect of casualties on the tactical outcome; and Concluding remarks.

10. Summary of Findings Regarding Battle Casualties. From the Conclusions section of the Summary:

"a. Excellent data, on the incidence of battle casualties, can be readily obtained for any unit down to company size and for any period from the punched card records of the AG section.

"b. As to the cause of casualties, data varying in quality from good to poor can be obtained by special analysis of the casualty files.

"c. Study of data from ordinary sources can yield only suggestive results on the dependence of casualties on the tactical situation and on their influence on the outcome of an action. Special field research would be necessary on the one hand to establish the activity of all companies, and on the other to fill in the pattern constructed from facts that are mentioned in the casualty reports."

11. Comments and Critique. This is an interesting pilot study of what could be made of the records normally kept during the Korean War. However, since it deals with a rather small segment of that war its findings need to be treated with some reservations.

BEST-1952b

1. Document Description. Best, Robert J., "A Study of Battle Casualties Among Equivalent Opposing Forces (Korea, September 1950)," Operations Research Office (ORO), Technical Memorandum ORO-T-23(FEC), 14 April 1952 (originally issued 5 September 1951), 165 pp. UNCLASSIFIED. Available from DTIC as AD-002 885.

2. Objectives and Scope. To develop as much quantitative information as possible about the battle casualties produced among opposing forces during a major period of clearly defined consecutive combat.

3. Populations Included. US and North Korean forces in the sector of the US 1st Cavalry Division, with passing references to other US units.

4. Timeframes Included. From 1 to 23 September 1950.

5. Casualty Types Included. KIA or DOW, seriously WIA, slightly WIA, seriously injured in action, slightly injured in action, MIA.

6. Time Intervals Included As. Daily casualties and casualty rates. In some cases, hourly casualty rates and distributions of casualties by time of day of occurrence are given.

7. Situational Descriptors Defined As. Gives a detailed narrative of the action, including task organization and the matchups of friendly and enemy units.

8. Data Sources Used. From the document's Summary: "The sources that describe the friendly side include the following: ordinary strength and casualty statistics; results of a special coding of individual casualty files; and morning reports and historical narratives. Sources which describe the enemy include the following: US intelligence on the designation and status of enemy units in contact with the 1st Cav Div; enemy statistics on enemy strengths, casualties, weapons, and ammunition; statements of enemy prisoners of war and US estimates of enemy casualties. These data are checked against one another."

9. Other and Miscellaneous. The document contains 50 tables and 16 figures. The table of contents includes the following: Casualty distribution of battle casualties by type and severity; Casualty distribution by type of missile, weapon responsible, and by time of day; Enemy units, strengths, casualties, weapons, and ammunition; Comparison of friendly and enemy strengths, casualties, and casualty rates; Tactical history and detailed correlation of casualty data with tactical narratives.

10. Summary of Findings Regarding Battle Casualties. From the document's Conclusions:

a. By accepting double the US casualty rate, or four times the number of actual casualties with a 2:1 superiority in manpower, the North Koreans obtained approximate military equality to US Forces. This enemy manpower, much of which was low grade, offset the US superiority in firepower and air support.

b. The enemy offensive failed because the already depleted enemy units could not continue to accept a high casualty rate even though enemy weapons continued to inflict a rather high casualty rate upon US Forces.

c. Among US Infantry companies and battalions, the success of a tactical mission appears limited by the casualties involved.

d. Tactical operations in general are very sensitive to the casualty rate and to the magnitude of accumulated casualties.

e. Among US divisions, the casualty rate reflected the over-all intensity of combat, the development of the situation, and the possession of the initiative by one side or the other. The experience of any one unit was most regular and constant (and therefore independent of these factors) at the regimental level. The experience of particular units became highly divergent at the battalion and company levels but among all units statistical regularities were operative.

f. The outstanding enemy weapon was the mortar. Enemy artillery was rather ineffective even when there was an adequate supply of ammunition. In general, enemy small arms and machineguns produced less effect than one would expect in hill warfare.

11. Comments and Critique. This is an important study, because it serves to connect the casualty experience of each side to the strength and losses of the other, and because it gives a detailed account of the tactical situation in which the casualties occurred. Its conclusion that the North Korean offensive failed because of high casualty rates (in absolute terms) may be too hasty. An at least equally legitimate interpretation of the data is that the North Korean operation failed because its casualty rate was so unfavorable, relative to that it was able to inflict upon the US forces.

BEST-1966

1. Document Description. Best, Robert J., "Casualties and the Dynamics of Combat," Research Analysis Corporation (RAC), Technical Paper RAC-TP-185, March 1966, 144 pp. CONFIDENTIAL. Available from DTIC (AD-372 260).

2. Objectives and Scope. From the Summary: "To assess the influences of personnel wastage on the course of recent ground warfare."

3. Populations Included. Primarily forces in World War II.

4. Timeframes Included. World War II.

5. Casualty Types Included. Various.

6. Time Intervals Included As. Various.

7. Situational Descriptors Defined As. Various.

8. Data Sources Used. Various, but mostly official or semi-official records.

9. Other and Miscellaneous. Apart from the introductory material, the Table of Contents is arranged as follows:

a. Part I–Casualties and Tactical Activity. Rifle companies; Companies and their parent battalions; Rifle battalions; Battalions and their parent regiments and divisions; Divisions and larger groups.

b. Part II–Unit Operability and Employment. Introduction: Are casualties causal?; Personnel susceptibilities; Susceptibilities by rank and duty; Special unit susceptibilities; Resultant impairment and performance; Unit employment.

10. Summary of Findings Regarding Battle Casualties. These are too numerous and detailed to summarize. The following are examples taken from various portions of the document (emphasis in the original).

a. The greater the casualties sustained by attacking battalions—or the greater the opposition encountered—the smaller their rate of advance.

b. Slackening of offensive progress is not accompanied by comparable decreases in casualties or volumes of support fire.

c. A number of statistical correlations have been found between casualties and other quantities related to maneuver units. Generally it is not at all clear that these quantities are directly related, and if they are, which is the independent (*i.e.*, causative) variable. ... The apparent and seemingly causal decrease in rate of advance with increases in casualties has been shown to be largely a matter of

increased duration. The casualties *could* be responsible for this. ... Yet casualties *could* also increase as a result of prolonged exposure, and increased duration *could* be determined entirely by other factors.

d. As the rate of German advance generally diminished [in Operation Barbarossa] and the degree of combat involvement increased, the overall casualty rate remained fairly steady. The casualty rate for the engaged units must therefore have decreased. Did the casualties brake the advance or was the primary reason [something else]? Doubt about the causative influence of casualties also arises from their increase with friendly support ... Finally, there is the direct correlation between casualties and definable indexes of combat activity.

e. The very fact that units sometimes, if only rarely, suffer catastrophic casualties just proves the potentiality of fire. So far as weapons of conventional type are concerned, further increases in firepower would only further accentuate these changes. The patterns of combat would remain essentially the same.

f. Quantitative regularities in aggregated casualty rates are mainly expressions of the prevailing intensity of combat. Although in part determined by casualties, prevailing intensity is in greater part determined by other constraints and restraints on the functioning of tactical systems: uncertainty and risk; delays and deficiencies in communications, command, and adaptive maneuver; respites for redeployment, reorganization, or resupply; and logistic insufficiencies.

11. Comments and Critique. This is a classic in this field, and is a work that should be consulted by all who are interested in casualties in land combat operations. Best's observations and cautions are well taken. Best's waves in division casualty data are similar to those Voevodsky-1972 found in wars.

BEYER-1962

1. Document Description. Beyer, James C. (ed), "Wound Ballistics [Wound Ballistics in World War II, Supplemented by Experiences in the Korean War]," Medical Department, United States Army, Library of Congress catalog card number 62-60002, 1962, 883 pp. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To place on record in readily usable form the most important studies related to wound ballistics made during World War II and the Korean War. Because of its focus on wound ballistics, it concentrates on wounding caused by penetrating fragments.

3. Populations Included. Primarily US Army, with occasional allusion to US Army Air Forces and to US Marine Corps.

4. Timeframes Included. World War II and Korean War.

5. Casualty Types Included. KIA, WIA, DOW.

6. Time Intervals Included As. Various.

7. Situational Descriptors Defined As. Various.

8. Data Sources Used. For the most part, special studies of limited scope.

9. Other and Miscellaneous. The document includes over 308 tables and 364 figures. The table of contents includes the following:

a. Enemy ordnance material. Japanese ordnance; German ordnance; Causative agents of battle casualties in World War II; North Korean forces ordnance material.

b. Ballistic characteristics of wounding agents.

c. Mechanism of wounding.

d. Casualty survey—New Georgia and Burma campaigns.

e. Study on wound ballistics—Bougainville campaign.

f. Examination of 1,000 American casualties killed in Italy.

g. Study of Fifth US Army hospital battle casualty deaths.

h. Casualty survey, Cassino, Italy.

i. Survey of battle casualties, Eighth Air Force, June, July, and August 1944.

j. Directional density of flak fragments and burst patterns at high altitude.

k. Personnel protective armor.

l. Wound ballistics and body armor in Korea.

10. Summary of Findings Regarding Battle Casualties. The findings are too numerous and varied to summarize here.

11. Comments and Critique. This is a major work, of primary importance in the study of wound ballistics, and a well-known classic.

BLOOD-1990

1. Document Description. Blood, Christopher G., "Shipboard and Ground Troop Casualty Rates Among Navy and Marine Corps Personnel During World War II Operations," Naval Health Research Center, Medical Decisions Support Department, P.O. Box 85122, San Diego, CA 92186-5122, Report Number 90-16, August 1990, 53 pp. UNCLASSIFIED. Approved for public release; distribution unlimited. Available from DTIC as AD-230 803.

2. Objectives and Scope. From the document's Summary: "The present investigation seeks to determine the rates of casualties aboard ships participating in World War II operations as well as Marine assault forces involved in the capture of Western Pacific islands."

3. Populations Included.See Objectives and Scope, above.

4. Timeframes Included.See Objectives and Scope, above.

5. Casualty Types Included. WIA, DOW, KIA, MIA.

6. Time Intervals Included As. Duration of the operation.

7. Situational Descriptors Defined As. None, aside from identification of the operation involved.

8. Data Sources Used. From the document's section on Method: "Navy afloat casualty rates were computed using servicemen on the Bureau of Personnel casualty lists kept at the Operational Archives division of the Navy Historical Center in Washington, DC. ... Shore-based casualty rates for Marine and Naval forces were computed largely on the basis of data tabled in the *History of US Marine Corps Operations in World War II.* These tables provided overall WIA and KIA frequencies for specific operations while data detailing the daily tallies of casualties as well as the strengths of the Marine units over the course of the operation were found in narratives in a number of historical accounts."

9. Other and Miscellaneous. Includes 4 tables and 9 figures.

10. Summary of Findings Regarding Battle Casualties. From the document's Summary: "The rate of shipboard casualties in the Asiatic-pacific theater across all operations was 0.56, while the rate in the European theater was 0.84. Individual operation rates ranged from 0.01 to 50.50. Among Pacific afloat operations there were 115 men wounded for every 100 killed. Eight of the 117 ship types had KIA rates more than double their WIA rates; among these only submarines and oilers involved more than ten vessels. Ground assault force rates averaged 15 times higher than ship-based rates. The highest rates for both afloat and ashore operations were seen for brief engagements occurring early in the war."

From the document's Discussion: "Typically, after the first waves of troops were ashore and firmly entrenched the ensuing days saw casualty rates decrease dramatically. In the week that followed

the initial landings, rates dropped at least 70 percent for the operations at Eniwetok, Saipan, Tarawa, and Iwo Jima."

11. Comments and Critique. Provides useful material on US Marine Corps casualties in World War II.

BLOOD-1992

1. Document Description. Blood, Christopher G., "Analyses of Battle Casualties by Weapon Type Aboard US Navy Warships," Naval Health Research Center, Medical Decisions Support Department, P.O. Box 85122, San Diego, CA 92186-5122, Report Number 91-1, 1991. UNCLASSIFIED. Also published in Military Medicine, vol 157, no 3, pp 124-130, March 1992, available from libraries.

2. Objectives and Scope. From the document's Introduction: "The objective of the present investigation is to determine the types of battle injuries which occurred among forces afloat in the last major conflict with US Navy involvement. Injury types will be analyzed by weaponry involved as well as by the types of vessels that were attacked."

3. Populations Included. US Navy forces afloat.

4. Timeframes Included. World War II.

5. Casualty Types Included. WIA and KIA.

6. Time Intervals Included As. Unspecified, but described as follows: "There were 513 incidents in which major combatants were either sunk or damaged, and on which causal information was available."

7. Situational Descriptors Defined As. Attack type, *i.e.*, kamikaze, gunfire, bomb, torpedo, mine, or multiple weapons.

8. Data Sources Used. From the document's section on Method: "Determination of the warships that were sunk or damaged during World War II operations was made using two historical sources. The Summary of War Damage and the United States Naval Chronology, World War II were examined to obtain a list of major afloat combatants which were attacked and on which casualties may have been sustained. Because the most detailed information was limited to battleships, carriers, cruisers, and destroyers, the current investigation was restricted to these types of warships. ... The Medical Officer Reports and After Action Reports maintained at the Navy Operational Archives division of the Navy Historical Center in Washington, DC were examined and BUMED diagnoses were extracted for casualty incidents corresponding to those found in the War Damage Summary and Naval Chronology. When medical information on these incidents was not available from the Historical Center, the deck logs of these ships, housed at the National Archives in Washington, were analyzed and the relevant information extracted. ... Additionally, Bureau of Personnel casualty lists kept at the Operational Archives were examined to determine the numbers of casualties aboard ships when partial or no information was available from the medical sources. Crew complements of the sunk, damaged ships were collected from the muster rolls housed at the National Archives."

9. Other and Miscellaneous. Includes 5 tables and 2 figures.

10. Summary of Findings Regarding Battle Casualties. From the document's Abstract: "Ship type and weapon were significant factors in determining the numbers of wounded and killed. Multiple weapon attacks and kamikazes yielded more wounded in action than other weapon types. Multiple weapons and torpedoes resulted in a higher incidence of killed in action than other weapons. Penetrating wounds and burns were the most prominent injury types. Kamikaze attacks yielded significantly more burns than incidents involving bombs, gunfire, torpedoes, mines, and multiple weapons. Mine explosions were responsible for more strains, sprains, and dislocations than the other weapon types."

11. Comments and Critique. Provides useful material on casualties to US Naval forces afloat in World War II.

BODART-1908

1. Document Description. Bodart, Gaston, "Militar-Historisches Kriegs-Lexicon (1618-1905)," C. W. Stern, Vienna and Leipzig, 1908, 956 pp. UNCLASSIFIED. Available from libraries.

2. . Objectives and Scope. To provide a dictionary of the statistical characteristics of all the battles and engagements since 1618 in which European powers played a role, listed in chronological order of their occurrence, with a view to their political as well as their material results, except for those which occurred during colonial wars.

3. Populations Included. Devoted mainly to participants in battles in which European nations played a role. However, battles of the US Civil War are included. The author claims that about 2,000 battles are listed (including naval engagements as well as land battles). The basic criterion used by the author for including battles was a combined loss of 1,000 men for both sides. An exception was made in the case of naval battles, where some were selected that had only 1,000 men or fewer total losses, on the grounds that the author wished to provide ocean battles a place commensurate with their importance.

4. Timeframes Included. Extends from 1618 to 1905.

5. Casualty Types Included. Killed in action, wounded in action, missing in action, prisoners. Some attention is also given to the sick and accidentally injured, although these are not always recorded.

6. Time Intervals Included As. From start to end of a battle, durations often being indicated in numbers of whole days.

7. Situational Descriptors Defined As. Essentially none. Only the victor and the defeated side are identified. The attacker and defender sides are not.

8. Data Sources Used. Various, but including Austria's Imperial Military Archives.

9. Other and Miscellaneous. Includes numerous tables. The Table of Contents includes the following.

a. Remarks on Losses in War.

b. Explanatory Notes.

c. Index to the Abbreviations.

d. Chronological-Statistical Presentation of the Major Engagements, Battles, Sieges, and Capitulations of the Period 1618-1905.

e. Tabular Summary of Major Battles Arranged by War and Category.

f. Duration of War.

g. Number and Density [in time] of Battles and Engagements in Individual Wars.

h. Participation of Individual States in the Battles of the Last Three Centuries.

i. Assessment of Victory and Defeat of the Warring States.

j. Participation in the Major Sea Battles of the Last Three Centuries.

k. Wars and Peace Treaties (French, Austrian, British, Russian, Prussian, Italian, Turkish, Spanish, Swedish, Netherlands, United States of America, and Japanese).

l. Comparison of Army Strengths in Major Battles of the Last Three Centuries.

m. Strengths of the Armies Led by the 50 Most Important Generals of Modern Times.

n. Troop Strengths in Sea Battles.

o. Number of Warships in the Major Battles of the Last Three Centuries.

p. The Greatest Sieges Since 1618.

q. The Greatest Investments of Beleaguered Places Since 1618.

r. The Longest Investments Since 1618.

s. The Number of Cavalry in Modern Wars.

t. Percentage of Cavalry Relative to the Number of Combatants.

u. Absolute and Relative Strength of Cavalry Led by the Ten Greatest Generals of Modern Times.

v. Number of Cannon in Land Battles of the Last Three Centuries.

w. Number of Guns in Sea Battles of the Last Three Centuries.

x. Victory of the Smaller Number Over the Greater Number.

y. Assessment of the Victor's Tactical Merit.

z. Battles With the Most Losses Since 1618.

aa. The Bloodiest Battles Since 1618.

ab. The Ratio of Killed to Wounded.

ac. Losses of Cannon.

ad. Bloody Losses of Officers of Warring States in the Period 1618 to 1905.

ae. Losses of Generals and Admirals.

af. Name Lists of All French Generals Killed in Battle Since 1618, Killed and Executed French Royalist Commanders, French Generals Guillotined During the Reign of Terror, French Generals Executed After the Fall of Napoleon I, French Admirals Who Died for Their Country Since 1618, British Admirals Who Died for Their Country Since 1618, Holland Admirals Killed During the Sea Battles of the 17th Century, All Italian Generals Killed in Battle Since 1805, All Austrian Generals Killed in Battle Since 1618, All Prussian and Brandenburg Generals Killed in Battle Since 1657, All German and Polish Generals Killed While Fighting for the French During the Napoleonic Wars, All American Generals Killed on Either Side in the Great Civil War.

10. Summary of Findings Regarding Battle Casualties. Several important observations are made regarding battle casualties. Among them are the following.

a. The percentage of bloody losses to armies has varied widely over the last 400 years and up to the last great east-Asian war exhibited a noticeable tendency to decrease.

b. The exa t statistical data, which we base on the results of many wars, teach us that the losses in men caused by sickness often considerably outweigh those felled by enemy fire. (This was the case in the Russo-Turkish War 1828-1829, and in the Crimean War 1853-1856, but especially in the colonial wars of England and France.)

c. The losses from desertion were very numerous in the 17th and 18th centuries, especially during the Seven Year's War 1756-1763, but most particularly in the War of the Bavarian Succession 1778-1779 where they amounted to 80 percent of the total losses on the Prussian side and to 15 percent on the Austrian side.

d. To investigate how often superiority in numbers gains the victory we ascertained the salient fact that only in 97 of the 201 largest battles did the numerically stronger win, in 94 cases on the other hand the lesser number lifted their banners in victory. The remaining 10 battles had equal strengths on each side. The proportion of victory by the more over the less numerous is therefore nearly equal to the proportion of the victory by the less over the more numerous.

e. In the 70 greatest sea battles of modern times the less numerous won 21 times (= 30 percent), in 7 cases (= 10 percent) the forces were about equal, in 42 sea battles (= 60 percent) the more numerous won over the weaker side.

f. The study of many hundreds of battles of modern times with regard to the percentage of dead to the wounded teaches us that the ratio of dead to wounded in the majority of battles can be put at .0:35, that therefore normally 1 of every 3 to 4 hit is killed or of 100 lost about 22 are dead $[10 \div (10 + 35) = 10 \div 45 = 0.2222...]$. This ratio proposed as normal nevertheless varies since battles are never fought under exactly equal conditions and indeed even battles that, as not seldom occurs, are after

the passage of years fought on exactly the same battlefield differ substantially in strength ratios, organization of the opponents, *etc.*

g. The proportion of mortally wounded to the more lightly wounded is very difficult to determine since so few states have reported such detailed lists; however the reporting of good lists of officer losses puts the statistician in the position of being able to draw some conclusions regarding the losses in men. Thus we find that the total losses to French officers during the whole of the Franco-Prussian War of 1870/71 amounted to 7,863 officers, of which 1,428 = 18 percent were killed immediately, 925 = 12 percent died of wounds, and 5,500 = 70 percent recovered. Therefore the sum of the killed and mortally wounded amounts to 30 percent of the total bloody losses. Fortunately, the ratio of wounded who die from their wounds to those who recover ought to improve significantly because of the continuous advances in the development of surgery.

11. Comments and Critique. This is a most remarkable book and provides a unique and extraordinarily useful compendium of data on battles. Its discussion materials are rich in important suggestions and observations. Most of the main points made in its discussion are also presented in English in Bodart-1916. Its chief limitation is the lack of situational descriptors, and the odd absence of information on which side was the attacker and which the defender.

BODART-1916

1. Document Description. Bodart, Gaston; and Kellogg, Vernon Lyman, "Losses of Life in Modern Wars and Military Selection and Race Deterioration," Oxford, Clarendon Press, 1916, 207 pp. Edited by Westergaard, Harald. UNCLASSIFIED. Available from libraries (copy in University of Alabama library under D 25.5. B6).

2. Objectives and Scope. To provide some basic factual and interpretive material on losses of life in wars.

3. Populations Included. Various.

4. Timeframes Included. Modern wars, covering the period from 1618 to just before World War I.

5. Casualty Types Included. KIA, WIA, MIA, and POW.

6. Time Intervals Included As. Not used.

7. Situational Descriptors Defined As. No descriptors are used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. This work consists of two separate and distinct parts. Part I is Bodart's contribution, and Part II (labeled as "a preliminary report and discussion) is Kellogg's contribution. We will consider only Part I, which occupies 156 of this volume's 207 pages. Its table of contents includes the following.

a. Austria-Hungary, 1618-1913. The years of war and years of peace in the past three centuries; Duration of the wars in which Austria-Hungary has been engaged (the number and frequency of battles, engagements, and sieges in each); General observations concerning the loss of human life in the wars of modern times; The proportion of killed to wounded; Losses of the Imperial Armies in the Thirty Years' War, 1618-48; Losses of the Imperial Armies in the Turkish Wars of the seventeenth century; Losses of the Imperial Armies in the Wars with Louis XIV, 1673-1714; The Quadruple Alliance against Spain; The two Turkish Wars of Emperor Charles VI; War of the Polish Succession, 1733-35; Wars of Austria with Frederick the Great; The war of Joseph II against Turkey, 1788-90; Insurrection in the Austrian Netherlands, 1789-90; The French Revolutionary Wars, 1805-15; Minor wars, 1816-48; The wars of the Revolutionary Period, 1848-9; The war with France and Sardinia, 1859; Danish-German War of 1864; The war with Prussia of 1866 and the Austro-Italian War of 1866; The occupation of Bosnia and Herzegovina; Suppression of uprisings in Southern Dalmatia and Krivoshian, 1869, 1882; The Boxer Rebellion in China, 1900; Comparative losses of Austria and other countries; The officer-losses of Austrian armies; Recapitulation of casualties among generals and staff-officers, 1618-1913.

b. France, 1614-1913. Wars of France in the last three centuries; General remarks on the losses of men in war; Period of the Thirty Years' War, 1618-48; The wars of Louis XIV; Wars under Louis XV and Louis XVI, 1715-92 (the era of the wars under Frederick the Great); The wars of the Revolution, 1792-1802; The Napoleonic Wars, 1804-15; Wars of modern France from 1816 to 1871; The Franco-German War, 1870-1; The Communard Insurrection, 1871; The colonial wars of France since 1871; Conclusion.

10. Summary of Findings Regarding Battle Casualties. Basically the same as in Bodart-1908.

11. Comments and Critique. This provides a version in English of the main points made in the analysis and discussion portions of Bodart-1908. It also contains much of the same data as Bodart-1908, albeit arranged to facilitate comparisons among wars rather than among battles. As a result, it does not provide any way to get at the strengths and losses to both sides in a given battle.

BOWEN-1988

1. Document Description. Bowen, Thomas E.; and Bellamy, Ronald F. (eds), "Emergency War Surgery (Second United States revision of The Emergency War Surgery NATO Handbook)," United States Department of Defense, 1988, 446 pp. UNCLASSIFIED. Available from Superintendent of Publications, US Government Printing Office, Washington, DC 20402. (Copy in USAMRIID Library, Bldg. 1425, Fort Detrick, MD 21701-5011.)

2. Objectives and Scope. To provide a handbook of information and procedures for use by military surgeons.

3. Populations Included. Not specified.

4. Timeframes Included. Not applicable.

5. Casualty Types Included. Wounded and injured.

6. Time Intervals Included As. Not applicable.

7. Situational Descriptors Defined As. Not applicable.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Chapter headings include General Considerations of Forward Surgery; Missile-Caused Wounds; Burn Injury; Cold Injury; Blast Injuries; Chemical Injury; Mass Casualties in Thermonuclear Warfare; Multiple Injuries; Shock and Resuscitation; Compensatory and Pathophysiological Responses to Trauma; Infection; Sorting of Casualties; Aeromedical Evacuation; War Surgery Within the Division; Anesthesia and Analgesia; Wounds and Injuries of the Soft Tissues; Crush Injury; Vascular Injuries; Wounds an Injuries of Bones and Joints; Wounds and Injuries of Peripheral Nerves; Amputations; Craniocerebral Injury; Maxillofacial Wounds and Injuries; Wounds and Injuries of the Eye; Laser Injury of the Eye; Wounds and Injuries of the Ear; Wounds and Injuries of the Neck; Wounds and Injuries of the Chest; Wounds of the Abdomen; Recuperative Abdominal Surgery; Wounds and Injuries of the Genitourinary Tract; Wounds and Injuries of the Hand; and Wounds and Injuries of the Spinal Column and Cord.

10. Summary of Findings Regarding Battle Casualties. Too numerous to summarize briefly.

11. Comments and Critique. Most of the information given is of only peripheral value or general interest to the PAR studies.

BOYD-1964

1. Document Description. Boyd, Donald M., *et al.*, "Casualty Predictions for Medical Workloads from Conventional Weapons, 1965-1970," Research Analysis Corporation (RAC), Technical Memorandum RAC-T-439, November 1964, 105 pp. SECRET. Available from DTIC (AD-394 660L).

2. Objectives and Scope. Paraphrased from the Summary: The problem is to determine medical workloads for Army Medical Service organizations generated by enemy use of conventional weapons in a theater of war. The primary objectives are to determine the expected rate and types of combat casualties that would require treatment by Army Medical Service organizations and to develop a computer program that will permit calculations of casualties by types from effects of these weapons within stated tactical situations. Detailed analysis of extensive historical experience and projection to the period of interest was selected as offering the highest level of confidence for long-range planning.

3. Populations Included. Combatants.

4. Timeframes Included. World War II, Korea.

5. Casualty Types Included. KIA, WIA,

6. Time Intervals Included As. From start to end of a war.

7. Situational Descriptors Defined As.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Tables 1 and 7 give the anatomical distribution of wounds for World War II and Korea. Figures 6 and 7 give the empirical distributions of WIA for combat divisions in World War I, World War II, and Korea, and Figures 8 and 9 give it for KIA. These Figures are based on this study's special historical analysis of the experiences of 96 selected divisions. Table 8 gives the WIA/KIA ratios for World War I, World War II, and Korea. Appendix C gives some examples indicating that gamma distributions give a good fit to the observed casualty distributions (*e.g.*, the cumulative distribution of casualties per division day). This suggestion (and the empirical data offered to support it) are of interest.

10. Summary of Findings Regarding Battle Casualties. The proposed method for forecasting casualties is believed to be useful.

11. Comments and Critique. This provides a useful compilation of data and suggestions for analysis that can be taken up in future studies. An unclassified summary of selected historical findings is in Robinson-1965, *q.v.*

BREDESON-1991

1. Document Description. Bredeson, Jean A., "Technical Notes on Comparison of Battle Outcomes Across Nationality," US Army TRADOC Analysis Command-Ft. Benjamin Harrison, Unnumbered, 2 May 1991, 51 pp. UNCLASSIFIED. Available from TRADOC Analysis Command, Fort Benjamin Harrison, Indiana, and DTIC.

2. Objectives and Scope. To analyze the outcomes of some selected battles described in the so-called Benchmarks data base (*see* McQuie-1988) in an effort to determine the effect of national character on winning or losing.

3. Populations Included. Only those battles in the Benchmarks data base that had roughly equal opposing forces were used (*i.e.*, no more than a 2 to 1 disparity in personnel strength). Thus, only about 117 battles were used.

4. Timeframes Included. All of the battles used occurred between 1937 and 1983.

5. Casualty Types Included. Battle casualties, as recorded in the Benchmarks data base.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. None used.

8. Data Sources Used. The Benchmarks data base. *See* McQuie-1988.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Asserted findings include the following.

a. The following nations do not differ with regard to the casualty rates sustained when attacking: Syria, Israel, Germany, USSR, Britain, and US.

b. The following nations tend to inflict comparatively high casualty rates upon their attackers: Japan, Israel, and USSR.

c. The following nations tend to suffer comparatively high casualty rates in defensive battles: Japan, USSR, North Korea, Egypt, and Syria.

d. The following nations tend to inflict comparatively high casualty rates upon defenders they attack: Syria and Israel.

e. The most successful nations when attacking tend to be Japan, USSR, and Israel.

e. The most successful nations when defending tend to be US, Israel, and Britain.

11. Comments and Critique. This study is limited in scope and effort. As a result, its sample size is too small to support broad generalizations. Larger and more comprehensive data bases are available, and could have been used given more time and effort. The study's choice of statistical methods has been criticized, and questions have been raised regarding the influence on its conclusions of non-sampling (*i.e.*, systematic) biases. Also, there is a question as to how long any putative past "national character" will persist in the future. For example, while the French in Napoleon's time terrorized all Europe they suffered a disastrous defeat in the Franco-Prussian War of 1870/71. On the other hand, Italians seem to have been generally inferior to their European neighbors in military prowess for several decades (see, for example, the remarks of Bodart-1908 on national character).

BRINKERHOFF-1985

1. Document Description. Brinkerhoff, John R.; Dupuy, Trevor N.; Johnson, C. C.; and Bader, Brian, "Casualty Estimates for Contingencies (CEC)," Data Memory Systems, Inc. (HERO Division), Contractor's Report No. 118, 1985, (Vol 1 is 41 pp, Vol 2 is 211 pp). UNCLASSIFIED. Available from DTIC (Vol 1 is AD-A183 255, Vol 2 is AD-A183 256). Contract Number MDA-903-85-C-0499.

2. Objectives and Scope. To compile and analyze data on personnel casualties that have occurred in minor contingency operations since 1945 in order to provide estimates of casualty rates which would be of use to planner of future minor contingency operations. In this context, a minor contingency is a military operation (other than a major war) involving armed hostilities, which is limited in duration (less than 6 months) and area (less than 1,000 kilometers radius of action) and consists of one or more engagements.

3. Populations Included. The contractor found 290 conflicts involving combat operations which occurred since 1945, and classified them as follows.

	Combat operations
Wars	38
Minor contingencies	105
Extended insurgencies	123
Peacekeeping operations	24
	290

However, of the 105 minor contingencies, only 72 were eligible for research, and of these only 21 had sufficiently reliable casualty data. Some 50 engagements occurred during these 21 minor contingencies, and data were found on 47 of them. To these were added some 28 engagements with adequate data from extended insurgency operations, making 73 engagements in all. Each of these 73 engagements was documented.

4. Timeframes Included. From 1945 through 1982.

5. Casualty Types Included. Total battle casualties, KIA, WIA, and CMIA.

6. Time Intervals Included As. From start to end of an engagement.

7. Situational Descriptors Defined As. Terrain (flat, rolling, rugged, or urban); weather (cold, temperate, or hot); surprise (blue surprise, no surprise, red surprise); posture (attack or defend); air superiority (blue superiority or no superiority); insertion means (overland, parachute, air landing, helicopter, ship, or unknown); opposition to insertion (opposed, unopposed, or unknown); and organizational type (foot, foot plus motor/mech/armor, mechanized with armor, airborne, special operations).

8. Data Sources Used. Various, and generally not stated.

9. Other and Miscellaneous. Includes a brief narrative account of the action for each of the 73 engagements treated.

10. Summary of Findings Regarding Battle Casualties. The chief finding is that battle casualties are highly variable from one engagement to the next, so that averages are not very satisfactory summaries of the data. The number of cases within any given category of descriptors is small. However, the WIA/KIA ratio for the entire group of 73 engagements averages to 3.76, and is rather less variable from case to case than other values. On the average, total battle casualty rates appear to decline as the force size or the duration of the engagement increases. Mean total battle casualties for extended insurgency engagements (24 ± 6) is about the same as for minor contingency engagements (27 ± 7), where $m \pm s$ means that the average is m and that the standard error of the average is s.

11. Comments and Critique. This provides a useful description of some selected contingency operations that occurred between the end of World War II and 1982. However, the sample size (total of 73 engagements) is marginal—only a few carefully chosen generalizations can be based upon a sample this small. The impact of several factors (such as the eight listed in paragraph 7 above) cannot be assessed with much assurance. This is because the number of observations corresponding to any particular combination of such factors is very low. For instance, although there are only 73 engagements, there are 12,960 possible combinations of factors and levels listed in paragraph 7 above. This means that, on the average only 1 of every 177 cells contains an observation. The situation is actually worse, since observations tend to cluster, that is, if a cell contains 1 observation, it tends to contain several observations. Hence, the ratio of cells with no observations to cells with some observations is even higher than the average of 177. Compare this treatment to that of Richardson-1970, which is less detailed but covers a larger number of conflict events. See also Richardson-1970 and Denton-1969.

BRYAN-1976

1. Document Description. Bryan, C. D. B., "Friendly Fire," G. P. Putnam's Sons, New York, 1976, 380 pp. UNCLASSIFIED. Available from publisher and libraries. Copy in Pentagon Library (DS 559.5 B79).

2. Objectives and Scope. This is an account of the impact of one particular friendly fire incident that occurred during the Vietnam War.

3. Populations Included. Concentrates on a particular incident.

4. Timeframes Included. Vietnam War.

5. Casualty Types Included. Death from friendly fire.

6. Time Intervals Included As. Not applicable.

7. Situational Descriptors Defined As. The military situation is described only sketchily.

8. Data Sources Used. Various, but primarily personal interviews and official records.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Generally applicable findings are not presented. Only a descriptive account of a particular incident and its effects on the family of the casualty are presented.

11. Comments and Critique. Of only tangential interest to PAR.

BURT-1965

1. Document Description. Burt, Jeffrey A.; and Engleman, Janice T., "Distribution of Combat Casualties by Causative Agent," Research Analysis Corporation (RAC), Technical Memorandum RAC-T-445, March 1965, 46 pp. UNCLASSIFIED. Available from DTIC (AD-386 202).

2. Objectives and Scope. To determine the relation between the distribution of battle casualties by causative agent and variable factors in the combat situation. Here distribution of casualties by causative agent refers to the percentages of total casualties resulting from artillery, small arms mines, bombs, *etc.*

3. Populations Included. Selected US Army units that participated in World War II or the Korean War.

4. Timeframes Included. World War II and the Korean War.

5. Casualty Types Included. KIA, WIA, and Coded for Record Only (CRO). These were added together to produce an overall "Total Battle Casualty" value.

6. Time Intervals Included As. From start to end of a particular battle or combat action. Durations ranged from 2 to 67 days, with an average of about 15.2 and a standard error of about 18.3.

7. Situational Descriptors Defined As. The factors used included the following for both friendly and enemy forces: personnel strength, artillery firepower, and small arms firepower. Also included were weather and type of action. To these were added the derived ratios of friendly to enemy: personnel strength, artillery firepower, and small arms firepower.

8. Data Sources Used. Chiefly US Army Office of the Surgeon General records.

9. Other and Miscellaneous.

10. Summary of Findings Regarding Battle Casualties. The estimated equation for total battle casualties is given as:

$$W = 28.05 - 1.45X_1 - 1.10X_2 + 1.22X_3 - 7.46X_4 + 5.61X_6 - 1.43X_7 \quad ,$$

where W = friendly casualty rate (casualties per 1,000 average personnel strength per day), X_1 = enemy small arms firepower (in units of 100,000 rounds/minute sustained rate of fire by the authorized weapons in the unit), X_2 = friendly artillery firepower (in units of 10,000 pounds/minute of projectiles fired by the authorized weapons in the unit), X_3 = enemy artillery firepower (in the same units as friendly artillery firepower), X_4 = ratio of friendly to enemy small arms firepower, X_6 = friendly personnel strength (in units of 10,000), and X_7 = a measure of the weather (ranges systematically from 1 to 12 inclusive in such a way that $X_7 = 1$ corresponds to the month with the highest and $X_7 = 12$ to the month with the least temperature and humidity in five or six selected major Korean cities). This equation was fitted to the data on 119,000 medical records of Korean casualties. The report states that

this yielded a correlation coefficient of 0.89 and a standard error of estimate of 5.38 casualties per 1,000 men per day. Similar equations are given for the percentage of the total friendly casualty rate attributable separately to artillery or to small arms fire.

11. Comments and Critique. Something similar to this was attempted by McQuie at PRC (*see* McQuie-1968), among other causative agent studies. His results should be compared to those in this paper. I know of no attempts to validate the fitted equations, or (except for McQuie's work) to apply the same technique to other data.

BUSSE-1968

1. Document Description. Busse, James, J., "An Attempt to Verify Lanchester's Equations," Marine Corps Operations Analysis Group (MCOAG), of the Center for Naval Analyses, Unnumbered, *circa* 1968, 17 pp. UNCLASSIFIED. Essentially the same paper was published as paper 9-1 in "Developments in Operations Research, Vol 2 " Proceedings of the Third Annual Israel Conference on Operations Research, held at Tel-Aviv, Israel, July 1969, Benjamin Avi-Itzhak (ed), Gordon and Breach Science Publishers, New York, 1971, ISBN: 0-677-39840-X, which is available from libraries.

2. Objectives and Scope. To compare data on Marine and North Korean strengths and losses during the Inchon-Seoul campaign of the Korean War with the results of Lanchester's square law. The intent is to emulate Engel's analysis of the Iwo Jima campaign see Engel-1954).

3. Populations Included. Combatants.

4. Timeframes Included. Korean War.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of the Inchon-Seoul campaign (15 September to 2 October 1950).

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Based on the US Marine Corps' Special Action Report and its Casualty Reporting Officer's data, plus US intelligence estimates of enemy strengths and losses.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. The Lanchester square law does not do a particularly good job of matching the casualty data throughout the action.

11. Comments and Critique. Later analyses (*see* Hartley-1989) confirm that the Lanchester square law does not fit the attrition very well throughout the Inchon-Seoul campaign. However, it does seem to provide an acceptable fit to the data for the three separate phases of the campaign (*i.e.*, the seizure of Inchon, advance to the outskirts of Seoul, and the taking of Seoul). Each of these phases lasted about a week. Some of the data may be in error, or "time shifted" due to the delayed reporting of casualties (*i.e.*, casualties suffered on day D are not reported until day $D + \delta$). As a result, the issue of the scope of applicability of the Lanchester square law as a model of attrition is still in doubt. Compare this treatment to that of Engel-1954 and Engel-1963.

There are some problems with Busse's data. He introduces North Korean units before they showed up in combat (as evidenced by POW's taken from them). He's overestimated the number of enemy forces operating at Inchon. He has failed to account for all of the US forces ashore (including a US Army

Division and a Republic of Korea (ROK) marine regiment, and has failed to introduced the US Marine Corps' 5,129 man Seventh Regimental Combat Team (RCT-7), which was landed on 21 September. These shortcomings cast some doubt on the validity of his results.

BZIK-1984

1. Document Description. Bzik, Karl D.; and Bellamy, Ronald F., "A Note on Casualty Statistics," Military Medicine, Vol 149, April 1984, pp 229-230, 1984. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. This is a letter to the editor noting that the decline in the percent of wounded dying of wounds for Vietnam as compared to World War II and Korea may be a statistical artifact.

3. Populations Included. US Army and US Marine Corps.

4. Timeframes Included. World War II and Korea for the US Army, Vietnam for the US Army and for the US Marine Corps.

5. Casualty Types Included. KIA, WIA, CRO, and DOW (died of wounds).

6. Time Intervals Included As. From start to end of a war.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Official records.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties.

a. "If CRO casualties are excluded from calculation, there has been no change in the percentage of casualties killed in action since the European campaign of 1945. In fact, amazing as it may seem, evidence suggests that about 20 percent of all combat casualties have been killed in action in all major wars, going back at least as far as the Crimean War of the 1850s."

b. "Similar considerations apply to the category of those dying of wounds. ... [Excluding the lightly wounded CRO casualties,] we calculate that 3.5 percent of Vietnam casualties died of wounds, a figure distinctly inferior to the 2.4 percent for the Korean Conflict, and certainly no better than the results in Europe at the end of World War II, but twice as good as in World War I and three times better than in the Crimean War."

c. "We believe that a rational argument can be made that no significant decrease in mortality has occurred since the end of World War II."

d. "Further, an evacuation doctrine which de-emphasizes first aid on the battlefield may actually be counterproductive." [Since medical aid care administered immediately may be more effective in preventing DOW than hospital care administered several minutes or a few hours later.]

11. Comments and Critique. At the time of its writing, the authors were colonels stationed at the Division of Combat Casualty Care, Letterman Army Institute of Research, Presidio of San Francisco. They also observe that "No one familiar with the difficulties associated with collecting combat casualty statistics can feel entirely confident that these data actually describe reality." This short note voices several cautions that need to be heeded in interpreting combat casualty statistics.See also Datel-1979, Datel-1981, and other works on database usage, problems, and fallacies.

CAA-1975

1. Document Description. War Gaming Directorate, US Army Concepts Analysis Agency, "FEBA Movement and Attrition Processes," US Army Concepts Analysis Agency, Staff Paper CAA-SP-75-1, 21 February 1975, 83 pp. UNCLASSIFIED. Available from US Army Concepts Analysis Agency.

2. Objectives and Scope. To apply multivariate statistical analysis techniques to historical combat data to explore the applicability of this approach to predicting such things as rates of advance and the attacker's and defender's casualty rates.

3. Populations Included. Some 60 World War II battles for which data collected by the Historical Research and Evaluation Organization (HERO) were readily available were selected for analysis.

4. Timeframes Included. All of the battles occurred in Italy between September 1943 and June 1944.

5. Casualty Types Included. Total battle casualties (KIA + MIA + CMIA), as recorded by HERO.

6. Time Intervals Included As. From start to end of a battle, as recorded by HERO.

7. Situational Descriptors Defined As. Several situational descriptors were reported by HERO, including the following: opposing force strengths, combat postures, weapon and equipment densities, environmental conditions (weather, season, and terrain). Additional indices were constructed as needed.

8. Data Sources Used. Data as recorded by HERO were used.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Study claims a good prediction of attrition rates.

11. Comments and Critique. The accuracy of the data used has been called into question (Helmbold-1986). The methods clearly suffer severely from over fitting the data using a plethora of "explanatory factors" with a very limited sample of data. *See* the works on Database Usage, Problems, and Fallacies.

CAA-1985

1. Document Description. US Army Concepts Analysis Agency, "Integrated Warfare—Representing the Decision Processes Within Computer Simulations of Combat," US Army Concepts Analysis Agency, 8120 Woodmont Avenue, Bethesda, MD 20814-2797, Technical Paper CAA-TP-85-1, Jan 1985, 177 pp. UNCLASSIFIED. Available from DTIC.

2. Objectives and Scope. To record the progress made on the subject of modeling integrated warfare escalation decisions in simulations of theater-level warfare. One model is proposed for US and North Atlantic Treaty Organization (NATO) forces, and another for Soviet and Warsaw Pact forces. For PAR, the model proposed for US and NATO forces is of interest, since it was based on a historical analysis. The remainder of this annotated bibliography entry deals only with the historical data analysis supporting the proposed model of NATO escalation decisions.

3. Populations Included. Participants in battles.

4. Timeframes Included. From 1600 to 1973.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. None used (although the CDB90 data base provides several descriptors; *see* the annotated bibliography entry for the CAA-1991 data base).

8. Data Sources Used. Use was made of the Helmbold-1961, Helmbold-1964a, and CAA-1991 data bases.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. The relationship between winning and the advantage parameter on the one hand, and between battle duration and intensity on the other, can be exploited to construct a practical model of the decision to escalate a theater-level conflict from conventional to nuclear warfare, or to deescalate it from nuclear to conventional.

11. Comments and Critique. This provides a practical model of escalation decisions firmly grounded on historical data.

CAA-1990

1. Document Description. Data Memory Systems, Inc, Fairfax, VA, "Ardennes Campaign Simulation Data Base (ACSDB)," US Army Concepts Analysis Agency, 8120 Woodmont Avenue, Bethesda, MD 20814-2797, Contract Number MDA904-87-C-0787, Feb 1990. UNCLASSIFIED. Hard copy documentation published as "The Ardennes Campaign Simulation Data Base," Data Memory Systems Incorporated Report, unnumbered, 18 December 1989. UNCLASSIFIED, work done under Contract No. MDA903-87-C-0787. Available from DTIC (diskettes as AD-M000 074 (33 diskettes), documentation as AD-A024 008).

2. Objectives and Scope. The Ardennes Campaign Simulation Data Base (ACSDB) is a data base of the World War II campaign fought in December 1944 and January 1945, popularly known as the "Battle of the Bulge," and is provided in both hard copy and computerized form. The hard copy documentation contains bibliographic, definitional, and other information; a set of full-scale color photographs of 1/100,000 scale maps of the Ardennes region with a clear acetate overlay on which are shown locations of US and German units on 16 December 1944; a user's guide for the ACSDB; a narrative on the single shot probability of kill (SSPK) data researched for the ACSDB; and a collection of photocopies of all records used for generation of the ACSDB totaling some 10 cubic feet of printed material. The computerized version of the ACSDB is about 39 megabytes in size, and uses the dBASEIV™ data base management system to facilitate storage and manipulation. American, German, and British combat units that were significantly involved are included.

3. Populations Included. The data include daily information on unit location, activities, order of battle, personnel, equipment, and logistics at the army, corps, division, and brigade level for the period 16 December 1944 through 16 January 1944, plus data on tactical air operations, tables of organization and equipment (TOE) of units, and equipment used by opposing forces in the Ardennes Campaign.

4. Timeframes Included. 16 December 1944 through 16 January 1945.

5. Casualty Types Included. Casualties are identified as killed; killed and wounded; killed, wounded and missing; or losses.

6. Time Intervals Included As. Daily.

7. Situational Descriptors Defined As. Given in narrative form in selected fields of the data base.

8. Data Sources Used. The data were obtained from both primary and secondary sources.

a. The primary records used for daily information on front line locations, boundaries between front line units, and other unit location data included US Army daily SITREPS (situation reports) and British Army War Diaries, and OKW briefing maps (which were prepared three times daily using

red and blue color markings to show the locations of German and Allied units on topographical maps of the area).

b. Other sources included unit histories, official histories, and chronologies. Use was also made of the manuscripts prepared by German division, corps and army commanders as part of the US Army's postwar Foreign Military Studies program.

c. Daily unit location data was generated using the same general approach for all three nations. First the daily locations of divisions and brigades were determined. This information was then reviewed and their front line traces compiled to generate the data on corps. The process was repeated using corps data for armies. Finally, the front line traces and locations of other significant unit elements of all forces were checked by comparing the daily front line locations of opposing Allied and German units. This step was necessary because the unit location data of opposing forces was derived separately. The proofing process involved plotting grid coordinates of units using the graphics feature of the Reflex™ data base management software. This check showed remarkably close correlation between the front line traces of the opposing forces, testimony to the accuracy of the German maps, the Allied situation reports, and the postwar manuscripts of the German officers.

9. Other and Miscellaneous. Documentation includes a User's Manual guide to the database.

10. Summary of Findings Regarding Battle Casualties. No specific findings presented, only data.

11. Comments and Critique.

a. This is a major effort to produce a comprehensive quantitative record of the events that occurred during the Ardennes Campaign. The data are in a form that lends itself to ready retrieval and collation.

b. Since the data were entered by several individuals at many different times, it was not possible to stick exactly to the stated data base format. For example, missing values may be variously coded as "99999999," "999.9," or as a blank field with no entries. This must be taken into account when using computer programs to process the data.

c. Some data are not coded in a manner that facilitates computer processing. For example, the same weather conditions may be variously described as "fog," "foggy," "limited visibility," "visibility limited to 100-200 meters," "moderately foggy," "fog obscured enemy positions," "visibility of enemy positions limited," "visibility hampered operations," *etc.* Computer processing of the information in these fields is impractical in their present format. With enough additional work, it might be possible to convert the information to a standard format.

e. There is no direct record in the data base as to which of the distances described in the hard copy documentation were actually entered into Fields 7 (Displacement) and 8 (Distance Opposed Advance) of the Unit Location file. To some extent that information can be inferred from the context, but not in a way that is conveniently programmed for computer manipulation of the information.

CAA-1991

1. Document Description. US Army Concepts Analysis Agency, Model Validation Office, "Data Base of Battles-Version 1990 (CDB90)," US Army Concepts Analysis Agency, 8120 Woodmont Avenue, Bethesda, MD, 20814-2797, 30 Apr 1991. UNCLASSIFIED. Available from DTIC (AD-M000 121).

2. Objectives and Scope. To provide a data base of battles for research on matters pertaining to US Army wargaming and simulation activities. Specific EEAs were not stated, but implicit ones include:

   a. What data are available?

   b. How can it best be presented?

3. Populations Included. Six hundred and sixty battles.

4. Timeframes Included. From about 1600 to the present.

5. Casualty Types Included. Total battle casualties (KIA + WIA + CMIA).

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Battle sequence (an arbitrary index or serial number); War in which battle/engagement was fought; Name of the battle/engagement; Location where battle was fought (country or region); Campaign in which battle was fought; Designation of the attacking forces; Name of the attacking force commander; Designation of the defending forces; Name of the defending force commander; Attacker's width of front at start of battle; Defender's width of front at start of battle; Time first widths of front became effective; Attacker's second width of front; Defender's second width of front; Time second widths of front became effective; Attacker's third width of front; Defender's third width of front; Time third widths of front became effective; Defender's posture type descriptor [0 = At most 1 defensive posture is given, 1 = A combination posture involving two distinct/separate postures, 2 = An average or intermixture of two or more postures, 9 = More than 1 posture, but whether separate or intermixed is not available]; Defender's primary defensive posture [HD = Hasty defense, PD = Prepared defense, FD = Fortified defense, DL = Delaying action adopted, WD = Withdrawal adopted, OO = Not available or not applicable]; Defender's secondary posture; Did defender's posture change along the front? [0 = No, 1 = Yes, 9 = Unknown]; Did defender's posture change with depth? [0 = No, 1 = Yes, 9 = Unknown]; Did defender's posture change over time? [0 = No, 1 = Yes, 9 = Unknown]; Primary local terrain description [First character: G = Rugged, R = Rolling, F = Flat, 0 = Other or not available; Second character: W = Heavily Wooded, M = Mixed, B = Bare D = Desert, 0 = Other or not available; Third character: U = Urban, M = Marsh or swamp, D = Dunes, 0 = Other or not available]; Secondary local terrain description; Primary local weather description [First character: W = Wet, D = Dry, 0 = Other or not available; Second character: H = Heavy Precipitation, L = Light Precipitation, O = Overcast (no precipitation), S = Sunny (no precipitation), 0 = Other or not available;

Third character (for local weather): H = Hot, T = Temperate, C = Cold, 0 = Other or not available; Fourth character (for general climate): E = Tropical (*i.e.*, "Equatorial"), D = Desert, T = Temperate, 0 = Other or not available]; Secondary local weather description; Tertiary local weather description; Relative surprise achieved by attacker [+3 = Complete surprise achieved by attacker, +2 = Substantial surprise achieved by attacker, +1 = Minor surprise achieved by attacker, 0 = Neither side achieved surprise, or it did not affect the outcome, −1 = Minor surprise achieved by defender, −2 = Substantial surprise achieved by defender, −3 = Complete surprise achieved by defender, 9 = Unknown or not available]; Attacker's relative air superiority in theater [+1 = Attacker had air superiority in the theater, 0 = Neither side had theater air superiority, −1 = Defender had air superiority in the theater, 9 = Unknown or not available]; Attacker's total personnel strength; Interpretation of attacker's total personnel strength [1 = Total strength is also initial strength, 2 = Total strength is an average daily strength, 3 = Total strength is the total strength engaged]; Attacker's initial personnel strength; Attacker's personnel reinforcements/replacements during battle; Attacker's personnel battle casualties; Attacker's personnel strength at battle's end; Defender's total personnel strength; Interpretation of defender's total personnel strength; Defender's initial personnel strength; Defender's personnel reinforcements/replacements during battle; Defender's personnel battle casualties; Defender's personnel strength at battle's end; Attacker's horse cavalry strength; Attacker's total number of tanks; Attacker's number of light tanks; Attacker's number of main battle tanks; Attacker's number of artillery tubes; Number of close air support sorties by attacker; Attacker's armor losses; Attacker's artillery losses; Attacker's close air support aircraft losses; Defender's horse cavalry strength; Defender's total number of tanks; Defender's number of light tanks; Defender's number of main battle tanks; Defender's number of artillery tubes; Number of close air support sorties by defender; Defender's armor losses; Defender's artillery losses; Defender's close air support aircraft losses; Attacker's relative combat effectiveness;[1] Attacker's relative leadership advantage;[1] Attacker's relative training advantage;[1] Attacker's relative morale advantage;[1] Attacker's relative logistics advantage;[1] Attacker's relative momentum advantage;[1] Attacker's relative intelligence advantage;[1] Attacker's relative technology advantage; Attacker's relative initiative advantage;[1] Attacker's win/draw/lose [+1 = Atk Win, −1 = Atk Loss, 0 = Draw, −9 = Unknown]; Distance attacker advanced/retreated; Attacker's mission accomplishment score [on scale of 1 to 10, 1 = Low, 10 = High, 0 = Unknown]; Defender's mission accomplishment score; Criterion for assigning attacker's win/draw/lose [1 if clear-cut, 2 if not, 0 = not available]; Degree of influence of force quality;[1] Degree of influence of reserves;[1] Degree of influence of mobility;[1] Degree of influence of air superiority;[1] Degree of influence of force preponderance;[1] Degree of influence of weather;[1] Degree of influence of terrain;[1] Degree of influence of leadership;[1] Degree of influence of planning;[1] Degree of

[1] +4 = Very strongly favors the attacker, +3 = Strongly favors the attacker, +2 = Favors the attacker, +1 = Somewhat favors the attacker, 0 = Favors neither side, −1 = Somewhat favors the defender, −2 = Favors the defender, −3 = Strongly favors the defender, −4 = Very strongly favors the defender, −9 = Unknown or not available.

influence of surprise;[1] Degree of influence of maneuverability;[1] Degree of influence of logistics;[1] Degree of influence of fortifications;[1] Degree of influence of depth of position;[1] Attacker's primary tactical scheme: part 1 [FF = Frontal attack; EE = Single envelopment; DE = Double envelopment; FE = Feint, demonstration, or holding attack; DD = Defensive plan; DO = Defensive/offensive plan; LF = Left flank; RF = Right flank; LR = Left rear; RR = Right rear; PP = Penetration; RC = River crossing; 00 = Not applicable, or not available]; Attacker's primary tactical scheme: part 2; Attacker's primary tactical scheme: part 3; Attacker's secondary tactical scheme: part 1; Attacker's secondary tactical scheme: part 2; Attacker's secondary tactical scheme: part 3; Attacker's primary resolution/outcome: part 1 [AA = Annihilated, PS = Pursued, WL = Withdrew with heavy losses, WD = Withdrew, BB = Breakthrough, PP = Penetration, RR = Repulse, SS = Stalemate, 00 = None of the above, or not available]; Attacker's primary resolution/outcome: part 2; Attacker's primary resolution/outcome: part 3; Defender's primary tactical scheme: part 1; Defender's primary tactical scheme: part 2; Defender's primary tactical scheme: part 3; Defender's secondary tactical scheme: part 1; Defender's secondary tactical scheme: part 2; Defender's secondary tactical scheme: part 3; Defender's primary resolution/outcome: part 1; Defender's primary resolution/outcome: part 2; Defender's primary resolution/outcome: part 3; Attacker strength error [± percent of tabulated value]; Attacker strength error; Attacker casualty error; Attacker casualty error; Defender strength error; Defender strength error; Defender casualty error; Defender casualty error; Number of active time periods for this battle [ranges from 1 to 10]; Time first active time period began/ended; Time second active time period began/ended; *etc.*

8. Data Sources Used. Various.

9. Other and Miscellaneous.

a. The data base is in the form of a set of diskettes in LOTUS-readable form available from DTIC. The files on these diskettes are as follows:

(1) README.TXT, an ASCII file describing the data base.

(2) CDB90DEF.WKS, a LOTUS-readable worksheet file containing definitions of the variables and coding scheme used in the data base.

(3) CDB90001.WKS, a LOTUS-readable worksheet file containing the database information for battles 1 through 74.

(4) CDB90075.WKS, a LOTUS-readable worksheet file containing the database information for battles 75 through 149.

(5) CDB90150.WKS, LOTUS-readable worksheet file containing the database information for battles 150 through 224.

(6) CDB90225.WKS, a LOTUS-readable worksheet file containing the database information for battles 225 through 299.

(7) CDB90300.WKS, a LOTUS-readable worksheet file containing the database information for battles 300 through 374.

(8) CDB90375.WKS, a LOTUS-readable worksheet file containing the database information for battles 375 through 449.

(9) CDB90450.WKS, a LOTUS-readable worksheet file containing the database information for battles 450 through 524.

(10) CDB90525.WKS, a LOTUS-readable worksheet file containing the database information for battles 525 through 599.

(11) CDB90600.WKS, a LOTUS-readable worksheet file containing the database information for battles 600 through 660.

10. Summary of Findings Regarding Battle Casualties. The history of this database is summarized here. CAA's data base of information on historical land combat battles and engagements exists in two distinct forms. One is the traditional printed report form, and the other is in the form of computerized data files. Both versions contain historical information on over 600 land combat battles that took place between 1600AD and 1990AD. The report version has gone through several iterations, as described below.

a. The first version of the data base is documented in CAA Study Report CAA-SR-84-6, "Analysis of Factors That Have Influenced Outcomes of Battles and Wars: A Data Base of Battles and Engagements," September 1984, in six volumes. It was prepared for CAA under contract number MDA903-82-C-0363, and is available from DTIC under the following accession numbers: AD-B086-797L, AD-B087-718L, AD-B087-719L, AD-B087-720L, AD-B087-721L, and AD-B087-722L.

b. The second version is documented as "changes to" the first version in HERO Report Number 129, "Combat History Analysis Study Effort (CHASE) Data Enhancement Study (CDES)," 31 January 1986, in five volumes. It was prepared for CAA under Contract Number MDA903-85-C-0252 and is available from DTIC under the following accession numbers: AD-A175-712, AD-A175-713, AD-A175-714, AD-A175-715, and AD-A175-716. The objective of the CDES work was to correct omissions, inconsistencies, and ambiguities in the battle and engagement data base being used in the CHASE Study. The scope of the CDES work included:

(1) Analyze about 400 data base problem reports generated while encoding the original HERO data into machine-readable format.

(2) State for each battle whether its total engaged personnel strength is the initial, average, or total strength.

(3) State for each battle whether HERO determined its victorious side on the basis of a clear-cut decisive resolution, or on the basis of mission accomplishment.

(4) Give for each battle duration data in hours and minutes rather than in "days."

(5) State for each battle the defender's width of front.

(6) State for each battle with a dual posture descriptor whether it represents an "average" or a "combination" posture.

(7) Provide for each battle estimates of the relative reliability of its personnel strength and casualty data.

(8) Develop strength and attrition histories for selected battles.

(9) Comment on CAA's attempt to eliminate unwanted redundancies in the data.

The principal findings of CDES are that, despite the care taken in the DATABASE contract to prepare the original data base, and despite the further effort in the CDES contract to rid it of errors, a number still remain. Lessons learned included the practical impossibility of assuring the high reliability of historical data bases.

c. The third version is documented as "changes to" the first and second versions in unnumbered HERO Report "Data Base Error Correction (DBEC)," 23 January 1987. It was prepared for CAA under Purchase Order Number MDA903-86-M-8560 and is available from DTIC under accession number AD-A176-750. The DBEC effort was motivated by a desire to purge the data base of as many errors as humanly possible. Its scope included:

(1) Correct advance rate data.

(2) Resolve discrepancies in the duration data.

(3) Correct a variety of errors.

(4) Provide definitions for two data types that were previously undefined.

(5) Provide a list of errata for the CDES report.

The principal finding of the DBEC effort was that discrepancies remain between some of the narrative descriptions of battle and the data base—no attempt was made to correct them within the scope of the DBEC effort. The major topic for future research is that not all of the errors in the data base have as yet been identified and corrected. The lessons learned underscored the difficulty of assuring high reliability in historical combat data bases.

d. In addition to the above, an independent review and reassessment of the data for about 60 selected battles whose data are considered to be statistically anomalous is documented in the unnumbered LFW Management Associates, Inc. report "Independent Review/Reassessment of Anomalous Data (IR/RAD)," unnumbered LFW Management Associates, Inc. Report, 22 Jun 87, in four volumes. Prepared for CAA under Contract Number MDA903-86-C-0396, and available from DTIC under accession numbers AD-195 381 (Volume I), AD-195 726 (Volume II), AD-195 382 (Volume III), and AD-195 383 (Volume IV). The objective of the IR/RAD work was to perform an independent review/reassessment of certain historical battle data. It was motivated by the CHASE Interim Progress Report's finding that the data for these particular battles are statistically anomalous. The scope of the IR/RAD effort included developing new and original historical data for 61 anomalous battles in 8 campaigns of World War II and the Arab-Israeli wars. The implied EEA was to provide a factual basis for determining whether the anomalies are attributable to actual changes in combat dynamics, or whether they are more likely due to flaws in the data base.

The principal finding was that, in virtually every case, the IR/RAD contractor's data differ substantially from those determined by the authors of the original data base. Major topics for future research include determining the validity, exact nature and extent, theoretical implications, and practical significance of these differences between the two groups of historical analysts. The most important lesson learned appears to be that it is very difficult to assure high quality in historical combat data bases.

e. Use was also made of ANDERSON-1988. That report, in conjunction with independent research by Mr. Robert McQuie of CAA, provided data on about 59 additional battles, and these have been added to the current version of CAA's land combat data base, Version 1990 (CDB90).

11. Comments and Critique. This provides what is perhaps the most complete and detailed data bases on battles that is currently available. The work described above has resulted in a comprehensive data base of land combat battles from 1600AD to the present, describing quantitatively many of their features. Despite its shortcomings, it is the largest and most comprehensive free world database of quantitative information on battles. It is particularly well suited to statistical analyses of the type described below in CAA-1986 (the CHASE study). Its preparation was motivated by the understanding that historical battle data are essential for important advances in the quality of Army modeling, together with a recognition that the previously-available combat data were either insufficiently detailed or not systematically organized into the quantitative data base form required for validating contemporary battalion to army-level models. The scope of the data base includes a tabulation of about 80 items of information and a synopsis of the action for each battle.

The principal finding is that it is feasible to construct an extensive and well-organized data base of quantitative information on battles. Important issues and topics for future research include devising improved criteria for deciding what data to put in the data base, developing improved approaches to

analyzing this sort of data, and inventing ingenious ways of applying the results to important Army issues. The most important lessons learned are that:

a. The successful development of a high-quality combat data base requires a multidisciplinary approach in which military archivists and historians work together with military operations analysts, statisticians, epistemologists, and scientists with a strong "hard science" background.

b. Developing a data base adequate for use in model development and model validation is an extremely difficult task. It requires a very substantial investment in time, resources, and talent.

c. Devising good ways to analyze and apply the data are at least as important as the data themselves. These often require more advanced technical training than compilation of the data itself.

Probably the estimates of the amount of error in the data are overly confident (*i.e.*, the actual errors are larger than reported here). In this connection, see Datel-1979 and Datel-1981.

CALL-1988

1. Document Description. CPT Michael Foncannon, "Lessons Learned," US Army Center for Lessons Learned, Fort Leavenworth, KS, no 88-1, 31 January 1988, 17 pp. UNCLASSIFIED. Available from US Army Center for Lessons Learned.

2. Objectives and Scope. Discusses commander losses in combat actions, and suggests steps to minimize either those losses or their effect on combat effectiveness.

3. Populations Included. US Army National Training Center experience, with allusions to historical experience of the US Army in World War II, the German army on the Eastern Front in World War II, and the Israeli army in the Arab-Israeli wars.

4. Timeframes Included. Various.

5. Casualty Types Included. Losses, otherwise unspecified, but apparently roughly equivalent to battle casualties.

6. Time Intervals Included As. Various.

7. Situational Descriptors Defined As. Situational descriptors (other than the names of a few operations) are not used.

8. Data Sources Used. Various, and unspecified.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Historically, high loss rates have been experienced in platoon, company, battalion, and regimental commanders. Some figures on that are put forward, and compared to National Training Center (NTC) experience. It is also stated (p 13) that "During 1987, fifteen percent of the command vehicle 'kills' recorded at the NTC were due to friendly fire."

11. Comments and Critique. The figures cited are interesting, but should be double-checked against original and authoritative sources before they can be used for purposes beyond those of the CALL newsletter.

CALL-1992

1. Document Description. US Army Center for Lessons Learned (CALL), "Fratricide Risk Assessment for Company Leadership," US Army Combined Arms Command (CAC), Fort Leavenworth, KS, CALL Handbook 92-3, March 1992, 24 pp. UNCLASSIFIED. Available from CALL.

2. Objectives and Scope. Describes measures that can be taken at the company level to minimize the risk of fratricide.

3. Populations Included. Primarily company level.

4. Timeframes Included. Focuses on future engagements.

5. Casualty Types Included. Fratricide.

6. Time Intervals Included As. From start to end of an engagement.

7. Situational Descriptors Defined As. Various factors relevant to fratricide are introduced.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. No specific findings regarding battle casualties are included.

11. Comments and Critique. This document provides information only tangentially related to the PAR studies.

CAMPBELL-1969

1. Document Description. Campbell, Edward G., "The National Archives and Military Records," Proceedings of the US Army Operations Research Symposium, 21-23 May 1969, 5 pp. UNCLASSIFIED. Available from Army Operations Research Society (AORS) and libraries. At the time, the author was employed by the US National Archives and Records Service, General Services Administration.

2. Objectives and Scope. To describe the state of the military records held by the US National Archives and Records Service.

3. Populations Included. US Army records only.

4. Timeframes Included. Focuses on World War II archival records.

5. Casualty Types Included. Not discussed.

6. Time Intervals Included As. From start to end of a war.

7. Situational Descriptors Defined As. Not applicable.

8. Data Sources Used. Archival records.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. No findings regarding battle casualties. However, it is pointed out that "Even after the reduction in volume of Army records from the original 7,500,000 cubic feet to the 150,000 cubic feet now held [2 percent of the original] (excluding personnel files), the amount of paper available to the historical researcher is so great that the unprepared searcher is often startled.

"At the Suitland records center more than 120,000 cubic feet of Departmental and field files are maintained on shelving that is 14 tiers high extending for a total linear footage of about 160,000 feet, or about 30 miles [he means 30 shelf-miles, *not* 30 tier-miles; this is a little over 2 tier-miles, each tier-mile being equal to 14 shelf-miles]. In addition, in the National Archives another 35,000 cubic feet of Departmental files occupy some 40,000 linear footage of shelving seven shelves high, another seven miles [approximately an additional 1 tier-mile, for a total of about $3\frac{1}{4}$ tier-miles]."

11. Comments and Critique. This provides a useful cautionary reminder for any who would embark on a search of the archival records.

CAREY-1987

1. Document Description. Carey, Michael E., "Learning from Traditional Combat Mortality and Morbidity Data Used in the Evaluation of Combat Medical Care," Military Medicine, Vol 152, pp 5-13, January 1987. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To analyze the value of traditional medical statistics as measures of the effectiveness of combat casualty care, and to propose more useful measures.

3. Populations Included. Total US Army.

4. Timeframes Included. Mexican War, US Civil War, Spanish American War, World War I, World War II, Korea, and Vietnam.

5. Casualty Types Included. For the US Civil War, World War I, World War II, Korea, and Vietnam the casualty types included are KIA, DOW, Total Battle Deaths, Died of Disease, Died of Injuries, Total Non Battle Deaths. For the other timeframes only the percentage of wounded dying of wounds is provided.

6. Time Intervals Included As. From start to end of a war.

7. Situational Descriptors Defined As. Not discussed in systematic fashion.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Contains information on the estimated presented body area (Table 5); the percentage of hits on various parts of the body during World War II, Korea, and Vietnam (Table 6); percent distribution of anatomical location of wounds for those killed, dying of wounds, and the living wounded in World War II, Korea, and Vietnam (Table 7); and surgical mortality for head, chest, and abdominal wounds for World War I, World War II, Korea, and Vietnam (Table 8).

10. Summary of Findings Regarding Battle Casualties. Cautions that what constitutes a "wound" is indefinite—does this include only those mortally wounded, those seriously but not mortally wounded, those lightly but not seriously wounded, or all of the foregoing?

(p 8) "Earlier treatment [by a surgeon] of those with major wounds increases the total numbers of those who live but, paradoxically, leads to an overall increased mortality [*i.e.*, DOW] since more men with lethal wounds are still alive when they reach a medical facility." The author dubs this "the Morrissey effect," because he attributes its first documentation for the US Army to Morrissey in his study of casualties during the Anzio campaign (see the reproduction of Morrissey's paper in Beyer-1962).

(p 9) "In summary, these data indicate that the percentage of deaths among all men hit, the WIA/KIA [ratio], and percentage of wounded who died of their wounds have remained relatively static

since World War II. Indeed, these parameters have remained so intransigent that any deviation in the future will demand great scrutiny to ascertain the true cause."

(p 9) "Traditional measurements as outlined in this paper [*e.g.*, WIA, KIA, DOW, *etc.*] can be used in traditional ways. Additionally, however, newer, sophisticated methods to describe wounding using trauma scores could more fully evaluate wound severity and the quality of medical care delivered. The trauma score combines anatomic and physiologic data to characterize the severity of wounding. Delineation of wound severity by trauma score methodology would have the dual advantage of accounting for minor wounds and taking into account the 'Morrissey effect' when analyzing combat data."

Also states (p 7) that "During World War II, information concerning fatal wounds gathered from Emergency Medical Tags and other records was 8-27 percent inaccurate."

11. Comments and Critique. Contains very useful information, and important cautions regarding the interpretation of "traditional" measurements of wounding and deaths from wounds.

CHANDLER-1988

1. Document Description. Chandler, David G. (ed), "Dictionary of Battles: The World's Key Battles from 405 BC to Today," H. Holt, New York (publisher), 1988, 255 pp. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. This is a dictionary of the world's key battles.

3. Populations Included. Battle participants.

4. Timeframes Included. From 405 BC to the present.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Contained in the narrative descriptions.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. None specifically stated.

11. Comments and Critique. This provides a useful compendium of battles.

CHERNOL-1983

1. Document Description. Chernol, Brian H., "Psychiatric Casualties in Combat," Military Review, July 1983, pp 26-32. UNCLASSIFIED. Available from libraries. At the time this was written the author was Chief, Behavioral Science Specialist Branch, Behavioral Science Division, Academy of Health Sciences, Fort Sam Houston.

2. Objectives and Scope. To discuss the problem of battle fatigue casualties and suggest ways of reducing its impact on unit effectiveness.

3. Populations Included. Not precisely defined.

4. Timeframes Included. Not precisely defined.

5. Casualty Types Included. The author distinguishes between psychiatric casualties (which include "soldiers with alcohol or drug reactions, soldiers with preexisting psychotic disorders whose condition is reactivated or exacerbated by exposure to combat, soldiers who become dysfunctional due to the nature of their injuries or wounds—for example, the loss of sexual organs, nuclear irradiation or facial disfigurement") and soldiers who experience battle fatigue (BF).

6. Time Intervals Included As. Not precisely defined.

7. Situational Descriptors Defined As. Not precisely defined.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties.

(p 28) "Based on US Army experience in previous conflicts and Israeli Defense Force experiences in more recent combat operations, it can be predicted that, in high-intensity conventional warfare, at least 1 psychiatric casualty will occur for every four battle casualties during the initial 30-day period.

"In the absence of a historical data base, predictions of psychiatric to battle casualty ratios in a sustained nuclear, biological and chemical (NBC) war range from 1-to-3 to 1-to-2 for a 30-day period. After 30 days of continual combat, psychiatric casualties may well begin to exceed battle casualties, and most unit personnel may be psychologically ineffective after 60 days of continued high intensity combat."

(p 30) "Approximately 80 to 90 percent of these BF casualties will return to their parent units within four days; those who do not recover will be evacuated to corps facilities such as an evacuation hospital. However, once soldiers are evacuated to corps-level medical facilities, few will ever return to their units, and many will exhibit long-term psychiatric problems."

(p 28) "One lesson learned during the North African Campaign in World War II was that BF is the inevitable result of combat. It will overcome any soldier when his individual limit of endurance is temporarily exceeded; it is not a sign of cowardice nor of an inadequate personality structure."

11. Comments and Critique. Provides a useful non-technical summary of the understanding of BF casualties at the time it was written.

CLARK-1954

1. Document Description. Clark, Dorothy Kneeland, "Casualties as a Measure of the Loss of Effectiveness of an Infantry Battalion," Operations Research Office (ORO), Technical Memorandum ORO-T-289, August 1954, 46 pp. UNCLASSIFIED. Available from DTIC.

2. Objectives and Scope. To investigate from actual combat data the validity of the statement that a unit may be considered no longer combat effective when it has suffered *N* percent casualties. Of the several variables which may affect the combat effectiveness of a military unit, only daily variations in numerical strength can be quantified. Casualty and replacement data from the morning reports of 44 infantry battalions taking part in seven engagements in World War II in the ETO were compiled and analyzed. Eleven other variables were also noted, and their contributions in the engagements were studied.

3. Populations Included. Forty-four infantry battalions in seven engagements in World War II in the ETO.

4. Timeframes Included. World War II ETO.

5. Casualty Types Included. Total casualties and net casualties (net casualties defined as casualties minus replacements).

6. Time Intervals Included As. From start to end of an engagement.

7. Situational Descriptors Defined As. Eleven situational descriptors in addition to the duration of the engagement were considered, as follows: condition of troops at beginning of engagement, unusual environmental stresses, the imperative of the assigned mission, morale, leadership, tactical plan, reconnaissance, enemy opposition, fire support and reinforcement, logistical support, and communications.

8. Data Sources Used. Battalion morning reports.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. The following are quoted from the study's Summary Conclusions:

a. The statement that a unit can be considered no longer combat effective when it has suffered a specific casualty percentage is a gross oversimplification not supported by combat data.

b. Casualties can be taken as a significant measure of loss of combat effectiveness only if the proper defining and limiting factors are specified:

(1) The type and size of unit must be stated.

(2) Ranges of loss percentages rather than averages should be used because of the wide variations in data.

(3) The nature of the unit's mission must be specified. Widely differing ranges of loss percentages are associated with a breakpoint from attack to defense and a breakpoint from defense to withdrawal or collapse.

(4) The time basis on which loss percentages are figured must be specified—cumulative, on day of breakpoint, or whatever.

c. The most meaningful approach to the analysis of an infantry battalion's loss of combat effectiveness in conventional warfare proved to be in terms of duration of time from the start of engagement to breakpoint, considering not only loss percentages but also replacements and the increasing magnitude of attrition factors. No brief categorical statements of these findings can be made.

d. As a measure of effectiveness of atomic attack on an infantry battalion, extrapolation from casualty data in conventional warfare suggests losses of 4 to 23 percent in enlisted men [would suffice to make it ineffective], provided the unit is fresh and at full strength and the resultant temporary demoralization can be swiftly exploited by conventional means. Complete demoralization of such a unit, by atomic attack alone, may be achieved by the infliction of losses in the range of 40 to 79 percent.

e. Proportionately higher losses in officers than in enlisted men are not characteristic of breakpoints in infantry battalions.

f. The very wide individual differences in the ability of infantry battalions to carry out a given mission cannot be accounted for in terms of casualties alone, no matter how the data are presented. Of the other interacting variables it is believed that failures and breakdowns in leadership, fire support and reinforcement, and communications are the most frequent and powerful influences.

11. Comments and Critique. This study is classic in its field, and as such is often referred to (and often misquoted or misunderstood). Note, however, that it studies the casualty situation on only one side in the engagement. Others have argued persuasively that winning and losing an engagement does not depend merely on the losses to one side, but that instead both the losses and strengths on each of the engaged sides must be taking into account (see Hartley-1989a, Hartley-1989b, Hartley-1989c, Hartley-1989d, Hartley-1990, Hartley-1991a, Hartley-1991b, Hartley-1991c, Hartley-1991d, Helmbold-1961, Helmbold-1964a, Helmbold-1964b, Helmbold-1967, Helmbold-1969, Helmbold-1971a, Helmbold-1971b, Helmbold-1986, Helmbold-1987, Helmbold-1990).

CLEAVER-1956

1. Document Description. Cleaver, Frederick W., "US Army Battle Casualties in Korea," Operations Research Office (ORO), Technical Memorandum ORO-T-71(AFFE), October 1956, 67 pp. UNCLASSIFIED. Available from DTIC (AD-117 828).

2. Objectives and Scope. To aggregate from battle casualty experience in the Korean war quantitative information on the casualty rates, causative agent distributions, and agent lethality (as measured by the proportion of deaths among total casualties) associated with the various types of operations conducted in that war.

3. Populations Included. Eighth US Army, Korean theater of operations.

4. Timeframes Included. Korean war.

5. Casualty Types Included. Chiefly KIA, WIA, and MIA.

6. Time Intervals Included As. From start to end of the Korean war.

7. Situational Descriptors Defined As. (p 1) "The Korean war can be divided arbitrarily into intervals in which the predominant types of operations of Eighth Army as a whole were one of the following: Offensive against the main enemy force; Offensive against an organized delaying force; Offensive against a partly disorganized delaying force; Offensive against fortified hill positions; Defensive against the main enemy force; Defensive with main pressure on non-US units; Withdrawal; and Position warfare."

8. Data Sources Used. Official records of the US Army's Office of the Surgeon General and the Adjutant General.

9. Other and Miscellaneous. The following is a list of tables taken from the document's table of contents: Casualty rates and status distributions for different types of operation; Summary of casualty data; Death percentages for branches of service; Causative agents of infantry battle casualties in offensive operations; Causative agents of infantry battle casualties in defensive operations; Causative agents of infantry battle casualties in withdrawal operations; Causative agents of infantry battle casualties in positional warfare; and Ratio of frequency of causative agents in each type of operation to their average for all operations; Agent-activity distributions for positional warfare; Small arms percentages for various activities; Artillery and mortar death percentages for various activities; Hand grenade death percentages for various activities; Mine and booby trap death percentages for various activities; and Summary of death percentages for each type of activity.

10. Summary of Findings Regarding Battle Casualties. The following is quoted from the study's Summary Conclusions:

a. Casualty rates in withdrawals, defense against the main enemy force, and offense against the

main enemy force differed from the World War II average given in FM 101-10 by factors of 2, 1.3, and 1.1, respectively.

b. The proportion of KIAs among total casualties in defense against the main enemy force exceeded the proportion in offense against the main enemy force by a factor of 1.7.

c. The proportion of casualties caused by small arms in different types of operations varied from 23.6 to 58.4 percent. Higher proportions occurred in those operations in which movement of the MLR [Main Line of Resistance] was rapid. The proportions caused by artillery and mortars ranged from 25.2 to 64.9 percent; higher values occurred in those operations in which movement of the MLR was slow.

d. The order in which agents ranked on the basis of the percentage of deaths among total casualties was (i) small arms (28.4 percent), (ii) mines and booby traps (23.8 percent), (iii) artillery and mortars (18.4 percent), and (iv) hand grenades (10.8 percent). These percentages varied with the types of activity in which the casualties were immediately engaged.

11. Comments and Critique. The finding that the relative percentage of casualties caused by small arms increases with the rate of movement may explain some of the peculiar results of regressions of casualties on causative agent (cf. Burt-1965 and McQuie-1968).

COBEN-1986

1. Document Description. Coben, Patricia; and Palinkas, Lawrence A., "Combat Casualties Among US Navy Personnel in Vietnam: 1965-1972," Naval Health Research Center, PO Box 85122, San Diego, CA 92138-9174, Report No. 87-19, 8 December 1986, 22 pp. UNCLASSIFIED. Available from DTIC AD-A189 904.

2. Objectives and Scope. To provide a descriptive account of four distinct aspects of combat casualties among Navy enlisted personnel in Vietnam between 1965 and 1972: (i) types of personnel injured in battle; (ii) types of injuries; (iii) wounding agents; and (4) the flow of patients into and from medical facilities in Vietnam. Naval Health Research Center files were searched for all hospital admissions which were identified as a battle wound or injury. Diagnoses were grouped into categories of injuries such as fractures, contusions, burns, open wounds of the head, trunk, upper and lower limbs, and multiple open wounds. Age, sex, pay grade, length of service, race, rate, unit identification code, wounding agent, reporting facility, type of admission, and patient disposition upon discharge were also identified.

3. Populations Included. US Navy enlisted personnel.

4. Timeframes Included. Vietnam.

5. Casualty Types Included. Combat casualties.

6. Time Intervals Included As. 1965 to 1972.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Naval Health Research Center files (specifically the Enlisted Medical History File).

9. Other and Miscellaneous. Tables include Casualties by Demographic Characteristics; Combat Casualties by Diagnostic Priority and Diagnostic Group; Combat Casualties by Age and Primary Diagnosis; Combat Casualties by Pay Grade and Primary Diagnosis; Combat Casualties by Grouped Occupation and Primary Diagnosis; Combat Casualties by Wounding Agent; and Treatment Facilities, Type of Admission, and Disposition.

10. Summary of Findings Regarding Battle Casualties. Results are based on the records of 2,636 sailors who were wounded or injured in hostile action in Vietnam during the period between 1965 and 1972. Altogether, these individuals accounted for 7,419 battle-related first hospitalizations with one or more diagnoses of accidents, poisonings, and violence. Almost one-half (45.6 percent) of the sailors wounded in Vietnam were medical corpsmen and most were 24 years of age or younger (82.8 percent). Rockets and bombs, mortars and bazookas, shell fragments, mines and booby traps, and bullets accounted for over 80 percent of the wounds and injuries. Three-fourths of the casualties were treated at a Naval Hospital,

hospital ship, or the Naval Support Facility at Da Nang. More than half of these admissions were direct from the battlefield while the remainder were transfers from other medical facilities. The mortality rate of wounded patients was much lower than has been reported for Army and Marine Corps casualties in Vietnam or casualties in previous conflicts (died in hospital amounted to only 0.3 percent of admissions, discharges amounted to 89.4 percent, and the remainder were transferred to another hospital facility).

11. Comments and Critique. This provides useful information on the casualties to Navy enlisted personnel in Vietnam.

COCHRANE-1959

1. Document Description. Cochrane, Rexmond C., "The 3rd Division at Chateau Thierry, July 1918," US Army Chemical Corps Historical Office, Army Chemical Center, Maryland, Study Number 14, July 1959, 106 pp. UNCLASSIFIED. Available from DTIC (AD-A955 194).

2. Objectives and Scope. This is one of the series of US Army Chemical Corps Historical Studies [on] Gas Warfare in World War I. It describes the experience of the US 3rd Division in July 1918.

3. Populations Included. US 3rd Division.

4. Timeframes Included. World War I.

5. Casualty Types Included. Gassed, gunshot wound, and psychoneurotic.

6. Time Intervals Included As. From start to end of July 1918.

7. Situational Descriptors Defined As. Detailed narrative account of the action is provided.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Contains tables giving: Losses of 3rd Division in all Campaigns; Casualties in Division Hospital Records [including psychoneurotic casualties]; Report of Deaths, 3rd Division; Division Gas Officer Report; Daily Hospital Admissions, 15-31 July [by regiment and branch of service, including gassed, gunshot wounds, and psychoneurotic]; and Seventh Army [German] Casualties 1-30 July 1918.

10. Summary of Findings Regarding Battle Casualties. No general statements regarding battle casualties are offered.

11. Comments and Critique. This provides a useful account of a particular situation involving gas warfare in World War I.

COCKRELL-1974

1. Document Description. Cockrell, James K.; and Carter, Donn, "Research Study on Predictive War Game Factors," RMC Research Corporation, Unnumbered, March 1974, 251 pp. UNCLASSIFIED. Available from the Technical Center of the Supreme Headquarters, Allied Powers in Europe (SHAPE). Prepared under SHAPE Technical Center Contract C.72-03.

2. Objectives and Scope. From the Introduction: "The purpose of this effort was to produce data and algorithms that can be used in SHAPE computer war games to predict the outcome of engagements between ground units in non-nuclear war situations. Outcome measures were to be distance advanced and primary resource attrition suffered in 24-hour periods."

3. Populations Included. One hundred and fifty attack days by forces of brigade to division size against defenses in place (as opposed to delaying actions) during the first 18 days (16 Dec 1944 to 2 Jan 1945) of the Ardennes campaign of World War II (Battle of the Bulge), and a second set of 100 battle days from the Lorraine Campaign that occurred between 8 Sep and 27 Nov 1944 in eastern France.

4. Timeframes Included. World War II.

5. Casualty Types Included. Personnel and armored vehicle losses.

6. Time Intervals Included As. Daily.

7. Situational Descriptors Defined As. The tabulated data include the sector of the front, the date, the number of infantry platoon equivalents, tank strength, antitank firepower, artillery firepower, personnel casualties, tank and tank-equivalent losses, visibility, mobility, attacker and defender posture, and the distance advanced. For precise definitions of these descriptors, see the RMC report.

8. Data Sources Used. From p 7: "The US National Archives Captured Records Center was the primary source for German unit records and other documents. These included microfilmed copies of unit operational records, war maps, and results of interviews or responses from captured German division, corps, and army commanders and staff officers. ... For US battle day information the primary source was the National Records Center of the Archives. After action reports, daily and other periodic reports, journal files, histories, and order of battle studies from Army level down to battalion level were examined to establish the composition, location, disposition, mission and activity of the units of interest."

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties.

a. The following 25-term equation was fitted to the attrition data:

(Attrition, as percent of strength times 1,000) =

$$
\begin{aligned}
&+ c_0 \\
&+ c_1(\text{A Inf Pltns} - \text{A Inf Pltns}_0) \\
&+ c_2(\text{D Inf Pltns} - \text{D Inf Pltns}_0) \\
&+ c_3(\text{A Tks} - \text{A Tks}_0) \\
&+ c_4(\text{D ATank} - \text{D ATank}_0) \\
&+ c_5(\text{A Arty} - \text{A Arty}_0) \\
&+ c_6(\text{D Arty} - \text{D Arty}_0) \\
&+ c_7(\text{A Mecz} - \text{A Mecz}_0) \\
&+ c_8(\text{Def UnPrep} - \text{Def UnPrep}_0) \\
&+ c_9(\text{Hi Vis} - \text{Hi Vis}_0) \\
&+ c_{10}(\text{Tank Mob} - \text{Tank Mob}_0) \\
&+ c_{11}(\text{A Inf Pltns} - \text{A Inf Pltns}_0)^2/2 \\
&+ c_{12}(\text{D Inf Pltns} - \text{D Inf Pltns}_0)^2/2 \\
&+ c_{13}(\text{A Tks} - \text{A Tks}_0)^2/2 \\
&+ c_{14}(\text{D ATank} - \text{D ATank}_0)^2/2 \\
&+ c_{15}(\text{A Arty} - \text{A Arty}_0)^2/2 \\
&+ c_{16}(\text{D Arty} - \text{D Arty}_0)^2/2 \\
&+ c_{17}(\text{A Inf} - \text{A Inf}_0)(\text{D Inf} - \text{D Inf}_0) \\
&+ c_{18}(\text{A Inf} - \text{A Inf}_0)(\text{A Tks} - \text{A Tks}_0) \\
&+ c_{19}(\text{A Tks} - \text{A Tks}_0)(\text{D ATank} - \text{D ATank}_0) \\
&\quad c_{20}(\text{D Inf} - \text{D Inf}_0)(\text{D ATank} - \text{D ATank}_0) \\
&+ c_{21}(\text{D Arty} - \text{D Arty}_0)(\text{A Inf} - \text{A Inf}_0) \\
&+ c_{22}(\text{D Arty} - \text{D Arty}_0)(\text{A Tks} - \text{A Tks}_0) \\
&+ c_{23}(\text{D Arty} - \text{D Arty}_0)(\text{Hi Vis} - \text{Hi Vis}_0) \\
&+ c_{24}(\text{German Attack} - \text{German Attack}_0) \\
&+ \text{NormRanVar}(0,\sigma) \quad .
\end{aligned}
$$

Here zero subscripts indicate "standard values," A and D stand for the attacker and defender, Inf Pltns the number of infantry platoons per km of front, Tks the number of tanks per km of front, ATank the anti-tank firepower per km of front, Arty the number of artillery rounds per km of front, Mecz the percent of the infantry that are mechanized, UnPrep whether the defense positions are not "prepared," Hi Vis whether visibility exceeded 700 meters, Tank Mob whether tank mobility was unrestricted beyond the defender's position, German Attack whether the Germans were attacking or not, and NormRanVar$(0,\sigma)$ a normal random variable of mean 0 and standard deviation σ.

b. Four such fits to the data were obtained, one each for (i) attacker's tank attrition, (ii) defender's tank attrition, (iii) attacker's personnel attrition, and (iv) defender's personnel attrition. Each of these four cases requires its own peculiar set of "standard values" (*i.e.*, the X_0 values for X = A Inf, *etc.*), its own peculiar set of coefficient values (*i.e.*, the c_k for $k = 0$ to 24), and its own standard error of estimate (*i.e.*, σ). There is no evident pattern in these fitted values among the four cases considered.

11. Comments and Critique. At the request of the SHAPE Technical Center, the well-known British statistician, Dennis V. Lindley, then of the University College of London, reviewed the RMC report. His findings were reported to the SHAPE Technical Center as an informal report addressed to Dr. Rex Goad and dated 24 January 1976, and copies can be obtained from them. Prof Lindley abstained from a detailed review of the attrition data because "... a substantial amount of the attrition data is missing: furthermore, they appear to be missing in a systematic way, in the sense that the occasions when internal evidence suggests large losses are just those occasions where no casualty figures are available." He also faulted the RMC statistical analysis of rates of advance for overfitting (*i.e.*, introducing too many terms into the regression equation) and pointed out that this will inevitably produce an R^2 value that is misleadingly high and not actually justified by the basic data. Clearly, RMC's attrition analysis suffers similar faults, so that it cannot be used without further justification or confirmation from other sources.

COMPTON-1983

1. Document Description. Compton, Jonathon, "Personnel Attrition Data," US Army TRADOC Systems Analysis Activity, White Sands Missile Range, New Mexico, Technical Report TRASANA, TR-29-83, ACN 67513, November 1983, 229 pp. UNCLASSIFIED-Limited. Available from DTIC (AD-B085 206L).

2. Objectives and Scope. To provide and demonstrate the availability of the fractional distribution of historical casualty data and the tactical circumstances surrounding the distribution of those casualties among subunits of US Army divisions in combat in World War II. Casualty data are examined down to company level for three US Army divisions in three World War II battles. Losses incurred by units within the divisions are tabulated from corrected morning reports, for each day of battle, and for the battle as a whole. The tactical circumstances surrounding those losses are recorded in a day by day narrative to include the role which the four principal elements of tactical planning may have played in the battle: mission, enemy disposition, troops involved, and terrain (including weather).

3. Populations Included. US 6th Armored Division, Bastogne Offensive, 31 December 1944-3 January 1945; US 7th Armored Division, St. Vith Defense, 17-23 December 1944; and US 28th Infantry Division, Schmidt Campaign, 2-13 November 1944.

4. Timeframes Included. World War II, winter 1944.

5. Casualty Types Included. KIA, WIA, MIA, and Non-Battle.

6. Time Intervals Included As. Daily casualty data.

7. Situational Descriptors Defined As. Provided in the form of a narrative account of the action.

8. Data Sources Used. US archival records (see Compton-1984 for an account of the sources consulted).

9. Other and Miscellaneous. Includes numerous maps, tables, organization charts, and a few other figures.

10. Summary of Findings Regarding Battle Casualties. Research on historical personnel attrition data has generally been confined to losses incurred at the division level and above. The same data have often been regarded as representative of the casualty picture below the division level. However, few analysis of subunit personnel losses are based on actual casualty data, even though this is where the majority of division losses are taken. Valid historical data are available to determine within a division which subunits took the casualties and to account for the tactical situation at the time those casualties were taken. The data show that the relatively stable historical casualty rate picture often seen at division level is not indicative of the casualty rate incurred among subunits of that division. In each of the three

battle examined, subunit casualties at regimental, battalion, and company levels differed widely, and there is no apparent pattern for casualty distribution at the subunit levels for the battles examined.

11. Comments and Critique. This provides an important and perhaps unique tabulation of the casualties to units within a division down to the company level. Although little seems to have been done in the way of analysis or interpretation of these data, since the data are available, it would seem to be possible to supply that lack.

COMPTON-1984

1. Document Description. Compton, Jonathon, "Methodology for Collection of Personnel Attrition Data," Special Studies Division, US Army TRADOC Systems Analysis Activity, White Sands Missile Range, New Mexico, Special Studies Technical Memorandum TRASANA-TM-1-84, July 1984, 65 pp. UNCLASSIFIED. Available from DTIC (AD-B122 270L).

2. Objectives and Scope. To outline procedures and sources for obtaining historical personnel casualty and attrition data. This report provides the reader with research sources and points of contact dealing with historical personnel attrition data, procedures for obtaining data from these sources, and a listing of bibliographies and sources of data related to attrition. The material is designed to enable the user efficiently to locate and obtain personnel attrition data.

3. Populations Included. Not applicable.

4. Timeframes Included. Not applicable.

5. Casualty Types Included. Not applicable.

6. Time Intervals Included As. Not applicable.

7. Situational Descriptors Defined As. Not applicable.

8. Data Sources Used. Archival records, primarily.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. The following approach is intended to be applicable with little modification to the general class of research and studies requiring data on personnel attrition. It is based on the author's experiences in collecting the data used in his report on personnel attrition (see Compton-1983).

a. The first step is to select the battle for which data are to be collected and analyzed. Many factors of a particular study will tend to govern this selection; however, in each case a literature search will be required.

b. The second step is to determine the assigned and attached units to the division involved in the battle. The principal source for these data is the Division G-3 Journals located at the Federal Records Center in Suitland, Maryland, and a publication entitled *Order of Battle*, published by the Office of Military History, US Army, which can be obtained on inter-library loan.

c. The third step is to collect the casualty data at the company level using the corrected morning reports located in the Federal Records Center at St. Louis, Missouri.

d. The fourth step is to obtain the description of the tactical situations down to battalion and company level, when available, in which the personnel casualties were taken. The principal sources for this are military histories, the after action reports, and the corrected morning reports.

e. The fifth step is to list the data, by unit, for each day that unit was in the battle, and develop the casualty distribution by day for the entire battle. The tactical situation is then correlated with the casualty picture.

f. This process is then repeated for each division battle selected.

g. Research to obtain one division's worth of casualty data and the corresponding tactical scenario will take approximately one man-month of work, using the above approach.

11. Comments and Critique. This provides a useful and helpful account of the most efficient steps for obtaining historical personnel attrition data for units up to and including division size.

CONNERAT-1971

1. Document Description. Connerat, William H., *et al* "Combat Operations Loss and Expenditure Data-Vietnam (COLED-V)," Research Analysis Corporation (RAC), Report RAC-R-131, August 1971, 326 pp. UNCLASSIFIED. Available from DTIC (AD-887 034L).

2. Objectives and Scope. From the Summary: "The major objective of the COLED-V project was to establish a valid and useful data bank on the losses of equipment and the expenditures and losses of ammunition in counterinsurgency warfare under a variety of combat and environmental conditions. ... Two other objectives of the COLED-V project were to establish the level of confidence that could be placed in the data bank, and to develop a methodology for use of the data bank to predict losses and expenditures for a variety of counterinsurgency combat conditions."

3. Populations Included. Ammunition and major items of equipment.

4. Timeframes Included. Vietnam War.

5. Casualty Types Included. Personnel casualties related to combat vehicle losses were recorded as killed in hostile action (KHA) or wounded in hostile action (WHA).

6. Time Intervals Included As. From the Summary: "Data were collected during the Fiscal Years 1968, 1969 and 1970. During the last half of the FY70 the collection responsibility was transferred from CDC [the US Army's Combat Developments Command] to the Major Item Data Agency, an Army Materiel Command agency located at Letterkenny Army Depot, Chambersburg, Pa. In July 1970, the Army decided that the established data bank was sufficiently large to fulfill its primary requirement, and COLED-V data collection was terminated."

7. Situational Descriptors Defined As. Unit Identification (date of loss or expenditure, unit identification code, parent unit, operation, location of unit when item was lost or expended, corps tactical zone, table of organization and equipment (TOE)); Mission (reconnaissance in force, clear and secure, cordon and search, security, base camp defense, or not under attack); battle intensity (heavy, moderate, light, or inactive); Terrain Type (jungle, open, forest/plantation, marsh/rice paddy, high grass, mountainous, city/village, or gullies); Weather Conditions (clear, rain, fog, or overcast); Visibility (daylight or darkness); Item Peculiar Parameters (line item number, federal stock number, nomenclature, age, miles or hours operated, date manufactured, destination, disposition, combat or noncombat, cause of loss); Combat Vehicle Related Casualties.

8. Data Sources Used. From p 26: "The evaluation made use of two primary data sources: issue data and combat loss and expenditure data. Issue data were derived from 'Worldwide Ammunition Requirements and Asset Reports, RCS-1332', published monthly in compliance with Army Regulation AR 700-22. Combat loss and expenditure data were compiled by COLED-V from Form USARV 496 in

compliance with USARV Regulations 700-10. In addition to these data, ammunition expenditure data prepared by the II Field Force (IIFF) were utilized. These data were extracted from IIFF Form 45-R for the Calendar Year 1969, which is a feeder report to RCS-1322."

9. Other and Miscellaneous. Extensive statistical tabulations of equipment losses and ammunition expenditures are presented in the Appendices.

10. Summary of Findings Regarding Battle Casualties. No general statement is made regarding personnel casualties.

11. Comments and Critique. This provides a remarkably complete statistical analysis of the Vietnam data on equipment losses and ammunition expenditures. However, it contains little information specifically concerned with personnel casualties.

COOX-1951

1. Document Description. Coox, Alvin D.; and Naisawald, L. Van Loan, "Survey of Allied Tank Casualties in World War II," Operations Research Office (ORO), Technical Memorandum ORO-T-117, 31 March 1951, 119 pp. UNCLASSIFIED. Available from DTIC (ATI-108 423).

2. Objectives and Scope. To present a detailed analysis of Allied tank casualties in World War II. The present study analyzes every cause of tank casualties, based upon a sample of 12,140 Allied tanks. This sample was derived from US, British, Canadian, and French records, and from every theater of operations.

3. Populations Included. Allied tanks and tank crews. Some German tank loss data are included.

4. Timeframes Included. World War II.

5. Casualty Types Included. Personnel casualties include KIA, WIA, and MIA.

6. Time Intervals Included As. From start to end of a war.

7. Situational Descriptors Defined As. Include the theater of operations and the month, and the causative agent.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Includes numerous tables and figures.

10. Summary of Findings Regarding Battle Casualties. The findings regarding personnel casualties were as follows: Limited data on Allied tank crew casualties indicated that an average of 2.0 to 2.5 crewmen per tank became casualties, including killed, wounded, and missing in action, to attack by gunfire, hollow charge, or mines [losses of tanks from artillery fire were found to be minimal]. A breakdown of these figures by crew position revealed only slight differences. Tank commanders suffered the highest over all casualty rate—57 percent—of those engaged. The gunners and cannoneers followed with 51 percent, while the hull positions suffered somewhat less—bow gunners 48 percent, and drivers 47 percent. Thus no one crew position was markedly "safer" than another. An important corollary to this conclusion emerged from another sample studied; namely that casualties to tank personnel, wholly outside their vehicles, amounted to 40 percent of the total casualties sustained. Of this figure 30 percent, or 11 percent of the total, became casualties while trying to escape from immobilized tanks.

11. Comments and Critique. The crew casualties were not the main focus of this study. However, its findings in that regard are interesting and important.

COPP-1990

1. Document Description. Copp, Terry; and McAndrew, Bill, "Battle Exhaustion: Soldiers and Psychiatrists in the Canadian Army, 1939-1945," McGill-Queen's University Press, Kingston, Montreal, Canada, ISBN: 0-7735-0774-4, 1990, 249 pp. UNCLASSIFIED. Available from publisher and libraries (copy in CAA library under 940.547571 COP).

2. Objectives and Scope. This is purely historical work analyzing some aspects of the relationship between psychiatrists and the Canadian military from 1939 to 1945. It is presented as a chapter in both the history of war and the history of psychiatry.

3. Populations Included. Canadian army personnel.

4. Timeframes Included. World War II.

5. Casualty Types Included. Psychiatric.

6. Time Intervals Included As. Various.

7. Situational Descriptors Defined As. Very few descriptors are used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Table 1 on page 58 gives a tabulation of battle casualties (killed and wounded) and NP casualties for 28 November 1943 to February 1944. Table 2 on page 81 gives the number of NP and battle casualties for the period 25 March to 17 June 1944.

10. Summary of Findings Regarding Battle Casualties. Not clearly stated, but in general it appears that NP casualties are roughly proportional to battle casualties. Observes that many World War I psychiatric casualties may have received other less stigmatizing diagnoses.

11. Comments and Critique. This provides a useful account of the manner in which the Canadian Army handled psychiatric casualties during World War II.

CORDESMAN-1990

1. Document Description. Cordesman, Anthony H., and Wagner, Abraham R., "The Lessons of Modern War," in 3 volumes—Vol 1: The Arab-Israeli Conflicts, 1973-1989; Vol 2: The Iran-Iraq War; Vol 3: The Afghan and Falklands Conflicts, Westview Press, Boulder and San Francisco, 1990. Vol 3, ISBN: 0-7201-2045-4; Vol 2: ISBN: 0-7201-2044-6; Vol 3: ISBN: 0-7201-2043-8. Vol 1, 394pp; Vol 2, 647pp; Vol 3, 471 pp. UNCLASSIFIED. Available from publisher and libraries (CAA Library Number is 355.48 COR).

2. Objectives and Scope. Attempts to document and to interpret for the immediate future the salient features of the Arab-Israeli Wars, the Iran-Iraq War, the Afghan Conflict, and the Falklands War.

3. Populations Included. Generally those engaged in military or quasi-military operations. Examples of the latter are Palestine Liberation Organization (PLO) and Afghan guerrilla groups.

4. Timeframes Included. Various timeframes, peculiar to the various wars included.

5. Casualty Types Included. Sometimes just the killed and wounded. In some instances, the captured are also listed. It is not always clear whether or not "killed" includes those died of wounds.

6. Time Intervals Included As. Usually from start to end of a war.

7. Situational Descriptors Defined As. No descriptors are given in tabular form. However, the general circumstances and conditions surrounding the wartime operations and campaigns are provided in narrative form.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. No general findings regarding battle casualties are explicitly stated.

11. Comments and Critique. Because the material presented is usually for entire wars, it has only limited application to the PAR studies.

DATEL-1979

1. Document Description. Datel, William E., "The Reliability of Mortality Count and Suicide Count in the United States Army," Military Medicine, Vol 144, August 1979, pp 509-512. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To describe the extent of correspondence found in death occurrences as reported by the Office of the US Army Surgeon General (OTSG) and the Office of the US Adjutant General (OTAG), covering the same population for the same period of time. A subsidiary purpose is to describe similarly the agreement on suicide as a cause of death in the identical population.

3. Populations Included. US Army active duty personnel worldwide.

4. Timeframes Included. 1 January 1975 through 31 December 1976 (calendar years 1975 and 1976).

5. Casualty Types Included. All deaths, and deaths by suicide.

6. Time Intervals Included As. Calendar years 1975 and 1976.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. The Army epidemiologist is blessed with a work environment wherein two institutionalized and independently operated data systems record the same phenomenon—occurrence of death. Both OTSG and OTAG operate and maintain electronic data processing systems, which include as input the personal identifiers and related information on all deaths of the Army active duty soldiers. These two data systems are separate and distinct from each other, arising from differing sets of requirements and performing different missions. Input data are collected by different individuals, using different documents. The workers who operate the systems are organizationally and spatially located in two separate Army agencies.

A third list ["Suicide in United States Army Personnel," W. E. Datel and A. W. Johnson, Jr., Military Medicine, Vol 144 (1979), pp 239-244] of all active duty Army suicides for the same 2-year period was also available for comparison.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Battle casualties are not separately described in this publication. However, its findings regarding discrepancies between OTSG and OTAG reports are significant for future work on battle casualty reports. Those findings are as follows.

a. The OTSG reported 1,836 soldier deaths, of which 8 were duplicates or near duplicates. Eliminating the duplicates left 1,828 deaths.

b. The OTAG reported 2,237 soldier deaths, of which 59 were duplicates. Eliminating the duplicates left 2,178 deaths.

c. The number of deaths common to both OTSG and OTAG lists was 1,561. A total of 884 deaths appeared on only one of the two lists: 267 of these were unique to the OTSG list and 617 were unique to the OTAG list. Thirteen additional deaths were listed in the third (suicide) source used, but did not appear on either the OTSG or OTAG list. The total number of deaths listed then amounts to 2,458 (= 1,561 + 884 + 13). Thus, OTAG reported 16 percent more deaths than did OTSG. Together both of them reported 11 percent more deaths than the individual high count. There was only 63.5 percent commonality between the OTSG and OTAG lists. The OTAG list contained 89 percent of the 2,458 total deaths, while the OTSG list contained only 74 percent of them.

d. The annual mortality rate (deaths per 100,000 per year) could then vary from 116.9 to 163.1, depending on which number of deaths (1,828 to 2,458) is used [apart from uncertainties in the strength number used as the base for these rates].

e. The OTSG reported 132 suicides, the OTAG 172, and the third source 255. Combining these three lists produced a total of 302 suicides reported as such on at least one of the three lists. Of these, only 236 (78.1 percent) also appeared on the OTSG list of deaths and only 248 (82.1 percent) appeared on the OTAG list of deaths. The varying suicide counts produce a greater than 2 to 1 difference in the range of resultant annual suicide rates.

f. The conclusion reached is that the level of agreement in the 2-year soldier mortality count between the two parallel electronic data processing systems in the US Army is unacceptable for epidemiological purposes. It is further concluded that, when epidemiological counts are made on health events other than simple death tabulations—for example on cause of death due to suicide—the reliability between the systems compared drops even lower.

11. Comments and Critique. As the document itself says (p 511) "Some of the implications of an unreliable death record system are painfully obvious and need not be delineated. For the epidemiologist, the most destructive implication is the one of suspicion. If mortality cannot be counted reliably, how then must go morbidity? As regards death, we have quite hard criteria for case definition; case finding in morbidity is much more influenced by observer differences. How reliable are our counts of mental illness? Of hypertension? Of battle wounds?"

DATEL-1981

1. Document Description. Datel, William E., "On Studying Morbidity Across All Three Armed Services," Military Medicine, Vol 146, August 1981, pp 590-590 (*i.e.*, one page in length). UNCLASSIFIED. available from libraries.

2. Objectives and Scope. Announces the availability of a publication.

3. Populations Included. US Army, Navy, and Air Force.

4. Timeframes Included. 1970-1979 for the Army, and from 1970 through 1978 for the Navy and Air Force.

5. Casualty Types Included. Diseased and injured.

6. Time Intervals Included As. 1970-1979.

7. Situational Descriptors Defined As. Not specified.

8. Data Sources Used. Compiled from US Army Surgeon General monthly reports on *Health of the Army*, US Navy Surgeon General annual or semiannual publications on *Medical Statistics US Navy*, and US Air Force Surgeon General annual reports on *Biostatistics of the USAF Medical Service.*

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. The 115-page document entitled "Disease Rates in the Military During the 1970s," by William E. Datel, is available from DTIC. It documents morbidity trends over a 10 year period and facilitates comparisons between services, sexes, and diseases. Disease rates are reported for all conditions, disease, injury, mental disorders including drug and alcohol disorders, infectious intestinal diseases, hepatitis, upper respiratory disease, genital organ disease, fractures, and adverse effects from medicinal and non-medicinal substances. Also reported are the average number of hospital beds occupied, the hospitalization ratio, the non-effective ratio, and the number of outpatient clinic visits.

In conducting the study it was discovered that certain factors severely impede the making of valid comparisons within the data. Such factors have to do with differences in how the counts were performed, how the disease clusters are organized, and which populations are identified for reporting. A plea is made for formation of an inter-service task force to study and put forth recommendations for development and operation of a standardized, unified data base.

11. Comments and Critique. This provides a useful cautionary note in making comparisons between services based on their medical statistics. (See also Datel-1979.)

DAVIS-1953

1. Document Description. Davis, Stanley W., *et al*, "A Study of Combat Stress, Korea 1952 (Preliminary Report)," Operations Research Office (ORO), ORO-T-41 (FEC), Mar 1953, 204 pp. UNCLASSIFIED. Available from DTIC (AD-016 398).

2. Objectives and Scope. This report documents the technical findings of a field team composed of physiologists, psychologists, and one psychiatrist. The data relate to the physiological and psychological changes that occur in combat infantrymen as a result of combat stress. Some preliminary conclusions are adduced.

3. Populations Included. A sample of about 100 infantrymen on or (as a control sample) behind the Main Line of Resistance (MLR).

4. Timeframes Included. Korean War.

5. Casualty Types Included. The physiological tests consisted largely of obtaining blood, urine, and saliva specimens and examining them for various constituents. The psychological tests were of two general types: (i) assessing the change in response to accurately definable visual and auditory stimuli, and (ii) assessing changes in the higher mental functions.

6. Time Intervals Included As. Data were gathered in Korea and Japan during the months of September through November of 1952.

7. Situational Descriptors Defined As. The groups examined are described as follows:

Group I.- Eleven men at Camp Omiya, Japan (used as control).

Group II.- Twelve men at Camp Omiya, Japan (used as control).

Group III.- Thirty-nine men of a point Company in a major assault. This group stayed active in the combat area for 16 hours, and also included some wounded individuals.

Group IV.- Thirteen men who were part of a Company occupying the assault area for 5 days.

Group V.- Twelve combat infantrymen in Regimental reserve position.

Group VI.- Another twelve combat infantrymen in Regimental reserve position.

Group VIII.- Seven in a miscellaneous group comprising psychiatric casualties, one wounded, and one man from a combat patrol.

In addition.- Interviews with 32 experienced combat soldiers were held at Sasebo, Japan, where they were awaiting return to the United States.

8. Data Sources Used. Personal observations and laboratory measurements.

9. Other and Miscellaneous. Details of the technical data gathered are included in this document.

10. Summary of Findings Regarding Battle Casualties. From the Summary:

a. Analysis of blood and urine specimens disclosed definite physiological changes occurring as a result of combat.

b. Physiological disturbances were found which are considered to be new findings in that they have not been noted previously in investigations of the effects of physiological stress. They are: (i) dehydration, and (ii) almost total absence of certain types of adult white blood cells. (The decrease in adult white cells has been found by others in the severely burned, and the acutely infected. Finding these changes in cases of combat stress may indicate how severe that stress is.)

c. Further indication of the severity of the combat stress is denoted by the fact that, in general, physiological function had not returned to normal four days after exposure to combat.

d. The function of the adrenal gland, particularly the adrenal cortex, in front-line infantrymen not in active combat, is normal, while following severe combat stress there is a prolonged, high level of adrenal activity.

e. The psychological tests of higher mental function used in this research failed to demonstrate a significant change in response to combat stress.

f. The administration of complex physiological and psychological tests to front-line infantrymen who had just been engaged in major combat proved feasible under conditions existing in Korea during the fall of 1952.

g. Through proper indoctrination, it is possible to obtain the complete cooperation of both officers and enlisted men designated as subjects for this type of experimentation despite their lack of complete understanding and considerable physical discomfort to themselves.

h. In this study it was found to be particularly difficult and at times impossible to control adequately such important variables as time and place of measurement, activity of the subjects, and food intake of the subjects.

i. During interviews with combat veterans, effective leadership was cited as one of the most important factors in lessening the stressful experiences of combat.

11. Comments and Critique. This study is an important, and possibly unique, contribution to the study of combat stress in terms of its physiological and psychological impact.

DAVIS-1954

1. Document Description. Davis, Stanley. W.; and Taylor, J. G., "Stress in Infantry Combat," Operations Research Office (ORO), Technical Memorandum ORO-T-295, 30 September 1954, 103 pp. UNCLASSIFIED. Available from DTIC (AD-69 455).

2. Objectives and Scope. To determine the extent to which combat stress affects the tactical usefulness of infantrymen and infantry units.

3. Populations Included. Able and George Companies, US 31st Infantry Regiment, 7th Division, plus a third group of men from three rifle companies of the US 15th Infantry Regiment, 3d Division.

4. Timeframes Included. Korean War.

5. Casualty Types Included. Casualty types were not central to this study.

6. Time Intervals Included As. Described as follows.

a. Able Company was the lead company in an attack on the Triangle Hill area north of Kumwha on 14 October 1952. The combat was intense and lasted 18 hours during which they suffered 61 percent casualties.

b. George Company occupied from 15 to 20 October [1952] a defense position in the same combat area that Able Company had attacked. It took 17 percent casualties during this less intense 5 day combat period.

c. The companies from which the third group was drawn had been assigned a regimental blocking position immediately behind the Main Line of Resistance (MLR) on the central front. Although not committed to combat, they were called on for frequent patrols and were subjected to heavy artillery fire.

7. Situational Descriptors Defined As. See the description of time intervals given immediately above. The document itself contains maps and narratives of the action.

8. Data Sources Used. Experimental measurements.

9. Other and Miscellaneous. Twelve psychological measures were employed to assess the effects of combat stress on such complex behavior as judgment, memory, abstraction, and the sensitivity of neural mechanisms. Twenty seven physiological measure were used.

a. Able Company was measured prior to combat and three times afterward (delays of 12 hours, 5 days, and 22 days).

b. George Company was measured twice post combat (delays of 12 hours and 11 days).

c. The third group was measured twice (testing times separated by 11 days).

10. Summary of Findings Regarding Battle Casualties. No specific findings regarding battle casualties. the findings do include the following.

a. There is evidence that being in a blocking position behind the MLR does not alter the normal physiological function of combat infantrymen.

b. A short period of intense combat results in a characteristic set of physiological changes for the average infantryman (a high degree of adrenal responsiveness, increased protein destruction, and a shift in the balance of body salts).

c. A period of prolonged, less intense combat results in a different set of physiological changes in the average infantryman (a low degree of adrenal responsiveness, normal protein destruction, and a shift in the balance of body salts opposite to that observed in short, intense combat).

d. Time taken to recover to normal physiological levels after intense combat of 18 hours is approximately 6 days; after less intense combat of 5 days it takes approximately 13 days.

11. Comments and Critique. As the document itself states, "The conclusions drawn in this study of necessity deal with the alternations of body function and, as such, do not satisfy the final goal, which is to provide the infantry commander with an understanding of the extent to which combat stress affects tactical usefulness of men and units."

DELBRUCK-1913

1. Document Description. Delbruck, Hans, "Numbers in History," published for the University of London Press by Hodder & Stoughton, London, 1913, 77 pp. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To present some considerations on the subject of numbers in battles.

3. Populations Included. Participants in battle.

4. Timeframes Included. From early times to the date of publication.

5. Casualty Types Included. Not clearly defined.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Subtitled "How the Greeks defeated the Persians, the Romans conquered the world, the Teutons overthrew the Roman Empire, and William the Norman took possession of England." The book is based directly on two lectures by the author to the University of London on 6 and 7 October 1913. These lectures themselves are based on the author's famous life work, "History of the Art of War Within the Framework of Political History," a four-volume work, originally published in German in the early 1900's. An English translation by Walter J. Renfroe, Jr. has been published by Greenwood Press, Westport, Connecticut. The English translation of Volume 1 was published by them in 1975, ISBN 0-8371-6365-X (CAA library number 355.009 DEL). The English translation of Volume 2 was published by them in 1980, ISBN 0-8371-8163-1 (CAA library number 355.009 DEL V2).

10. Summary of Findings Regarding Battle Casualties. No specific general findings regarding battle casualties are offered. However, the author does state (p 11) that "as important as the number are in war and in the decision of war, just as difficult is the determination of these numbers for the historian."

11. Comments and Critique. The author is famous for his critical analysis of the numbers reported for several notable battles, such as Marathon, Salamis, Cannae, Agincourt, and others. These lectures underline his cautions regarding the veracity of numerical reports of strengths and casualties.

DENTON-1969

1. Document Description. Denton, Frank H., "Factors in International System Violence—1750 to 1960," The RAND Corporation, Paper P-4216, October 1969, 32 pp. UNCLASSIFIED. Available from RAND and libraries.

2. Objectives and Scope. Gives a progress report on research still in its early stages. Describes the procedure for collecting data and presents a few initial findings.

3. Populations Included. Warring nations.

4. Timeframes Included. From 1750 to 1960.

5. Casualty Types Included. Not clearly defined.

6. Time Intervals Included As. From start to end of a war.

7. Situational Descripto.s Defined As. Those warlike actions that resulted in at least 1,000 casualties.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Claims that 296 violent incidents meeting the criteria of size and European civilization participation were found. The following distribution of casualties by incident are reported.

Casualty range	Percentage of incidents
1,000- 2,000	40.8
2,000- 6,000	21.6
6,000-15,000	16.6
15,000-30,000	8.5
Over 30,000	12.4

11. Comments and Critique. This paper is a preliminary report. It is not known whether any further efforts were made along the line indicated. See also Brinkerhoff-1985, Richardson-1960, Singer-1972, Small-1982, and Wright-1942.

DOD-1991

1. Document Description. Directorate for Information Operations and Reports (DIOR), "Worldwide US Active Duty Military Personnel Casualties—October 1, 1979 through December 1, 1991," US Department of Defense, M07, Dec 1991, 38 pp. UNCLASSIFIED. Available from DTIC and NTIS (AD-A248 397).

2. Objectives and Scope. To provide data on worldwide active duty military personnel casualties as reported during the period October 1, 1979 and December 31, 1991. It is intended to provide summary information for the Office of the Secretary of Defense and various other Department of Defense (DOD) and Federal Government offices. It is not a record of day-to-day casualty counts. Since there is a lead time for casualty information to be reported by field activities to the military service casualty offices and then to the Office of the Secretary of Defense, the data cannot be used for publication or release as current data. The information has been generated from an automated data base of casualty information certified and reported by the military services. The reports presented for publication are based on the reporting requirements set forth in DOD Instruction 7730.63, "Reports on Active Duty Military Personnel Casualties in Official Combat Areas and in Noncombat Areas," dated August 26, 1982. This publication includes only those personnel casualties reported by date of publication. Subsequent casualty reports will be included in future publications with appropriate adjustments.

3. Populations Included. Worldwide US forces, by service.

4. Timeframes Included. 1 October 1979 to 31 December 1991.

5. Casualty Types Included. KIA; DOW; Died While Missing; Died While Captured; deaths due to Accident, Illness, Homicide, Self-Inflicted, Pending; Missing (MIA and Captured/Interned); Missing (Nonhostile); Returned to Military Control (from MIA, from Captured, and from Nonhostile Missing).

6. Time Intervals Included As. Same as Timeframe.

7. Situational Descriptors Defined As. As indicated in tables listed in paragraph 9 below.

8. Data Sources Used. The principal personnel agencies of the various services.

9. Other and Miscellaneous. Table of Contents includes the following tables: Total; Army; Navy; Air Force; Marine Corps; Casualties by Casualty Group and Military Service, October 1, 1979 through December 31, 1991; Deaths by Casualty Type and Military Service; Deaths by Home State of Record and Military Service; Deaths by Pay Grade and Race; Deaths by Pay Grade and Military Service; Deaths by Attained Age and Military Service; Deaths by Place of Casualty and Military Service; and Deaths by Place of Casualty and Casualty Group.

10. Summary of Findings Regarding Battle Casualties. None stated.

11. Comments and Critique. This provides a useful summary of deaths worldwide for US forces over an extended period of time. See also Datel-1979 and Datel-1981.

DODGE-1890

1. Document Description. Dodge, Theodore Ayrault, "Alexander: A History of the Origin and Growth of the Art of War From the Earliest Times to the Battle of the Ipsus, BC 301, With a Detailed Account of the Campaigns of the Great Macedonian," The Riverside Press, Cambridge, First edition 1890, second edition 1898, *ca.* 690 pp. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. As stated in the title.

3. Populations Included. Participants in battle.

4. Timeframes Included. As stated in the title.

5. Casualty Types Included. Killed and wounded in combat.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Occasionally given in narrative form.

8. Data Sources Used. Not given.

9. Other and Miscellaneous. Appendix B gives a table of "Losses in Some Ancient Battles," including Marathon, Plataea, Chaeronea, Thebes, Granicus, Issus, Arbela, Jaxartes, and Hydaspes.

10. Summary of Findings Regarding Battle Casualties. States that "The wounded are mostly estimated at the usual [for its time] rate of ten wounded to one killed, which is low. Twelve to one would be nearer." Gives a comparison between the losses in these ancient battles and the "usual per cent" based on the US Civil War experience, according to which KIA in the US Civil War ran about 4 or 5 percent and had a WIA/KIA ratio equal to about 3.

11. Comments and Critique. Note that Dodge does not give a clear definition of "wounded." His figures are intriguing, but may not be accepted without confirmatory evidence.

DODGE-1891

1. Document Description. Dodge, Theodore Ayrault, "Hannibal: A History of the Art of War Among the Carthaginians and Romans Down to the Battle of Pydna, 168 BC, With a Detailed Account of the Second Punic War," The Riverside Press, Cambridge, 1891, *ca.* 680 pp. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. As stated in the title.

3. Populations Included. Participants in battle.

4. Timeframes Included. As stated in the title.

5. Casualty Types Included. Killed and wounded in combat.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Occasionally given in narrative form.

8. Data Sources Used. Not given.

9. Other and Miscellaneous. Appendix A gives a table of "Casualties in Some Ancient Battles," including Marathon, Plataea, Chaeronea, Thebes, Granicus, Issus, Arbela, Megalopolis, Jaxartes, Hydaspes, Heraclea, Asculum-279BC, At Rhone, Geronium, Cannae, Nola 2, Beneventum, Nola 3, Asculum-209BC, Grumentum, Metaurus, Crotona, Mago's Battle, and Zama.

10. Summary of Findings Regarding Battle Casualties. States that "From the difficulty of determining the wounded, only the killed are given in the above table. The discrepancies are not greater than can be found in histories of our own [*i.e.*, the US] civil war. A discussion on losses in ancient battles will be appended to the table in the volume on Caesar."

11. Comments and Critique. Dodge's figures are intriguing, but may not be accepted without confirmatory evidence.

DODGE-1895

1. Document Description. Dodge, Theodore Ayrault, "Gustavus Adolphus: A History of the Art of War From its Revival After the Middle Ages to the End of the Spanish Succession War, With a Detailed Account of the Campaigns of the Great Swede, and of the Most Famous Campaigns of Turenne, Conde, Eugene and Marlborough," The Riverside Press, Cambridge, 1895, *ca.* 860 pp. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. As stated in the title.

3. Populations Included. Participants in battle.

4. Timeframes Included. As stated in the title.

5. Casualty Types Included. Killed and wounded in combat.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Occasionally given in narrative form.

8. Data Sources Used. Not given.

9. Other and Miscellaneous. Appendix B gives a table of "Casualties in Some Modern Battles," including Breitenfeld, Alte Veste, Lutzen, Nordlingen, Rocroy, Marston Moor, Freiburg, Allerheim, Lens, St. Antoine, Arras, The Dunes, Sinsheim, Senef, Entzheim, Narva, Luzzara, Klissow, Schellenberg, Blenheim, Ramillies, Turin, Oudenarde, Malplaquet, and Pultowa.

10. Summary of Findings Regarding Battle Casualties. In general, appears to estimate the number wounded in these battles at the rate of about 2 wounded to 1 killed. Gives a comparison between the ancient battles and statistics based on the US Civil War, according to which KIA in the US Civil War ran about 4 or 5 percent and had a WIA/KIA ratio equal to about 3.

11. Comments and Critique. Note that Dodge does not give a clear definition of "wounded." His figures are intriguing, but may not be accepted without confirmatory evidence. In particular, they should be compared to those in Bodart-1908.

DODGE-1900

1. Document Description. Dodge, Theodore Ayrault, "Caesar: A History of the Art of War Among the Romans Down to the End of the Roman Empire, With a Detailed Account of the Campaigns of Caius Julius Caesar," The Riverside Press, Cambridge, 1900, *ca.* 800 pp. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. As stated in the title.

3. Populations Included. Participants in battle.

4. Timeframes Included. As stated in the title.

5. Casualty Types Included. Killed and wounded in combat.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Occasionally given in narrative form.

8. Data Sources Used. Not given.

9. Other and Miscellaneous. Appendix A gives a table of "Casualties in Some Ancient Battles," including Marathon, Plataea, Chaeronea, Thebes, Granicus, Issus, Arbela, Megalopolis, Jaxartes, Hydaspes, Heraclea, Asculum-279BC, Rhone, Geronium, Cannae, Nola 2, Beneventum, Nola 3, Asculum-209BC, Grumentum, Metaurus, Crotona, Mago's Battle, Zama, Aduatuca, Gergovia, Ilerda, Pharsalus, Thapsus, and Munda.

10. Summary of Findings Regarding Battle Casualties. In general, appears to estimate the number wounded in ancient battles at the rate of ten wounded to one killed. Gives a comparison between the ancient battles and statistics based on the US Civil War, according to which KIA in the US Civil War ran about 4 or 5 percent and had a WIA/KIA ratio equal to about 3.

11. Comments and Critique. Note that Dodge does not give a clear definition of "wounded." His figures are intriguing, but may not be accepted without confirmatory evidence.

DODGE-1904

1. Document Description. Dodge, Theodore Ayrault, "Napoleon: A History of the Art of War, From Lutzen to Waterloo, With a Detailed Account of the Napoleonic Wars," The Riverside Press Cambridge, ISBN numbers of the AMS reprint are 0-404-02160-3 for the entire four-volume set, 0-404-02164-6 for volume four, Published in four volumes from 1904 to 1907, reprinted by AMS Press. Inc. in 1970, *ca.* 770pp (Volume 4 only). UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. As stated in the title.

3. Populations Included. Participants in battle.

4. Timeframes Included. 1644 to 1815, with passing reference to some battles of the US Civil War, the Franco-German War of 1870/71, and the Crimean War.

5. Casualty Types Included. Killed and wounded (combined) in combat.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Occasionally given in narrative form.

8. Data Sources Used. Not given.

9. Other and Miscellaneous. Appendix E to Volume 4, entitled "Modern Casualties," gives tables of (i) Number [and percent] Killed in Some Modern Battles, (ii) Number [and percent] Killed and Wounded [combined] in Some Modern Battles, (iii) Percentage from Above Tables of Killed and Wounded Per Numbers and Nations, (iv) Percentage of Killed and Wounded Per Nation, (v) Sundry Casualties in Recent Wars.

10. Summary of Findings Regarding Battle Casualties. In the introductory remarks to his casualty tables in Appendix E to Volume 4, Dodge states that "Accuracy throughout these tables cannot be assumed. The numbers in Frederick's battles, given by the Great German General Staff, may be relied upon. Those of the Franco-German War and of our [*i.e.*, the US] Civil War are correct. But the numbers present and the loses in the [French] Revolutionary and Napoleonic battles, and in most of those of that or prior eras, on either side, are largely estimated, with a tendency to increase the casualties. Some are no doubt properly stated, although never with the accuracy of our Civil War records, where every man killed or wounded is accounted for on the muster-rolls. Some might be cut down by a quarter. The averages may, however, come within 12 or 15 percent of the truth, and we have no better sources than those from which these figures are drawn. As such tables always possess a peculiar interest, they are appended.

"It must constantly be borne in mind that the smaller the number engaged, the larger the proportionate loss the men will stand; and that to average the losses of many battles will produce a

smaller percentage than to average those in few, because in part the fighting is less stubborn.

"Thus, a body of 10,000 men often loses 25 percent killed and wounded in one battle; but a body of 100,000 men rarely loses more than 10 or 12 percent, Similarly, the average losses in fifty battles will be much lower than those in ten.

"The column of 'Usual Percentages' gives about the average loss, *in stoutly contested battles* [emphasis in original], of the number engaged. This has been got at by averaging many hundred battles.

"Only those battles are given in which the losses are fairly ascertained. Many noted battles are omitted for lack of data."

11. Comments and Critique. Note that Dodge does not give a clear definition of "wounded." His figures are intriguing, but may not be accepted without confirmatory evidence. In particular, they should be compared to those in Berndt-1897 and Bodart-1908. Also, Dodge's description of the "usual percentages" given here should be compared to that of Dodge-1890.

DOST-1972

1. Document Description. Dost, Helmut E., "Marine Corps and Army Helicopter Employment and Attrition Statistics for Southeast Asia Operations From October 1965 Through December 1971," Center for Naval Analyses, Marine Corps Operations Analysis Group Study MCOAG-Study-1008, October 1972, in 2 volumes. UNCLASSIFIED. Available from DTIC AD-523 337 (Volume 2).

2. Objectives and Scope.

3. Populations Included. US Marine Corps and US Army helicopters.

4. Timeframes Included. October 1965 through December 1971.

5. Casualty Types Included. Helicopter losses.

6. Time Intervals Included As. Not specified.

7. Situational Descriptors Defined As.

8. Data Sources Used. Official records of helicopter operations.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Volume 2 presents tables of monthly data summaries of sortie expenditure and attrition. The presentation covers an overall accumulation of 2,434,000 combat helicopter sorties by the US Marine Corps and 31,074,000 combat helicopter sorties by the US Army. There were 247 combat losses to US Marine Corps helicopters and 1,899 to US Army helicopters. An additional 28 (Marine) and 167 (Army) helicopters were lost to ground attacks.

11. Comments and Critique. Since this publication deals with equipment losses, it is only of tangential interest to the PAR studies.

DOUGHERTY-1990

1. Document Description. Dougherty, Paul J., "Armored Vehicle Crew Casualties," Military Medicine, Vol 155, September 1990, pp 417-420. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To review the nature of possible injuries to crew members of armored fighting vehicles as reflected in historical and experimental data.

3. Populations Included. Armored vehicle crew members.

4. Timeframes Included. World War II, Arab-Israeli War of October 1973, and Vietnam War.

5. Casualty Types Included. Primarily the wounded in action.

6. Time Intervals Included As. From start to end of a war.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Tables include Causes of Damage to Tanks; and Anatomical Distribution of Wounds.

10. Summary of Findings Regarding Battle Casualties. The anatomical distribution of wounds to armored vehicle crew members appears to be similar to that for infantrymen. However, the distribution of crew members who are killed in action is somewhat higher than the overall occurrence of soldiers killed in action for a major campaign (24.9 percent for armor crew members in the Sixth Armored Division during 10 months of operations in northwest Europe in 1944 and 1945, versus 21.3 percent for the infantry soldiers). Furthermore, they experience a larger number of burn casualties (25 percent for tank crew members versus about 10 percent to 12 percent overall incidence for hospitalized patients). They also experience a higher proportion of open fractures and traumatic amputations (45 percent for extremity wounds to tank crew members versus about 31 percent to 37 percent for US soldiers in World War II). Casualties of armor vehicle crew members are different from those of conventional infantry soldiers, who have historically dominated combat casualty statistics. If armor/mechanized units are used in a future war of high intensity, such as the October 1973 Arab-Israeli war, the Army Medical Department must be prepared to handle a somewhat different casualty load, which includes a larger number of burned casualties as well as possibly a larger number of open fractures and traumatic amputations.

11. Comments and Critique. The findings and conclusions of this article are interesting. However, the author himself observes that "The anatomical distribution of injuries to armored vehicle crew members only is hard to obtain."

DREA-1983

1. Document Description. Drea, Edward J., "Unit Reconstitution—A Historical Perspective," Combat Studies Institute, US Army Command and General Staff College, No 3, 1 December 1983, 79 pp. UNCLASSIFIED. Available from national Defense University Library (UB 146.D74 1983). Prepared for the US Army Combined Arms Operations Research Activity (CAORA).

2. Objectives and Scope. To address the following questions:

a. What criteria might a commander use to withdraw a unit from combat operations; what criteria constitute grounds for the commander to recommend a unit be withdrawn from combat?

b. How does the distribution of casualties within a particular unit affect unit reconstitution?

c. What is the logistical system's response to personnel or equipment losses much above anticipated levels?

3. Populations Included. Historical examples, mainly from World War I and World War II, were used to illustrate the process of unit reconstitution and to suggest general criteria for identifying units needing reconstitution. Special emphasis is placed on US 28th Infantry Division's experience at Schmidt.

4. Timeframes Included. Mainly World War I and World War II, with some material from the Arab-Israeli Wars and Vietnam.

5. Casualty Types Included. Combat and non-combat losses.

6. Time Intervals Included As. Various.

7. Situational Descriptors Defined As. Provided as part of the narrative accounts.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Observes that after about 30 to 40 days on the line in an active theater, people tire and get careless and sick rates and casualty rates climb steeply. States that post World War II studies indicated that the average combat infantryman was unfit for service duty after 200 to 240 aggregate combat days—any man in combat that long and still uninjured who displayed signs of "combat exhaustion" would require at least six months treatment to make him useful for a noncombat assignment. In the Italian Campaign, the British estimated that their riflemen would last 400 combat days because they rotated them out of the line at the end of each 12 days for a 4 day rest. In Fifth Army (Italy) a rifle battalion could expect to lose from battle and non-battle casualties about 25 percent strength after 30 days; 40 percent after 50 days; 60 percent after 100 days; 90

percent after 200 days, and be virtually destroyed after 300 combat days (10 combat days = 17 calendar days).

It is also stated (page 39) that "While casualty figures should provide the best guide for a commander about the status of his forces, accurate casualty figures are normally unavailable until several days after the fact, if ever. At Schmidt the 28th Division lacked information about events at foxhole level that exacerbated this natural lag in reporting. Furthermore, one commander deliberately supplied misleading information to division in order to conceal the extent of his regiment's reverses." Tabulates (pp40-41) the official report of casualties and requisitions for replacements by day for the 28th Division during the Schmidt fighting.

11. Comments and Critique. For the most part, only tangentially related to the PAR studies. However, the comments about combat exhaustion are potentially important.

DUMAS-1923

1. Document Description. Dumas, Samuel; and Vedel-Petersen, K. O. "Losses of Life Caused by War," Clarendon Press, Oxford, 1923, 191 pp. UNCLASSIFIED. Available from US Navy Library (D 25.5 .D8).

2. Objectives and Scope. To present some data on losses of life in wars, and to offer a few observations upon them.

3. Populations Included. Mostly combatants in wars, but with some attention to the civil population.

4. Timeframes Included. From the Seven Year's War (1756-1763) through World War I.

5. Casualty Types Included. The emphasis is on deaths, but some distinction is often made between killed, wounded, died of wounds, and died of disease.

6. Time Intervals Included As. For an entire war.

7. Situational Descriptors Defined As. The chapter in Part I on "Various Influences Upon the Loss of Life Occasioned by War" discusses the influence of such factors as the season, the scene of operations, the commissariat, clothing, arms, medical service, sanitation, nationality, recruitment, military training, and leadership.

8. Data Sources Used. Various.

9. Other and Miscellaneous. In two parts bound in one volume: Part I (Up to 1913) and Part II (The World War). Table of Contents for Part I includes the following: The Sources; Total Losses Occasioned by War; Losses According to Rank; Losses According to Branches of Service; Losses According to Various Military Classes [mainly actives versus reserves]; Various Influences Upon the Loss of Life Occasioned by War; The Mortality of the Civil Population; The Army in Time of Peace; and Conclusion. The Table of Contents for Part II includes the following: Military Losses (Belligerent Countries; British Empire; France; Germany; Austria-Hungary; Italy; and Summary); Civil Losses (Great Britain and Ireland, France, Italy, Germany, Austria-Hungary, and Finland). Includes numerous tables.

10. Summary of Findings Regarding Battle Casualties. The available data have serious shortcomings, but may be the best obtainable. In proportion to their relative numbers, losses of officers substantially exceeds that of men. Prior to World War I it was often the case that deaths from disease equaled or exceeded those killed in action. Infantry regularly suffered the bulk of the casualties, both numerically and proportionally. The proportion of wounded who died of wounds tended to be around 10 to 15 percent. Fratricide caused significant casualties (but the actual numbers are not cited).

11. Comments and Critique. This is a classical and widely-consulted work. However, its editor describes it as preliminary and somewhat tentative. Its figures are often based on disparate criteria (*i.e.*, one table will give killed, another killed and wounded, and yet another killed and died of wounds). Accordingly, they have to be read carefully to see what they include or exclude. Except in selected instances, attrition rates cannot be inferred because the size of the population at risk is not given. However, there seems to be enough information presented for some of the wars to estimate the ratio of wounded to killed.

DUNN-1971

1. Document Description. Dunn, L. P., "A Lanchester Fit to Selected Land Battles," Lulejian and Associates, February 1971, 46 pp. UNCLASSIFIED. May be available from DTIC. A copy of the original is in Helmbold's personal files. Prepared for Assistant Chief of Staff, Studies and Analysis, Headquarters, US Air Force, under Contract No. F44620-70-C-0056.

2. Objectives and Scope. Presents the results of a regression analysis of 182 land battles, from 280 BC to 1945, to determine appropriate coefficients for a fit of the time invariant integral of a generalized Lanchester relationship.

3. Populations Included. Combatants in land combat battles.

4. Timeframes Included. From 280 BC to 1945.

5. Casualty Types Included. Losses (which sometimes represent total battle casualties, and sometimes only the killed and wounded).

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. None, except for the name of the battle and its date.

8. Data Sources Used. Primarily Helmbold's CORG reports (see Helmbold-1961 and Helmbold-1964a).

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Victory tends to be correlated with the attrition ratio. Chronological grouping of the data indicates that the Lanchester exponent increases with time. A separate regression on World War II data results in a Lanchester exponent midway between a linear law and a square law and good correlation when using the generalized Lanchester equations. Mistaken identification of the attacker and defender can cause sizable errors in the regression.

11. Comments and Critique. Since the analysis presented here falls afoul of the Constant Fallacy (see Helmbold-1993), its findings regarding the form of attrition relation are incorrect. However, the correlation of victor with attrition ratio is consistent with the other findings.

DUPUY-1970

1. Document Description. Dupuy, R. Ernest; Dupuy, Trevor N., "The Encyclopedia of Military History from 3500 BC to the Present," Harper & Row, Publishers, New York, Library of Congress Card No. 74-81871, 1970, 1406 pp. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. To present to both scholar and general reader a comprehensive survey of the history of war and of military affairs in the world throughout recorded human experience; and to provide a reliable, relatively complete, and authoritative reference work covering the entire sweep of world military history.

3. Populations Included. Various.

4. Timeframes Included. From 3500 BC to the present.

5. Casualty Types Included. Various, and often unstated.

6. Time Intervals Included As. Various.

7. Situational Descriptors Defined As. Given in narrative form.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Organized by chronology and geographically. The chronology is divided arbitrarily into 21 specific time periods, and one chapter is devoted to each period. Each chapter is introduced by an essay on the principal military trends of the period, which is followed by a chronological survey of the major wars of the period, and then by military operations of more limited extent according to individual geographic regions.

10. Summary of Findings Regarding Battle Casualties. None offered.

11. Comments and Critique. This provides a useful compendium of information on military operations. It is particularly well indexed.

DUPUY-1977

1. Document Description. Dupuy, T. N., "Analyzing Trends in Ground Combat," History, Numbers, and War: A HERO Journal, Vol 1, No 2, Summer 1977, pp 77-91. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To analyze the validity of the following ten propositions.

a. As advancing technology has made weapons increasingly lethal, changes in warfare become more radical than in the past.

b. Casualty rates have declined over the years.

c. History proves that a successful attacker should be three times as strong as the opposing defender.

d. The numerically inferior force is usually victorious.

e. The moral is the physical as 3 to 1.

f. God is on the side of the heavier battalions.

g. Modern technology permits faster advance rates in combat.

h. The October Arab-Israeli War casualty rates were higher than those of previous wars.

i. In the October Arab-Israeli War more tanks were lost to anti-tank missiles and rockets than to guns.

j. In the October Arab-Israeli War, 70 percent of the tank casualties were knocked out by guns (mostly tank guns); the tank is still the best anti-tank weapon.

3. Populations Included. Various.

4. Timeframes Included. Various, but generally from about 1600 to 1977.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. Not specified, but usually from start to end of a battle.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. This material also served as the basis for a chapter in *Numbers, Prediction, and War: The Use of Military History in Combat Analysis*, by T. N. Dupuy, Bobbs-Merrill, 1977.

10. Summary of Findings Regarding Battle Casualties. These are as follows.

a. Despite revolutionary changes in weapons technology, changes in tactics have been slow to adapt.

b. Casualty rates have tended to decline with the passage of time, but there have been occasional local exceptions to this trend.

c. The 3-to-1 figure is not very helpful as a guide, since a 3-to-1 superiority has not consistently been either necessary nor sufficient for victory in battle.

d. Since the better-known battles tend to be ones in which the underdog overcame its opponent, it is possible that this effect may have led some to believe that numerical inferiority is a virtue. But if that is the basis, it is hazardous to generalize it to other cases.

e. The speed of movement of large forces over great distances appears to reflect limitations on human capability more than it reflects the road speed of trucks.

f. In fact, casualty rates in the October Arab-Israeli War were not higher than the historical trends would suggest.

g. It may be that Egyptian anti-tank missiles were very effective against Israeli tanks early in the war, but that as the Israelis adapted to them (and as their tactical situation changed from defending to attacking) losses from tank guns dominated.

11. Comments and Critique. This is an interesting *tour d'horizon* by a noted military historian. It illustrates the difficulties in gathering and interpreting historical data relevant to several important issues regarding casualties and their effect on combat outcome. It can also serve as a useful source of hypotheses for more detailed investigation. However, some of the numerical data presented differ from that found in other works by the same author.

DUPUY-1982

1. Document Description. Dupuy, T. N.; and Martell, Paul, "Great Battles on the Eastern Front," The Bobbs-Merrill Company, Inc, ISBN 0-672-52674-3, 1982, 249 pp. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. To describe selected campaigns on the Eastern Front in World War II.

3. Populations Included. Combatants in campaigns.

4. Timeframes Included. World War II, Eastern Front.

5. Casualty Types Included. Casualties not reported.

6. Time Intervals Included As. From start to end of a campaign.

7. Situational Descriptors Defined As. Narrative accounts of the major campaigns on the Eastern Front are provided.

8. Data Sources Used. Various, but not indicated.

9. Other and Miscellaneous. Includes numerous tables and a figures. However, no casualty data are presented.

10. Summary of Findings Regarding Battle Casualties. No generalizations regarding battle casualties are offered.

11. Comments and Critique. Although no information on casualties is provided, this source is quite useful in describing the major campaigns on the Eastern Front in World War II, and in providing information on the forces involved in them. If information on casualties in Eastern Front operations should become available, this book could be quite helpful in interpreting them.

DUPUY-1986

1. Document Description. Dupuy, Trevor N.; Brinkerhoff, John R.; Johnson, Curtiss C., "Ground Forces Attrition in Modern Warfare," Historical Evaluation and Research Organization, January 1986, 208 pp. UNCLASSIFIED. Limited edition, copy in Helmbold's personal files. Much of this material later appeared in Dupuy-1990, *q.v.*

2. Objectives and Scope. To provide military analysts with some background information that will help them understand and analyze current combat operations and project the possible outcomes of future combat.

3. Populations Included. Combatants in battles.

4. Timeframes Included. Various.

5. Casualty Types Included. Various, and often unspecified.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Handled only sketchily.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Includes a selected list of some of the principal sources consulted.

10. Summary of Findings Regarding Battle Casualties. Many assertions regarding battle casualties are offered.

11. Comments and Critique. Since it is impossible to relate the assertions regarding battle casualties directly to the totality of data, they need to be treated more as hypotheses than findings. Some of the more significant assertions are the same as those put forward by Berndt-1897 and Bodart-1908 (though not attributed to them). Nevertheless, this is an ambitious work and provides an interesting collection of material. *See* Dupuy-1990 for a more widely accessible presentation of essentially the same material.

DUPUY-1990

1. Document Description. Dupuy, T. N., "Attrition: Forecasting Battle Casualties and Equipment Losses in Modern War," HERO Books, Fairfax, VA, ISBN 0-915979-26-8, 1990, 176 pp. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. To provide scholars with an understanding of the military significance of personnel and materiel attrition in modern or contemporary war. An incidental purpose is to provide military and intelligence analysts with background information that will help them understand and analyze the dynamics of combat. The basis for this treatment of attrition is the historical analysis of combat.

3. Populations Included. Combatants.

4. Timeframes Included. Mainly from 1600 to 1973.

5. Casualty Types Included. Focuses on battle casualties but also discusses: the relation of WIA to KIA; the relation of DNBI to battle casualties; the impact of improved medical care; and the distribution of casualties by branch of service and rank.

6. Time Intervals Included As. Primarily from start to end of a battle, with a few remarks on casualties from start to end of a war.

7. Situational Descriptors Defined As. Attention is given to terrain, weather, posture, strength/size, surprise, and sophistication.

8. Data Sources Used. Various, and not always identified.

9. Other and Miscellaneous. Includes numerous tables and figures.

10. Summary of Findings Regarding Battle Casualties. Too numerous to summarize briefly.

11. Comments and Critique. This is essentially a commercialized version of Dupuy-1986, and many of the same comments apply. Nevertheless, this is a useful collection of material in a widely available form, and provides an excellent source of hypotheses

EGGENBERGER-1967

1. Document Description. Eggenberger, David, "A Dictionary of Battles," Thomas Y. Crowell Co., New York, Library of Congress Card No. 67-12400, 1967, 526 pp. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. Attempts to provide the essential details of all the major battles in recorded history, which number over 1,560 separate and distinct military engagements.

3. Populations Included. Combatants.

4. Timeframes Included. From 1479 BC to the 1960s.

5. Casualty Types Included. Various.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Given in the narrative descriptions.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Battle descriptions are listed under their geographic locations.

10. Summary of Findings Regarding Battle Casualties. No generalizations regarding battle casualties are offered.

11. Comments and Critique. This provides a useful compendium of information on battles.

EISNER-1964

1. Document Description. Eisner, Mark J.; and Son, Sam Buu, "Spike Wounds in the Vietnamese Guerrilla War," Research Analysis Corporation (RAC), Technical Memorandum RAC-T-420 (SEA), Feb 1964, 25 pp. CONFIDENTIAL. Available from DTIC (AD-349 593).

2. Objectives and Scope. To compile statistics on the number and nature of spike wounds as a basis for decisions concerning the development of protective devices.

3. Populations Included. Admittees to Republic of Vietnam Armed Forces (RVNAF) hospitals for 1962.

4. Timeframes Included. Vietnam War.

5. Casualty Types Included. Spike wounds.

6. Time Intervals Included As. 1962.

7. Situational Descriptors Defined As. The data are analyzed by province of origin, activity level, physiological location of wounds, type of wounding agent, and local vegetation category.

8. Data Sources Used. RVNAF hospital records.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Too detailed to summarize here–see the original document.

11. Comments and Critique. This provides an insight into the wounding characteristics of certain types of unconventional weapons.

EMBER-1987

1. Document Description. Ember, Melvin, "Human Relations Area Files (HRAF)," Yale University, 1987. UNCLASSIFIED. Available from HRAF.

2. Objectives and Scope. The Human Relations Area Files (HRAF) is an international, not for profit educational and research organization whose primary purpose is to foster the comparative study of human behavior, study of human behavior, society, and culture. Based at Yale University, HRAF has been developing programs and services to this end since it was incorporated nearly 40 years ago. Organized as a consortium, HRAF is supported primarily by the annual membership dues of some 200 colleges, universities, libraries, museums and research institutes in the Unites States and 20 other nations. Its staff of 20 includes nine social scientists, five of whom hold Ph.D.'s. The HRAF archive provides a unique service to subscribing members in the form of easy to use cross-referenced cultural data. Available on microfiche, each full package includes information on nearly 350 different national and ethnic groups around the world.

3. Populations Included. Societies.

4. Timeframes Included. Various.

5. Casualty Types Included. Various.

6. Time Intervals Included As. Various.

7. Situational Descriptors Defined As. Various.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. The HRAF files have been used in a study of warfare among primitive peoples, sponsored by the National Science Foundation. This works suggests that warfare among such groups often is triggered by sudden catastrophes (such as drought, flood, pestilence, or frost) leading to severe deprivation and the resultant desperate need for food and other resources. Other factors did not seem to be as important in triggering warfare among primitive peoples.

11. Comments and Critique. The information in the HRAF files is rather far removed from that of interest to the PAR studies. However, it is a potentially valuable resource that could be drawn upon for certain investigations.

ENGEL-1954

1. Document Description. Engel, Joseph H., "A Verification of Lanchester's Law," Journal of the Operations Research Society of America, Vol 2, No 2, May, 1954, pp 163-171. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To show how to verify the applicability of certain generalized Lanchester equations to a simple combat situation where there is strong *a priori* reason for believing that the equations are valid.

3. Populations Included. US and Japanese forces.

4. Timeframes Included. World War II.

5. Casualty Types Included. KIA and battle casualties.

6. Time Intervals Included As. From start to end of the battle of Iwo Jima.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Primarily official US Marine Corps histories of the action.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. From the concluding remarks: "A technique has been shown for verifying the applicability of a certain type of generalized Lanchester equations to a certain kind of combat situation. This technique was applied to an analysis of the battle of Iwo Jima, in which it was found that the equations did describe the situation. The parameters characterizing this situation were determined."

11. Comments and Critique. This seminal paper inspired many subsequent analyses and explorations of the validity of simple combat attrition laws such Lanchester's square law and analogues or generalizations of it.

ENGEL-1963

1. Document Description. Engel, Joseph H., "Combat Effectiveness of Allied and German Troops in the World War II Invasion of Crete," Operations Evaluation Group (OEG), Interim Research Memorandum IRM-35, 8 February 1963, 12 pp. UNCLASSIFIED. Available from Center for Naval Analyses and DTIC.

2. Objectives and Scope. An analysis is made of statistics pertaining to the landing of German troops, and landing or withdrawal of British and allied troops during the invasion of Crete by the Germans in World War II, using information on total casualty experience on each side, and assumptions that Lanchester's Law holds. The combat effectiveness of the average individual troops on each side are computed and compared with similar figures for the battle of Iwo Jima.

3. Populations Included. German and allied troops.

4. Timeframes Included. World War II.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. Thirteen days from start of the German landings to the end of the Crete operation.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Mainly an unpublished Operations Research Office (ORO) analysis of the airborne invasion of Crete.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Data, characterized as estimates, on the daily strengths and losses for the Crete operation are presented. The analysis indicates that the Germans were more efficient in causing casualties (per individual German) than the allied (British and Greek) forces. The figures used in this report (of the 21,300 Allied casualties, 5,200 were killed) imply that the WIA/KIA ratio amounted to 3.1 (16,200/5,200).

11. Comments and Critique. The data may provide a weak check on the form of the attrition relation. Compare this with Engel-1954 and other works on the form of attrition relationships.

ETHERIDGE-1981

1. Document Description. Etheridge, Elizabeth W.; and Anderson, Michael R., "Criteria for Reconstitution of Forces," US Army Combined Arms Combat Developments Activity, Combined Arms Studies and Analysis Activity, Fort Leavenworth, KS 66027, Technical Report TR 7-81, September 1981, 128 pp. UNCLASSIFIED. Available from DTIC (AD-A111 803).

2. Objectives and Scope. To relate the need for reconstitution actions to the condition of a unit in combat. The approach was to construct a standard series of descriptors of a unit's condition for each of several scenarios, and then to ask officers to evaluate the combat effectiveness of the unit and to decide whether it needed to be reconstituted. Descriptors of unit condition included remaining personnel strength; status of the unit's major weapon systems and equipment; ability of the support system to perform routine resupply and repair; combat support (primarily field artillery and close air support); commander's perception of enemy strength, condition, and intentions; and selected intangible factors such as strength and experience of leadership, unit cohesion, troop training, and morale.

3. Populations Included. Hypothetical mechanized infantry battalion task force defending in Europe.

4. Timeframes Included. Hypothetical scenario.

5. Casualty Types Included. Not explicitly used.

6. Time Intervals Included As. Casualties presumably were those which might be experienced by the hypothetical battalion task force in its hypothetical future operations.

7. Situational Descriptors Defined As. As indicated in paragraph2 above.

8. Data Sources Used. Responses to questionnaires.

9. Other and Miscellaneous. Questionnaire was administered in April 1981 to a sample of Infantry and Armor officers in the US Army Command and General Staff College, and in October 1981 to Infantry and Armor officers at the US Army War College and in the Advanced Courses at the US Army Infantry School and the US Army Armor School.

10. Summary of Findings Regarding Battle Casualties. (Paraphrased from the study summary.) In spite of written comments by the officer respondents emphasizing the importance of leadership, troop quality, and enemy capabilities, they were not much influenced by these indicators or by the status of combat support in deciding whether the hypothetical unit needed to be reconstituted. Instead, they focused almost exclusively on the status of personnel and materiel resources. Moreover, they responded to the reconstitution questionnaire in much the same way regardless of experience levels or rank. Personnel status was the overriding consideration for all groups in determining whether the unit needed reconstitution. When personnel strength is reduced to 40 or 50 percent, or when major equipment

availability is reduced to 30 or 40 percent, decisions are needed on reconstitution. The respondents were influenced very little by their knowledge of threat capabilities, or by intangible indicators of the quality of leadership and of troops.

11. Comments and Critique. Although this study is only tangentially related to the PAR analysis, it provides useful information on the potential weight of objective effects (such as attrition) versus other factors in the military decision process.

FAIN-1970

1. Document Description. Fain, William W.; Fain, Janice B.; Feldman, Leon; and Simon, Susan, "Validation of Combat Models Against Historical Data," Consolidated Analysis Centers Inc. (CACI) and Center for Naval Analyses (CNA), Professional Paper No. 27, 14 April 1970, 18 pp. UNCLASSIFIED. Available from publisher and DTIC.

2. Objectives and Scope. Discusses the validation of warfare models through the use of historical data.

3. Populations Included. Combatants.

4. Timeframes Included. Korean War.

5. Casualty Types Included. Battle casualties.

6. Time Intervals Included As. Varies by campaign.

7. Situational Descriptors Defined As. Discusses the Heartbreak Ridge, Soyang River I, Soyang River II, and Inchon-Seoul campaigns.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. From p 17: "What we have done is demonstrate that [the Tactical Warfare Simulation Program] TWSP does allow a sufficient range of tactical and maneuver options to match real life behavior and that when tactics similar to those used in real life are employed, attrition of the Lanchester form in TWSP produces casualties that agree reasonable well with casualties of historical record."

11. Comments and Critique. Contains many sound comments on the philosophical underpinnings and practical methods for undertaking model validation as applied to combat models.

FAIN-1977

1. Document Description. Fain, Janice B., "The Lanchester Equations and Historical Warfare: An Analysis of Sixty World War II Land Engagements," History, Numbers, and War, Vol 1, No 1 (Spring), 1977, pp 34-52. UNCLASSIFIED. Available from libraries. Originally published as an Unclassified paper contained in the Proceedings of the 34th Military Operations Research Symposium, December 3-5, 1974 (SECRET).

2. Objectives and Scope. To repeat Willard's analysis (see Willard-1962) using a different data base.

3. Populations Included. Combatants in battles.

4. Timeframes Included. World War II.

5. Casualty Types Included. Total battle casualties.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. All of the sixty battles were fought in the Italian Theater in the vicinity of Salerno, Volturno, Anzio, and Rome during the period September 1943 to June 1944.

8. Data Sources Used. Taken from the HERO report "A Study of the Relationship of Tactical Air Support Operations to Land Combat, Appendix B, Historical Data Base," dated 1971. This Historical Evaluation and Research Organization report was prepared for the United Kingdom's Defence Operational Analysis Establishment (DOAE) under contract D-4052.

9. Other and Miscellaneous. Includes numerous tables and figures.

10. Summary of Findings Regarding Battle Casualties. Force ratios are not good predictors of victory in combat. The Willard regression coefficient for the 60 battles is -0.413 versus Willard's value of -0.594. Fain interprets this to indicate that Lanchester's square law is not valid.

11. Comments and Critique. Fain's interpretation of the regression coefficient is incorrect because the regression approach used commits the Constant Fallacy (see Helmbold-1993).

FAIN-1988

1. Document Description. Fain, Janice B., *et al*, "Forced Changes in Combat Posture," Data Memory Systems, Inc., 30 September 1988, 237 pp. UNCLASSIFIED. Available from DTIC. Prepared for the US Army Concepts Analysis Agency under Contract No. MDA903-87-C-0807. See also the article "Armored Combat Simulation Predict's War's Consequence," by Charles F. Hawkins, in Signal, July 1992, pp 29-30.

2. Objectives and Scope. To determine the causes of and relationships governing forced changes of tactical posture by military units in combat, for the purpose of improving the representation of transitions from one tactical posture to another in Army combat simulations and war games.

3. Populations Included. US land combat forces involved in forced posture changes.

4. Timeframes Included. World War II to the present.

5. Casualty Types Included. Total battle casualties.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Similar to those described in the CAA Data Base of Battles (*see* CAA-1991).

8. Data Sources Used. Uses a total of 83 battles fought since 1940 and involving US forces, 59 from the CAA-1991 and 24 from Anderson-1988.

9. Other and Miscellaneous. The breakpoint model proposed here was later revised by Hawkins—see (among others) Hawkins, Charles F., "Armored combat Simulation Predict's War's Consequence," Signal, July 1992, pp 29-30.

10. Summary of Findings Regarding Battle Casualties. Proposes breakpoint models that require as inputs such items as the following, together with selected threshold values.

a. Distance advanced/width of front.

b. Final personnel ratio.

c. Attacker casualties.

d. Defender casualties.

e. Final casualty ratio.

11. Comments and Critique. This study ignores certain crucial past works in the area of breakpoint analysis. It also commits the statistical sin of overfitting. In fact, its results on breakpoints can be explained much more simply by the ADV parameter than by the complicated scheme it proposes (*see*

Helmbold-1986 and Helmbold-1990). However, the additional battle data generated to support it are useful.

FM-1987

1. **Document Description.** US Army Command and General Staff College, Fort Leavenworth, KS, "Staff Officer's Field Manual, Organizational, Technical, and Logistical Data," US Army, Field Manual FM 101-10-1 (vol 1 is FM 101-10-1/1, Vol 2 is FM 101-10-1/2), October 1987, (Vol 1, 1459pp; Vol 2, 365pp). UNCLASSIFIED. Available from Department of the Army. Volume 2 includes the following information.

Chapter 1 contains engineer planning data for specialized tasks in each major engineer mission area: mobility, countermobility, survivability, general engineering, and topographic operations which support combat operations. Data listed are intended only to be a guide for division or higher level staff planners. The United States Army Engineer School at Fort Belvoir, Virginia, is the proponent for this first chapter.

Chapter 2 contains supply planning data to include the food, water, clothing, equipment, arms, ammunition, fuel, and materials needed to conduct combat operations. The proponent for this chapter is the United States Army Logistics Center at Fort Lee, Virginia.

Chapter 3 provides detailed transportation and movement planning data used for computing transportation requirements in support of military operations by air, motor, rail, and water. The United States Army Logistics Center at Fort Lee, Virginia, is the proponent for Chapter 3.

Chapter 4 contains planning data for strength accounting, replacement operations, casualty forecasting and reporting, and administrative services. The proponent for this chapter is the United States Army Soldiers Support Center at Fort Benjamin Harrison, Indiana. The main subsections of Chapter 4 (Personnel Service Support) are: Planning Considerations; Enemy Prisoners of War, Terrorists, and Enemy Civilian Internees; Military Prisoners and Crime Rates; and Personnel Losses, Loss Estimates, and Replacements. The main subsections of Chapter 5 (Health Service Support Planning for Evacuation and Hospitalization) are: Planning Considerations; Medical Evacuation Policy; Medical Transportation: Calculation of Patient Evacuation Requirements; Planning Hospital Beds; and Calculation of Hospital Bed Requirements.

Chapter 5 presents health service support planning data for evacuation and hospitalization. The United States Army Academy of Health Sciences, Fort Sam Houston, Texas, is the proponent for this chapter.

Chapter 6 contains guidance for operational force requirements planning. It includes general background material and information on combat service support development, planning procedures, combat service support structure, and combat service support development. The proponent for this chapter is the United States Army Command and General Staff College, Fort Leavenworth, Kansas.

2. Objectives and Scope. From the Preface: "FM 101-10-1 consists of 2 volumes. This first volume provides planning data for commanders and staff officers (planners) at all echelons. These planning data pertain to table(s) of organization and equipment (TOEs) and standard requirement codes (SRCs) which are limited to divisions, armored cavalry regiments, separate brigades, and airborne special forces groups. Volume II contains planning factors for engineer, supply, transportation and movement, personnel services, health services, and operational force requirements. Data pertaining to corps and theater Army units' TOEs are in FM 101-10-2." It incorporates the latest developments and changes available to support the AirLand Battle doctrine an the Army of Excellence. It is for use by staff officers at all echelons as a guide for obtaining planning data in support of combat operations. It provides data which can be applied to combat, combat support, and combat service support units from theater through company.

3. Populations Included. US Army.

4. Timeframes Included. World War II, Korean War, Mid-East Wars, and Vietnam Conflict.

5. Casualty Types Included. Battle and nonbattle losses, KIA, WIA, DOW, CMIA, DNBI.

6. Time Intervals Included As. Various.

7. Situational Descriptors Defined As. Communications zone; combat zone (infantry, mechanized, and armor divisions, and nondivisional units); in the attack (covering and security force action, meeting engagement, of a position—first day and succeeding days, of a fortified zone—first day and succeeding days); on the defense (meeting engagement, of a position—first day and succeeding days, of a sector—first day and succeeding days, inactive situation, pursuit, retirement and delay).

The loss rate planning factors in Vol 2 apply primarily at Division and Corps level. Loss rate planning factors include those for distribution of battle losses by branch of service for Infantry, Armored, and Airborne divisions (Table 4-17); for battle and nonbattle losses for divisions in contact, divisions in corps and reserve, and nondivisional units as a function of general type of operations for the force as a whole (covering and security force action attack and defense, with several subcategories under each of these two) (Table 4-18); Korean War experience (Tables 4-19 and 4-22); World War II experience (Tables 4-20 and 4-22); special estimates for airborne operations (Table 4-23); and theater level planning factors (Table 4-26).

8. Data Sources Used. Not identified.

9. Other and Miscellaneous. Volume 1 contains TOEs, but is not relevant to PAR. Volume 2's chapters 4 and 5 are relevant to PAR. Chapter 4, on Personnel Service Support, contains the following major sections:

a. Planning considerations (Introduction; Finance services).

b. Enemy Prisoners of war, terrorists, and enemy civilian internees (Enemy prisoners of war—conventional operations; Enemy prisoners of war—stability operations; Terrorists: Enemy civilian internees).

c. Military prisoners and crime rates (Military prisoners; Crime rates).

d. Personnel losses, loss estimates, and replacements (Personnel losses; Nuclear, biological, and chemical loss estimates; Combat zone loss estimates; Communications zone loss estimates; Theater-level nonnuclear loss estimates; Replacements).

Chapter 5, on Health Service Support Planning for Evacuation and Hospitalization, contains the following major sections:

a. Planning considerations (Introduction; Battle casualties; Patient admissions and admission rates; Classification of patients; Estimation of probable patient workload).

b. Medical evacuation policy (Theater evacuation policy; Intratheater evacuation policy; Impact of theater evacuation policy on health service support requirements; Factors determining the evacuation policy; Acceptable percentage of fill for available hospital beds).

c. Medical transportation (Coordination; Resources).

d. Calculation of patient evacuation requirements (Time factors; Computations).

e. Planning hospital beds (Factors influencing the number of operating beds; Designated bed capacity).

f. Calculation of hospital bed requirements (Application of methodology; Definition of terms; Example problem; Methodology for the combat zone; Methodology for the communications zone; Methodology for the continental United States; Nuclear, biological, and chemical operations; Estimation of enemy prisoner of war bed requirements; Changes in evacuation policy).

Tables are set forth showing various types of loss rates for various wars, echelons, and types of operation.

10. Summary of Findings Regarding Battle Casualties. The findings are too numerous to summarize here, but see paragraphs 7 and 9 above.

11. Comments and Critique. The document contains neither descriptions of nor references to the sources and methods used to arrive at the tabulated values and proposed estimation procedures. Accordingly, their validity cannot be verified.

12. Summary of Findings Regarding Battle Casualties. See paragraph 7 above.

13. Comments and Critique. This document provides the official planning factors. However, they are presented with ample cautions that various adjustments to them should be made to adapt them to

specific conditions according to the actual situation. Unfortunately, the nature of such adjustments, and how they are to be made, are not very clearly explained, and appear to depend almost entirely upon expert judgment.

FM-1991

1. Document Description. Academy of Health Sciences (HSHA-TD), Fort Sam Houston, Texas, "Health Service Support in a Theater of Operations," US Army, FM 8-10, 1 March 1991, 173 pp. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. This manual explains the purpose of health service support in a theater of operations. It discusses the current health service support system structure and the modernization initiative known as Medical Force 2000. This modernization initiative is to be completed by the year 2000. As the keystone manual of the Army Medical Department, Field Manual FM 8-10 is for the use of nonmedical unit commanders and their staff, command surgeons, and medical unit commanders and their staff. It is to be used as a guide in obtaining as well as providing health service support in a theater of operations. Information in this publication is applicable across the operational continuum. It is compatible with the Army's combat service support doctrine in support of the AirLand Battle. A series of field manuals currently under development will provide techniques and procedures for specific health service support organizations and activities in the theater of operations. These manuals will be published over the next several years.

3. Populations Included. Various.

4. Timeframes Included. Not used.

5. Casualty Types Included. Various.

6. Time Intervals Included As. Not used.

7. Situational Descriptors Defined As. Discussed only in general terms.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. No specific findings presented.

11. Comments and Critique. This document provides a useful description of the organization, doctrine, and functions of the US Army medical health support system in a theater of operations. The viewpoint is rather general, but provides a broad perspective upon the health service support system, within which more specific items can be seen in proper relationship to one another. By its concentration on the health care system, however, it provides little or no information on the casualty categories other than WIA and DNBI.

FOX-1889

1. Document Description. Fox, William F., "Regimental Losses in the American Civil War, 1861-1865," Albany Publishing Company, Albany, NY, 1889, 582 pp. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To record various statistics about losses to regimental sized units during the Civil War.

3. Populations Included. Mostly Union troops.

4. Timeframes Included. American Civil War.

5. Casualty Types Included. Killed, wounded, died of wounds, and died of disease.

6. Time Intervals Included As. Not specifically identified.

7. Situational Descriptors Defined As. Only a few descriptors are used, other than the names of the battles.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Table of Contents includes the following: Maximum of killed in Union regiments; maximum of percentages; maximum of regimental losses in any one battle; proportion of wounded to killed; Percentage of killed in various regiments in particular battles; losses in officers, general, surgeons and chaplains; loss in each arm of the service; deaths from disease; classification of deaths by cause; the colored troops; 300 fighting regiments—statistics and historical sketch of each; complete list of battles, with regiments sustaining greatest loss in each, and their casualties; the number killed and deaths from disease or other causes; Confederate losses. Includes numerous tables.

10. Summary of Findings Regarding Battle Casualties. The ratio of wounded in action to killed in action is about 4.8, but varies greatly in particular instances. Total regimental battle losses (including killed in action, died of wounds, wounded in action, and missing in action) ran as high as 82 percent in one case. However, such losses in excess of 50 percent were unusual. Page 541 gives a tabulation o Union losses (killed, wounded, and missing) in the following battles: Gettysburg, Spotsylvania, Wilderness, Antietam, Chancellorsville, Chickamauga, Cold Harbor, Fredericksburg, Manassas-1862, Shiloh, Stone's River, and Petersburg Assault.

11. Comments and Critique. Most of the figures on killed are for killed in action plus died of wounds within some unspecified time after the battle. Many of the other tabulations are for losses to regiments during the entire war, or are for regiments in particular battles with no indication of how strong the regiments were or what units opposed them. Thus, the information is of limited use to PAR.

Page 559 quotes General Order No. 63, dated 14 May 1863, to Lee's Army of Northern Virginia to the effect that casualty reports are no longer to include the number of men taken into action nor those lightly wounded. The same page indicates that at least some units responded to this by reporting only those wounded who would have to be discharged (thereby omitting those lost to their unit for some period of time who eventually returned to it).

GIDDINGS-1955

1. Document Description. Giddings, W. Philip; and McFetridge, Elizabeth M. (eds), "Volume II: General Surgery (of the series *Surgery in World War II*, prepared by the US Army Medical Department)," Office of the Surgeon General, US Army, 1955, 374 pp. UNCLASSIFIED. Available from libraries (copy in National Defense University Library, RD 270.G36 1955, c.1).

2. Objectives and Scope. This volume of general surgery is set apart from other volumes of the history of the Medical Department of the United States Army in World War II by a number of special considerations. It provides a picture not only of surgery performed in forward Army medical units, but of extremely urgent surgery; all abdominal injuries constituted emergencies, and all casualties with abdominal injuries were nontransportable.

3. Populations Included. Some 3,154 abdominally injured patients of the 2d Auxiliary Surgical Group.

4. Timeframes Included. World War II (specifically the campaigns of Monte Cassino, Rapido River, Anzio Beachhead, Gustav Line, Volterra, Invasion of Southern France, Gothic Line Assault, Colmar Pocket, Saar Valley, and Bavaria).

5. Casualty Types Included. Abdominally injured.

6. Time Intervals Included As. Basically from January 1944 to mid-May 1945.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Official records of the 2d Auxiliary Surgical Group.

9. Other and Miscellaneous. Major subsections include: (Part I) Resuscitation, Control of Pain, and Anesthesia; (Part II) Abdominal Injuries and the Initial Surgery of Abdominal Wounds; (Part III) Colostomy. Includes numerous figures and a few tables.

10. Summary of Findings Regarding Battle Casualties. Not specifically called out. Pages 82-83 and 85-88 detail the source of the data and major issues in its interpretation. Page 90 gives a chart of the number of abdominal injuries treated each week from January 1944 to May 1945. Page 91 gives a chart of their distribution by branch of service. Page 94 notes the case fatality rate of about 24 percent. Page 97 notes that about 97 percent of the 3,154 abdominal injuries were caused by missiles of war (2,123 or 70 percent by high explosive fragmenting weapons of various types and the remainder by small arms weapons). Pages 97-99 describe the anatomical location of these wounds. Pages 103-106 discuss the effects of delayed treatment on the case fatality rate and concludes that the case fatality rate depends jointly on the severity of the wound and on the time lag from wounding to operation.

The chain of evacuation is described on pages 9-10 as follows. Resuscitation began at the battalion aid station, ordinarily located about 500 yards behind the line of combat. Here (as in the collecting and

clearing stations further to the rear) the main objective was to make the patient transportable, so therapy was limited to measures such as control of hemorrhage, splinting and bandaging, closure of sucking chest wounds, or administration of plasma or morphine.

Collecting stations were located about a mile beyond the battalion aid stations. Division clearing stations were usually located about 5 miles behind the collecting station, were reached by an ambulance, and could care for about 100-150 patients at a time. Here the patient's status was carefully appraised and it was decided whether he could withstand the additional journey of several miles to the evacuation hospital, where necessary surgery could be performed, or whether he should be taken at once to the field hospital for emergency surgery. The field hospital, which consisted of three platoons, with a capacity of 100 beds per platoon, was located adjacent to the division clearing station. It was staffed and equipped for major emergency surgery and for the care of patients for a maximum of 12 days after operation. It was always far forward—near, or sometimes in front of, heavy artillery positions.

Patients operated on in a field hospital were eventually moved to the rear. Whenever possible, they were returned to duty directly from an army hospital. If this was not practical, they were moved, as soon as their condition permitted, to a station or general hospital. These were fixed installations, equipped and staffed for the performance of reparative operations designed to hasten healing, prevent irreparable damage or deformity, and expedite the wounded person's return to duty.

11. Comments and Critique. This provides a valuable insight into the treatment of abdominal wounds by the 2d Auxiliary Surgical Group. It is not clear how widely their experience can be generalized.

GILCHRIST-1928

1. Document Description. Gilchrist, H. L., "A Comparative Study of World War Casualties from Gas and Other Weapons," Chemical Warfare School, Edgewood Arsenal, 1928, 51 pp. UNCLASSIFIED. Available from libraries (copy from US Army Military History Institute, Carlisle Barracks, PA).

2. Objectives and Scope. From the Introduction, "In submitting this publication no attempt has been made to give a history of chemical warfare, the employment of chemicals in military operations during the war, either offensively or defensively; or the rapid strides made in this method of warfare since its introduction; or its medical aspects. The following chapters are intended to cover only such phases of the subject as deal with casualties resulting from the use of gas and their comparison with casualties resulting from weapons other than gas; their after effects and the humaneness of their use in war."

3. Populations Included. Primarily US Expeditionary Forces, but casualties to Germans, French, British, Italy, Japan, Rumania, Serbia, Belgium, Greece, Portugal, Montenegro, Austria, Turkey, and Bulgaria are alluded to.

4. Timeframes Included. World War I.

5. Casualty Types Included. Killed or died (includes deaths from disease as well as died of wounds), wounded, and missing.

6. Time Intervals Included As. Various.

7. Situational Descriptors Defined As. None.

8. Data Sources Used. Described in the Introduction as being based on "data obtained from official documents on file in the War Department and other reliable sources." A list of 27 references is included in the document.

9. Other and Miscellaneous. Chapter headings include the following: General, casualties in different armies, causes of gas casualties in the American Expeditionary Forces, warfare gases and their relation to blindness, mustard gas casualties in the American Expeditionary Forces, after effects of warfare gases, preliminary report on the residual effects of warfare gases, relation of tuberculosis to warfare gases, and relative humaneness of chemical warfare. Chart VII on page 19 shows hospitalized casualties by causative agent.

10. Summary of Findings Regarding Battle Casualties. For the US Army Expeditionary Forces, gas caused many casualties, of which a small proportion died, while non-gas weapons caused about the same number of casualties, but a much higher proportion of deaths.

11. Comments and Critique. This provides a valuable overview of World War I chemical weapon experience.

GOAD-1973

1. Document Description. Goad, Rex, "Prediction of Opposed Movement and Casualty Rates," Operations Research Division, SHAPE Technical Centre, The Hague, Professional Paper STC-PP-75, July 1973, 26 pp. UNCLASSIFIED. Available from publisher and libraries. Carries a disclaimer that the views expressed are those of the author and not necessarily those of the SHAPE Technical Centre (STC). It is essentially the text of a briefing to be presented at the NATO Conference on Statistical Design of Experimental Field Trials to be held in Rapallo, Italy, 10-14 September 1973.

2. Objectives and Scope. To outline various attempts to produce predictive analytical relationships between opposing side's resources, mission, and environmental factors, and to discuss what conclusions may be warranted.

3. Populations Included. Various.

4. Timeframes Included. World War II.

5. Casualty Types Included. Not precisely specified.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Not precisely specified.

8. Data Sources Used. Various, primarily the same Italian battles so often used by HERO and others—*see* Historical Evaluation and Research Organization, "A Study of Tactical Air Support Operations to Land Combat," 1971 and the CDB90 database (CAA-1991). Other data used included Cockrell-1974.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. "Overall, the work performed so far by HERO, RMC-Vertex [Cockrell-1974], and STC demonstrates that there is a clear case to be made for asserting that opposed movement rates and casualties suffered—either by the attacker or defender—cannot adequately be accounted for by force ratio alone."

11. Comments and Critique. This represents the results of one of the more thoughtful and careful analyses of the historical data on casualties.

GOAD-1974

1. Document Description. Goad, Rex, "Predictive Equations for Opposed Movement and Casualty Rates for Land Forces," Operations Research Division, SHAPE Technical Centre, The Hague, Professional Paper STC-PP-90, August 1974, 47 pp. UNCLASSIFIED. Available from DTIC (AD-921 726). Carries a disclaimer that the views expressed are those of the author and not necessarily those of the SHAPE Technical Centre (STC).

2. Objectives and Scope. To discuss the results of STC's contract with the RMC-Vertex Corporation (*see* Cockrell-1974), and STC's efforts to apply them to present day problems.

3. Populations Included. Primarily US and the opposed German troops in the World War II Ardennes and Lorraine campaigns.

4. Timeframes Included. World War II.

5. Casualty Types Included. Not precisely specified.

6. Time Intervals Included As. From start to end of a campaign.

7. Situational Descriptors Defined As. In addition to categorizing attacker missions and the related attacker advance distance, information was sought on the attachment and detachment of units to divisions and combat commands, on daily unit changes in personnel strength, and on holdings of major equipment. Other descriptors that were collected included details of the type of defensive preparation that had been made, the local visibility conditions, limitations on attacker tank and infantry mobility, the physical environment, and the lengths of frontages along the line of contact.

8. Data Sources Used. For US forces, the primary source was the National Records Center of the Archives. After Action reports, daily and other periodic reports, journal files, histories, and order of battle studies from army level down to battalion were also examined to establish the composition, location, disposition, mission, and activity of the units involved. German force data were obtained mainly from the US National Archives Captured Records Center. The records held there included microfilmed copies of unit operational records, war maps, and results of interviews of captured German commanders. Most of the main data sources are archival documents available only at the US National Archives.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Despite the title, this paper concentrates almost exclusively on the prediction of opposed movement rates, and contains hardly anything about STC's experience on the casualty rate aspects.

11. Comments and Critique. Because it is practically silent on the casualty rates, this paper is only tangentially related to PAR. *See* Cockrell-1974 for more information about casualty rates.

GOLDICH-1973

1. Document Description. Goldich, Robert L., "US Military Personnel and Casualties in Principal US Wars: By Branch of Service from the Revolutionary War to the Vietnam War; by Preservice Home State from World War I to the Vietnam War," US Library of Congress, Congressional Research Service, D-650, 2 August 1973, 19 pp. UNCLASSIFIED. Available from publisher and libraries. This is a revised and updated version of a previous issue authored by Roger F. Swanson.

2. Objectives and Scope. To tabulate the number of US military personnel who served and who became casualties in the principal wars involving US forces.

3. Populations Included. US military personnel of all services (except that the Coast Guard is excluded).

4. Timeframes Included. From US Revolutionary War through the Vietnam War.

5. Casualty Types Included. Battle deaths (which in some cases appears to include an unknown number of those who died of wounds after the battle), wounds not mortal, and other deaths (representing in-service deaths from disease or injury not specifically related to enemy action).

6. Time Intervals Included As. From start to end of a war.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. "The figures contained in this statistical survey are based entirely upon Department of Defense sources, their applicability being dependent upon the accompanying footnotes."

9. Other and Miscellaneous. Includes numerous tables.

10. Summary of Findings Regarding Battle Casualties. No general findings are stated. (It would be possible to use its figures to estimate the WIA/Battle Death ratio.)

11. Comments and Critique. This provides a useful compendium of the total war casualties experienced by US forces. The footnotes to the tables clarify the definitions of terms and their applicability. However, since its figures are for an entire war, their applicability to PAR is limited.

GOLDSMITH-1986

1. Document Description. Goldsmith, Martin, "Applying the National Training Center Experience—Incidence of Ground-to-Ground Fratricide," The RAND Corporation, RAND Note N-2438-A, Feb 1986, 28 pp. UNCLASSIFIED. Available from publisher and DTIC (AD-A179 262).

2. Objectives and Scope. From the Abstract: "This Note uses data from the National Training Center (NTC) instrumentation and observer systems to measure the frequency of fratricidal ground-to-ground engagements, to make some estimate of their importance to battle outcome, and to gain insights into the causes. Because the available data do not include infantry weapons, this study covers only vehicle system engagements and simulated artillery engagements."

3. Populations Included. Fratricide in training units at the NTC.

4. Timeframes Included. Not stated.

5. Casualty Types Included. Fratricide.

6. Time Intervals Included As. From start to end of a simulated tactical engagement.

7. Situational Descriptors Defined As. Mainly by type of mission assigned to the BLUFOR training unit (*i.e.*, night attack, defend sector, defend battle position, deliberate attack, and movement to contact/hasty attack).

8. Data Sources Used. National Training Center records and personal observation of NTC operations.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. From the Conclusions sections on pp 15 and 27: "Of the BLUFOR instrumented vehicles shown as killed in a wide range of battles, approximately 1-3 percent are killed by friendly (direct) fire. In most cases the fratricides occur as isolated instances. However, cases of multiple fratricide are noted, particularly in conditions of darkness. ... The NTC may underplay the frequency of night fighting and does not provide simulation of some situations that might be expected to lead to fratricide. ... The NTC artillery observer/controller teams judge approximately 3 percent of artillery fire missions to be fratricidal. This figure does not vary a great deal among various types of battle."

11. Comments and Critique. This provides a key insight into the kinds of fratricidal incidents that occur during training exercises at the NTC.

GOODMAN-1989

1. Document Description. Goodman, Rowland Charles, "Mass Surrenders," CORDA, 233 High Holborn, London, WC1V 7D, YR3961, August 1989, 26 pp. UNCLASSIFIED. Available from publisher.

2. Objectives and Scope. This is essentially a "think-piece" or "white paper" on the subject of mass surrenders.

3. Populations Included. Selected instances of mass surrender on land and on the sea.

4. Timeframes Included. Franco-Prussian War of 1870 to the Fall of Dien Bien Phu in 1954.

5. Casualty Types Included. Not used.

6. Time Intervals Included As. Not specifically identified.

7. Situational Descriptors Defined As. Given in narrative form.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Table of Contents includes the following headings: Introduction; Why study surrenders; The nature of surrenders; Types of surrenders; Definitions of terms; Data collection for surrenders on land; Data collection for surrenders and scuttlings at sea; Data selection; Analysis of naval surrenders and scuttlings; Analysis of land surrenders; and Suggestions for future work. List of some cases of land surrenders and of some naval surrenderings or scuttlings are given in the Appendices.

10. Summary of Findings Regarding Battle Casualties. No specific findings are stated.

11. Comments and Critique. This provides a useful introductory discussion and some helpful ideas on how to organize a potential more detailed analysis of mass surrenders. However, since it contains little specific information on casualties or their influence on mass surrenders it is only tangentially related to the PAR studies.

GOULD-1952

1. Document Description. Gould, A. H.; and Gee, H., "An Analysis of Infantry Rates of Advance in Battle," (British) Army Operational Research Group, Report No. 17/52, November 1952, 28 pp. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. To analyze data available from small scale infantry advances in World War II to determine the feasibility of quoting a figure representative of "The average rate of infantry advance," at the same time assessing the influence of a number of operational variables on (i) the rate of advance and (ii) the associated casualties per company.

3. Populations Included. Selected British battalions.

4. Timeframes Included. World War II campaigns in Italy (January, June, July, and October 1944) and in Northwest Europe (January-March 1945).

5. Casualty Types Included. Described as "total casualties," and apparently meant to include KIA, WIA, and CMIA.

6. Time Intervals Included As. From start to end of an advance.

7. Situational Descriptors Defined As. Topography, day versus night, distance covered in the attack, strength of the attack, and strength of the opposition.

8. Data Sources Used. War Diaries of the units involved.

9. Other and Miscellaneous. Tables of more than 300 instances are provided.

10. Summary of Findings Regarding Battle Casualties. The number of casualties per company were found to be markedly dependent on:

a. Strength of opposition.

b. Duration of the action.

c. The other factors allowed for in the analysis do not statistically show any well defined influence on the casualties per company. There is a slight indication that the casualty rate in Northwest Europe was higher than in Italy, but the size of the difference is not statistically significant. The number of casualties per company does not appreciably alter with the number of companies taking part in the attack (all other conditions being equal).

11. Comments and Critique. This provides a useful compendium of information on a sizable number of battalion level attacks in World War II. However, it lacks information about the strength of enemy opposition (other than a rough categorization of the opposition as "heavy" or "slight").

HAMMERMAN-1982

1. Document Description. Hammerman, Gay, "Conventional Attrition and Battle Termination Criteria: A Study of War Termination," Historical Evaluation and Research Organization, DNA-TR-811-224, 1 August 1982, 82 pp. UNCLASSIFIED. Available from DTIC (AD-A148 773). Contract DNA 001-81-C-0283, Task V99QAXNL-00083.

2. Objectives and Scope. From the document "In trying to understand why wars have ended when they have, and to predict when present and future wars will end, it is tempting to examine the endings of battles and campaigns, and try to draw parallels with, or extrapolate to, the endings of wars. In the present essay an attempt will be made to clarify the circumstances under which battles and campaigns end, so that similarities and lack of similarities with war endings will be more clearly exposed."

3. Populations Included. Various.

4. Timeframes Included. Various.

5. Casualty Types Included. Various.

6. Time Intervals Included As. From start to end of a battle, campaign, or war.

7. Situational Descriptors Defined As. Mostly given in narrative form. A table of selected wars on page 70 uses such descriptors as "loser's loss of capital city," "strong increased internal opposition to the war," and so forth.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Table of contents includes: Battles, campaigns, and wars–When do they end? A historical analysis; War termination–Concepts and terminology; Three case studies of war termination (French-Tunisian Conflict, 1961; China-India War, 1962; India-Pakistan War, 1965); Survey of the literature on war termination; War termination matrix: Notes and commentary.

10. Summary of Findings Regarding Battle Casualties. From pages 72-73:

a. The ratio of winner casualties to loser casualties shows no pattern and a wide variation. Nor is it very meaningful, since it does not take into consideration differences in the strengths of the two sides.

b. In general, it is not useful to compare casualty figures and casualty rates for wars of different lengths and wars involving forces of widely different strengths. In general, casualty numbers increase with increasing war duration, although not in a linear fashion. On the other hand, attrition rates generally decline with increasing war duration. Generally, casualty numbers are low for small forces and high for larger ones, although the relation between casualties and force size is not linear either. Moreover, there is in each case a wide variation from one situation to the next.

c. The most meaningful ratio is that of the overall casualty rate of the winner to that of the loser. Nevertheless, there is no basis for practical termination prediction in any of the comparisons made.

11. Comments and Critique. This provides a useful survey and critique of the literature on war termination, and makes several helpful comments on the strengths and weaknesses of various approaches to that problem.

HAMPTON-1987

1. Document Description. Hampton, Linda L., "Using the Deployable Medical Systems Clinical Data Base for Manpower Requirements Criteria Studies," Proceedings of the 25th Annual US Army Operations Research Symposium, 13-15 October 1987, Ft. Lee, VA, 1987, pp 339-343. UNCLASSIFIED. Available from libraries. Author was at the Academy of Health Sciences when this paper was written.

2. Objectives and Scope. The Academy of Health Sciences performs the Manpower Requirement Criteria studies for the staffing requirements of the Areas of Concentration and Military Occupations Specialties in the Army's health care system. To determine these requirements the number of patients (workload) and the theater time requirements for each patient are needed.

3. Populations Included. US Army personnel.

4. Timeframes Included. Not used.

5. Casualty Types Included. Hospitalized patients.

6. Time Intervals Included As. Not used.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Various, but most importantly the Deployable Medical Systems (DEPMEDS) data base.

9. Other and Miscellaneous. Describes an approach to estimating the type and number of health care personnel required by the Army.

10. Summary of Findings Regarding Battle Casualties. None stated.

11. Comments and Critique. This provides a useful description of one method for estimating the number and type of US Army medical personnel required to treat hospitalized patients in a theater of operations.

HAMZA-1987

1. Document Description. Hamza, Ann H.; and Banks, James H., "Direct Fire Fratricide at the National Training Center," Presidio of Monterey Field Unit, Training Research Laboratory, US Army Research Institute, Research Report Tracking No. A 831 201, December 1988, 13 pp. UNCLASSIFIED. Available from DTIC (AD-A203 319).

2. Objectives and Scope. From the Foreword: "This report describes direct fire fratricide data on rotating battalion task forces at the NTC [National Training Center, Fort Irwin, California] and examines factors likely to impact on fratricides. The NTC data were compared with historical fratricide data. Some probable contributory factors of fratricide are identified and training recommendations for reducing fratricidal incidence are discussed."

3. Populations Included. Fratricides by the BLUFOR training unit's direct fire weapons.

4. Timeframes Included. Fiscal Year 1985-86.

5. Casualty Types Included. Fratricides.

6. Time Intervals Included As. From start to end of a mission.

7. Situational Descriptors Defined As. Only a few descriptors are used. However, data on the seasonal distribution of the incidence of war are presented.

8. Data Sources Used. Data were compiled from digital data collected by the NTC instrumentation system for 39 battalion task forces during 206 missions. Fifty-eight percent of these battles were fought by armor-heavy task forces and 42 percent by mechanized infantry-heavy task forces. Historical data were taken from Shrader-1982, *q.v.*

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. About 5 percent of the recorded BLUFOR firings resulted in a friendly BLUFOR hit, kill, or near miss—about 3 percent resulted in a hit or kill. However, the proportion of BLUFOR fratricidal firings was 12 percent during offensive missions as compared to 3 percent during defensive missions. The fratricide rate was lowest for the mid-range zone (500 to 1500 meters) and higher for either shorter or longer ranges. It is pointed out that a 3 percent loss from fratricide translates into the loss of about 46 BLUFOR armored fighting vehicles over the course of a typical year's activity at the NTC.

11. Comments and Critique. This document's examination of factors likely to impact on fratricides, its comparison of the NTC data with historical fratricide data, its identification of probable contributory factors of fratricide, and its discussion of training recommendations for reducing fratricidal incidence are brief and lack depth.

HARBOTTLE-1905

1. Document Description. Harbottle, Thomas Benfield, "Dictionary of Battles From the Earliest Date to the Present Time," E. P. Dutton & Co., New York, Library of Congress Card Number 66-22672, 1905 (Republished 1966 by Gale Research Company, Detroit), 298 pp. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. To provide a dictionary of battles, arranged in alphabetical order by name of the battle. Each entry gives a short narrative description of the action. Strengths and losses are included for several of the entries.

3. Populations Included. Various.

4. Timeframes Included. From very early times up to shortly before 1905.

5. Casualty Types Included. Various.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Given in the narrative description.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. No findings are presented.

11. Comments and Critique. This provides a useful compilation of information on battles. However, we note that Laffin-1986 (Introduction, p *xiii*) states that "Harbottle was not a military historian and he made many mistakes," and gives several examples.

HARTLEY-1989a

1. Document Description. Hartley, Dean S. III, "Can the Square Law be Validated?," Data Systems Research & Development Program, Oak Ridge Gaseous Diffusion Plant, operated by Martin Marietta Energy Systems, Inc. for the US Department of Energy, K/DSRD-57, March 1989, 72 pp. UNCLASSIFIED. Available from publisher and DTIC.

2. Objectives and Scope. From the Abstract: "This paper addresses the question of validating the homogeneous Lanchestrian square law of attrition by the use of historical data. The available data and some analysis techniques are examined." In essence, the scope involves checking the validity of the Lanchester square law using data from Busse-1968.

3. Populations Included. US and North Korean forces, as in Busse-1968.

4. Timeframes Included. Korean War.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of the Inchon-Seoul campaign.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Busse-1968, supplemented by various histories of the Inchon-Seoul operation.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. From the Conclusions: "It appears that any square law effects are largely masked by other factors. The results of the Inchon-Seoul analysis show that the major factor is one that causes a jump in the daily casualty rates followed by an abrupt reduction in casualty rates to approximately the original level. My reading of the verbal accounts of the campaign lead me to suspect that this change was the result of a North Korean change from a withdrawal and hasty withdrawal posture to a prepared defense posture and then a resumption of the withdrawal posture when Seoul was essentially taken by US and ROK forces." In other words, the fit of Lanchester's square law to the Inchon-Seoul data for the entire campaign is not good. However, the fit is substantially improved if the campaign is broken into three natural phases (seizure of the Inchon beachhead and advance to the outskirts of Seoul, the capture of Seoul, and the ensuing pursuit of North Korean forces withdrawing northward).

11. Comments and Critique. This provides a useful analysis of the Inchon-Seoul campaign in the fashion of Engel-1954, Busse-1968, and Samz-1972. A version of this paper is to appear in the Naval Logistics Research Journal sometime in 1993. Its findings show that we have only a limited understanding of the range of validity of Lanchester's square law.

HARTLEY-1989b

1. Document Description. Hartley, Dean S. III; and Kruse, K. L., "Historical Support for a Mixed Law Lanchestrian Attrition Model: Helmbold's Ratio," Data Systems Research & Development Program, Oak Ridge Gaseous Diffusion Plant, operated by Martin Marietta Energy Systems, Inc. for the US Department of Energy, K/DSRD-113, November 1989, 51 pp. UNCLASSIFIED. Available from publisher and DTIC.

2. Objectives and Scope. To argue the case for a mixed linear-logarithmic attrition model expressible as

$$x' = -Dx^p y$$
$$y' = -Axy^p \quad ,$$

where primes denote differentiation with respect to time and p lies between 1 and 2.

3. Populations Included. Combatants.

4. Timeframes Included. From 1600 to about 1973.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Chiefly the CAA Database of battles (*see* CAA-1991).

9. Other and Miscellaneous. This is the first in a series of reports on research in historical validation of attrition in combat (*see* also Hartley-1989a, Hartley-1989c, Hartley-1990, and Hartley-1991).

10. Summary of Findings Regarding Battle Casualties. From the Abstract: "Helmbold defined the 'activity ratio' to be the ratio of the Lanchester square law attrition coefficients [*see* Helmbold-1961]. He derived an equivalence between this ratio and a ratio containing the initial and ending force sizes, herein called the Helmbold ratio, and demonstrated a relationship between the Helmbold ratio and the initial force ratio in a large number of battles. This paper reexamines the implications of this relationship and concludes that its existence, rather than being supportive of the Lanchester square law, is supportive of a mixed law lying between the Lanchester linear law and a Lanchester logarithmic law. It is shown that the Helmbold relationship can discriminate between several attrition formulations; however, while this is a necessary condition, it is not sufficient to conclude that data fitting the relationship were caused by a given attrition formulation. The conclusion is that the data are not fine enough to determine the differential form of the attrition equations but do lead to a statistical statement about the outcomes of battles.

11. Comments and Critique. While Hartley's results can be interpreted as indicating that the attrition follows an equation that is not of the Lanchester square law form, they can equally be interpreted as indicating that the attrition coefficients vary in a systematic fashion from one battle to the next. This ambiguity in interpreting the results is at the heart of the Constant Fallacy (*see* Helmbold-1993). This ambiguity is not resolved by Hartley's findings. Accordingly, the scope of applicability of Lanchester's square law as a model of attrition is not determined by Hartley's data or analysis. That the available data are, for the most part, not "fine enough" to determine the differential form of the attrition equations was stated in Helmbold-1961 and Helmbold-1964a.

HARTLEY-1989c

1. Document Description. Hartley, Dean S. III, "The Constraint Model of Attrition," Data Systems Research & Development Program, Oak Ridge Gaseous Diffusion Plant, operated by Martin Marietta Energy Systems, Inc. for the US Department of Energy, K/DSRD-114/R1, November 1989, 24 pp. UNCLASSIFIED. Available from DTIC.

2. Objectives and Scope. From the Abstract: "Helmbold demonstrated a relationship between a ratio containing initial force sizes and casualties, herein called the Helmbold ratio. This paper uses analytical and simulation techniques to examine some of the complexities of the Helmbold ratio and demonstrates that a constraint model of attrition captures some aspects of historical data. The effect that the constraint model would have on warfare modeling is uncertain However, some speculation has been attempted concerning its use in large-scale simulations."

3. Populations Included. As in Helmbold-1961 and Helmbold-1964a.

4. Timeframes Included. As in Helmbold-1961 and Helmbold-1964a.

5. Casualty Types Included. As in Helmbold-1961 and Helmbold-1964a.

6. Time Intervals Included As. As in Helmbold-1961 and Helmbold-1964a.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Helmbold-1961 and Helmbold-1964a.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. From the Conclusions: "The constraint model of attrition can reproduce one historical parameter—position in Helmbold space. Plausible military interpretations have been made for some constraints. The results derived from this research do not imply that the constraint model of attrition is valid in a causal sense; however, they do show that this validity is conceivable."

11. Comments and Critique. This paper has been superseded by later research (*see* Hartley-1990 and Hartley-1991a).

HARTLEY-1990

1. Document Description. Hartley, Dean S. III, "Historical Validation of an Attrition Model," Data Systems Research & Development Program, Oak Ridge Gaseous Diffusion Plant, operated by Martin Marietta Energy Systems, Inc. for the US Department of Energy, K/DSRD-115, May 1990, 51 pp. UNCLASSIFIED. Available from DTIC.

2. Objectives and Scope. From the Abstract: "Helmbold demonstrated a relationship between the Helmbold ratio, a ratio containing initial force sizes and casualties, and the initial force ratio in a large number of historical battles. It has been shown that at least two models of warfare could produce these results, a mixed linear-logarithmic Lanchestrian attrition law and a constraint [on battle engagement and termination] model of attrition. This paper examines the distribution statistics of the historical data and determines that the mixed model is favored. The differential form of the mixed law model that best fits the casualty data is found. This model also provides a parameter to predict the victor."

3. Populations Included. As in CAA-1991.

4. Timeframes Included. As in CAA-1991.

5. Casualty Types Included. As in CAA-1991.

6. Time Intervals Included As. As in CAA-1991.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. CAA-1991.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. From the Conclusions: "Based on the analyses of expected distributions, we conclude that the mixed linear-logarithmic Lanchester model of attrition is more likely to be valid for these historical data than the proposed constraint model of attrition. The tests of various assignment rules for choosing the side to call X show the Helmbold relationship to be basic to the historical data, rather than a result of the radial symmetry of Helmbold space. ...

"The confirmation of Helmbold's 'V' parameter ..., in spite of the difference in the basic structure of the attrition law, is useful. ...

"Further research will be undertaken to confirm the results of this data."

11. Comments and Critique. This is a useful contribution to the literature. However, because of relatively small sample size used, and because of the persistent problem in interpreting attempted fits of attrition equations to data involving only the initial and terminal force sizes—which runs afoul of the so-

called "Constant Fallacy" (*see*, for example, Helmbold-1993), the findings regarding the form of attrition relationship must be taken with considerable reservation.

HARTLEY-1991a

1. Document Description. Hartley, Dean S. III, "Confirming the Lanchestrian Linear-Logarithmic Model of Attrition," Data Systems Research & Development Program, Oak Ridge Gaseous Diffusion Plant, operated by Martin Marietta Energy Systems, Inc. for the US Department of Energy, K/DSRD-263/R1, February 1991, 136 pp. UNCLASSIFIED. Available from DTIC. This is a revision to the report of the same title published in December 1990.

2. Objectives and Scope. From the Abstract: "The results of this paper confirm the results of earlier papers, using a large database of historical results. The homogeneous linear-logarithmic Lanchestrian attrition model is validated to the extent possible with current initial and final force size data and is consistent with the Iwo Jima data. A particular differential linear logarithmic model is described that fits the data very well. A version of Helmbold's victory-predicting parameter ratio is also confirmed, with an associated probability function."

3. Populations Included. As in CAA-1991.

4. Timeframes Included. As in CAA-1991.

5. Casualty Types Included. As in CAA-1991.

6. Time Intervals Included As. As in CAA-1991.

7. Situational Descriptors Defined As. As in CAA-1991.

8. Data Sources Used. CAA-1991.

9. Other and Miscellaneous. The proposed form of attrition relationship is as follows, where primes denote differentiation with respect to time, zero subscripts denote initial values, and e, C, D, and G are constants independent of the time t and (aside from random variations) are also independent of the particular battle:

$$x' = -e^{C} x_0^{D} y_0^{G}$$
$$y' = -e^{F} x_0^{G} y_0^{D} \quad .$$

In addition, the auxiliary parameters α and β are defined as follows:

$$\alpha = D - G - 1$$
$$\beta = C - F \quad .$$

10. Summary of Findings Regarding Battle Casualties. From the Conclusions: "Using data from more

than 850 battles, we have determined:

1. The data confirm the earlier proposition of a Helmbold relationship with α between 1.0 and 2.0, that is, intermediate between the Lanchester linear and logarithmic laws.

2. This result is consistent across different collections of data (data set segmentation).

3. This result is consistent over time (battle date segmentation).

4. This result is consistent over variations in battle size (battle size segmentation).

5. This result is consistent over connected groups of battles (campaign segmentation).

6. Any differences in national battle abilities are of secondary importance to this result.

7. The internal battle results of the Okinawa Campaign are consistent with this result.

8. The historical data for the Iwo Jima Campaign are as consistent with this result as they are with a square law assumption.

9. The data confirm that the Helmbold V parameter is a good predictor (in the sense of guessing the known values of one variable from the known values of other variables) of victory. ...

These results are the basis for the propositions ... reproduced here to emphasize their importance.

Proposition 0. There is a 'law' of attrition.

Proposition 1. Attrition in sufficiently large battles follows a homogeneous linear-logarithmic Lanchestrian law, with α approximately equal to 1.35 and β approximately normally distributed about -0.22 with standard deviation 0.7, the value of β depending on the specifics of the battle.

Proposition 2. The differential equations for the attrition are stated in [the Other and Miscellaneous paragraph above], where $D = 0.75$ and $G = 0.40$ and C and F depend on the specifics of the battle.

Corollary 1. Attrition in battle may be separated into two components: one is the contribution of the sizes of the forces in the battle; the second is the contribution of other factors, responsible for the variance in the Helmbold relationship.

Proposition 3. The impact of attrition on victory in battle is mediated by comparative fractional attrition rates, expressed by the V parameter.

Proposition 4. The factors impacting victory, other than attrition, are most influential when the absolute value of the V parameter is small. The effect of these parameters may be estimated [by an equation] to produce a probability that the inference about victory from the V parameter is correct.

11. Comments and Critique. This is a useful contribution to the literature. However, because of the persistent problem in interpreting attempted fits of attrition equations to data involving only the initial

and terminal force sizes—which runs afoul of the so-called "Constant Fallacy" (*see* Helmbold-1993), the findings regarding the form of attrition relationship must be taken with considerable reservation. Also, the connection between victory and the V parameter are better fitted by a logistic function than by the one proposed by Hartley. The "linear-logarithmic" attrition equation proposed by Hartley is more correctly written as

$$C_x/T = -\mathrm{e}^{C} x_0^D y_0^G$$
$$C_y/T = -\mathrm{e}^{F} x_0^G y_0^D \quad ,$$

where C_x and C_y are the casualties to sides X and Y, respectively, T is the duration of the battle, and e, C, D, and G are constants independent of the duration T and also (except for random variation) independent of the particular battle fought. This formulation corresponds more nearly to what Hartley actually did in statistical fitting procedures, but it clearly does not imply anything about the form of the differential equations governing attrition dynamics.

HARTLEY-1991b

1. Document Description. Hartley, Dean S. III, "User's Guide to the Oak Ridge Spreadsheet Battle Model," Data Systems Research & Development Program, Oak Ridge Gaseous Diffusion Plant, operated by Martin Marietta Energy Systems, Inc. for the US Department of Energy, K/DSRD-413, May 1991, 55 pp. UNCLASSIFIED. Available from DTIC. See also the companion report Hartley-1991d.

2. Objectives and Scope. From the Abstract: "The Oak Ridge Spreadsheet Battle Model (ORSBM) is a combat effects predictor model. Given a description of a battle, it predicts the duration, surprise, advance rate, total advance, casualties, combat systems losses, and victor for the battle. Further, the model produces confidence ranges for each result. The form of the equation used to calculate casualties has been validated; however, the application of the input data to these equations and the other calculations reflect statistical fits to historical data. The historical data are extensive, but not exhaustive. Therefore, using the model to forecast the results of future battles, while providing a superior forecast to other alternatives, will result in inaccuracies. ... The model is implemented as a LOTUS 1-2-3™ spreadsheet. Separate sections describe the operating instructions, the input requirements, and the output interpretation. An additional section is included that contains the mathematical logic of the model to enable its transference to other spreadsheets or modeling environments."

3. Populations Included. Not used.

4. Timeframes Included. Not used.

5. Casualty Types Included. Not used.

6. Time Intervals Included As. Not used.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. See the companion report, Hartley-1991d.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Contained in the details of the formulae used, which are not reproduced here.

11. Comments and Critique. This is a useful contribution to the literature. However, because of the very real potential for "overfitting" when so many adjustable parameters are invoked to fit historical data, the model may turn out to be a poor predictor. Accordingly, additional validation and verification of the model is needed. The ORSBM allows for, and is sensitive to, nationality inputs, although this seems rather inconsistent with the finding in Hartley-1991a that nationality makes little difference.

HARTLEY-1991c

1. Document Description. Hartley, Dean S. III; Posen, Keith J.; Bader, Brian R.; Morstein, Jonathan; and Brinkerhoff, John R., "Forecasting Relative Combat Effectiveness: A Feasibility Study," Data Systems Research & Development Program, Oak Ridge Gaseous Diffusion Plant, operated by Martin Marietta Energy Systems, Inc. for the US Department of Energy, K/DSRD-598, July 1991, 56 pp. UNCLASSIFIED. Available from DTIC.

2. Objectives and Scope. From the Executive Summary: "[To address an important issue] this feasibility study examined one methodology for developing values of relative troop quality. The methodology sought to compare historical levels of combat effectiveness (troop quality) with basic measures of societal conditions. If strong relationships between the societal factors and the level of combat effectiveness could be established, then such measures might be useful for predicting combat effectiveness in other cases.

"By using the Quantified Judgment Model and historical data on World War I and World War II combat engagements, values for relative combat effectiveness were established for Germany, the United States, the United Kingdom, and Russia/Soviet Union. Archival research produced data for numerous societal measures for the corresponding time periods. Using statistical analyses, the relationships between the societal factors and the level of relative combat effectiveness were examined."

3. Populations Included. Battle participants.

4. Timeframes Included. Primarily World War I and World War II.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. The societal factors considered included the following: per capita industrial production factors (coal, iron, steel, sulfuric acid, electricity, motor vehicles registered); per capita transportation/communication factors (railway mileage, rail passengers, number of ships, shipping tonnage, number of mail items, number of telegrams); per capita agricultural factors (hectares in wheat, barley, and oats; output of wheat, barley, and oats; number of horses, cattle, pigs, and sheep); per capita educational system factors (primary school pupils, primary school teachers, secondary school pupils, university students); per capita vital statistics (infant mortality rate, death rate, birth rate); and per capita financial activity (banknote circulation, bank deposits, government spending, tax revenues).

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. From the Executive Summary: "The analyses found that measures indicating the degree of industrialization were most closely related to the level of relative combat effectiveness. That is, in World War I and World War II, by knowing the degree of industrial sophistication, the level of relative combat effectiveness for the major participants could be predicted."

11. Comments and Critique. From the Executive Summary: "The feasibility study was not pursued in enough detail and breadth to ensure its validity, generality, and applicability to other nations. It simply demonstrated that it may be possible to do so with further study that generates enough quality data on combat engagements and societal factors. This study serves as promising initial research that offers useful results if pursued on a larger scale." The emphasis on the effects of nationality seem to be inconsistent with the finding in Hartley-1991a that nationality makes little difference.

HARTLEY-1991d

1. Document Description. Hartley, Dean S. III, "Predicting Combat Effects," Data Systems Research & Development Program, Oak Ridge Gaseous Diffusion Plant, operated by Martin Marietta Energy Systems, Inc. for the US Department of Energy, K/DSRD-412, August 1991, 360 pp. UNCLASSIFIED. Available from DTIC. See also the companion report Hartley-1991b.

2. Objectives and Scope. From the Executive Summary: "The motivation for the research reported in this document was a need by The Office of the Secretary of Defense/Net Assessment for a methodology of comparing the relative combat effectiveness of Soviet and US forces. The implication is that numbers of tanks, artillery, aircraft, and troops are only partial descriptions of the usefulness of military forces. This research focuses on determining what other factors have reasonable indications of significant impact and how these other factors interact with the force size factors."

3. Populations Included. Battle participants.

4. Timeframes Included. From 1600 to 1973.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. As described under CAA-1991.

8. Data Sources Used. As described under CAA-1991.

9. Other and Miscellaneous. This work was the basis for the companion report and model described in Hartley-1991b, *q.v.*

10. Summary of Findings Regarding Battle Casualties. Contained in equations too detailed to be reproduced here.

11. Comments and Critique. From the Executive Summary: "Currently, this model is the only battle model with an historical basis; however, before it is implemented on the battlefield, it should be validated against an independent set of data." While it is rather misleading to say that this is the "only" model based on history, nonetheless the care and detail in its use of historical data is impressive. One of the problems is that so many adjustable parameters have been introduced to fit the historical data that "overfitting" may have taken place, in which case the model is not well suited to prediction. However, continued experimentation and adjustment of this model could produce exciting results. The emphasis on the effects of nationality seem to be inconsistent with the finding in Hartley-1991a that nationality makes little difference.

HEIDENRICH-1993

1. Document Description. Heidenrich, John G., "The Gulf War: How Many Iraqis Died?," Foreign Policy, Spring 1993, pp 108-125. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. The author's aim is to analyze the available information on Iraqi casualties in the Gulf War of February 1991, in order to debunk various inflated estimates of Iraqi combat deaths.

3. Populations Included. Iraqi army personnel.

4. Timeframes Included. Gulf War of February 1991.

5. Casualty Types Included. Killed.

6. Time Intervals Included As. From start to end of the war.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. The author's review of various estimates of Iraqi dead, includes an estimate by the US Defense Intelligence Agency (DIA) stating that "Upon review, it has been determined that little information is available which would enable this Agency to make an accurate assessment of Iraqi military casualties. An analysis of very limited information leads DIA to tentatively state the following (error factor of 50 percent or higher):

Killed in Action: Approx. 100,000
Wounded in Action: Approx. 300,000
Deserters: Approx. 150,000"

After citing other estimates of Iraqi dead varying from 100,000 or more to less than 10,000, the author sums up his conclusions as follows: "If the maximum estimates are to be believed, the Iraqi military suffered up to 9,500 dead and 26,500 wounded throughout the [Kuwaiti Theater of Operations] for a total of 36,000 casualties, of which three-quarters occurred during the ground offensive. ... If the minimum estimates of Iraqi casualties are correct—and that appears to be the case—then the real toll of Iraqi dead and wounded from DESERT STORM was smaller still. Those estimates place Iraqi dead in the [Kuwaiti Theater of Operations] at 1,500. The figure for Iraqi wounded probably numbered around 3,000, of which 2,000 were captured while another 1,000 or so managed to escape. About one-third of those casualties occurred during the air campaign and two-thirds during the ground campaign."

11. Comments and Critique. This is an excellent example of analysis based on publicly available records. It is a well-taken caution on the interpretation of widely-publicized figures. Whether its results will eventually be confirmed by official Iraqi records remains to be seen.

HEITMAN-1903

1. Document Description. Heitman, Francis Bernard, "Historical Register and Dictionary of the United States Army," US Government Printing Office, 1903, Over 626 pp. UNCLASSIFIED. Available from copy in Pentagon Library. In 2 volumes. This is the unofficial work of a private compiler, purchased and published by direction of Congress.

2. Objectives and Scope. To tabulate the most significant aspects of the history of the US Army from its initial authorization by Congress on 3 June 1784 to the late 1800s.

3. Populations Included. US Army troops.

4. Timeframes Included. Contains some information on strengths and losses in the War of the Revolution, Indian War of 1790-1795, Indian War of 1811-1813, War of 1812, Seminole Indian War 1817-1818, Black Hawk War 1831-1832, Seminole Indian War 1835-1842, Mexican War 1846-1848, Civil War 1861-1865, Spanish-American War 1898, and the Chinese Insurrection 1900-1901.

5. Casualty Types Included. Usually, dead and (separately) died of wounds (wounded in action given for the Spanish-American War of 1898 and for the Chinese Insurrection 1900-1901).

6. Time Intervals Included As. From start to end of a war.

7. Situational Descriptors Defined As. None.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Includes numerous tables.

10. Summary of Findings Regarding Battle Casualties. No general findings are stated.

11. Comments and Critique. This may be a good source of information on some of the lesser-known actions during the 1800s.

HELMBOLD-1961

1. Document Description. Helmbold, Robert L., "Historical Data and Lanchester's Theory of Combat," Combat Operations Research Group (CORG), HQ, US Continental Army Command, Staff Paper CORG-SP-128, 1 July 1961, 178 pp. UNCLASSIFIED. Available from DTIC (AD-480 975). See also the companion paper Helmbold-1964a.

2. Objectives and Scope. The purpose of this paper is to search for empirical relations among various quantitative aspects of ground combat suggested by Lanchester's square law model. The motivation for considering this problem is discussed at some length in the introductory section. Theoretical and methodological issues bearing on the problem are discussed. Data on 92 historical battles are studied for information bearing on the problem. Areas where the results may be applied are indicated.

3. Populations Included. Battle participants.

4. Timeframes Included. From 1741 to 1945.

5. Casualty Types Included. Various, but mostly losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Not used for the most part, but some attention is given to surprise and enveloping maneuvers.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. The findings are too numerous to recite all of them; however, they include the following. Surprise accompanied by a successful enveloping maneuver may be highly advantageous to the attacker, but if unsuccessful may be disastrous. The principal determinants of victory are contained in the advantage parameter, $V = \ln\mu$. The parameters suggested by the Lanchester square law of attrition are good indices of the corresponding real-world phenomena. The attrition coefficient ratio and the advantage parameter depend on initial force ratio. Several factors which might be expected to influence victory in battle (such as force ratios) actually have little influence on it. It appears that no nation has consistently been superior to its opponents.

11. Comments and Critique. The findings can be used as a rough general check on the validity of a ground combat model. Expressing combat model results in terms of the associated Lanchester parameters could help in the interpretation of results. The findings can also be used for historical analysis and criticism, as well as useful background information and guidance to studies of large scale combat modeling. Despite its age, this is still an important paper.

HELMBOLD-1964a

1. Document Description. Helmbold, Robert L., "Historical Data and Lanchester's Theory of Combat: Part II," Combat Operations Research Group (CORG), HQ, US Combat Development Command, Staff Paper CORG-SP-190, August 1964, 132 pp. UNCLASSIFIED. Available from DTIC (AD-480 109). See also the companion paper Helmbold-1961.

2. Objectives and Scope. The purpose of this paper is to test the validity of the conclusions reached in a previous work [Helmbold-1961]. Data on 83 historical battles are studied for information bearing on this problem. The information obtained from these battles is compared with those previously obtained, and the results of the comparison are carefully analyzed. With a few exceptions, the validity of the earlier findings is confirmed.

3. Populations Included. Battle participants.

4. Timeframes Included. From 280 BC to 1944 AD.

5. Casualty Types Included. Various, but mostly losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Not used for the most part, but some attention is given to surprise and enveloping maneuvers.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. The findings are too numerous to recite them all, however, in general this analysis (based on a new and independent sample of battles) strongly supports the findings obtained in Helmbold-1961. Again, surprise accompanied by a successful enveloping maneuver may be highly advantageous to the attacker, but if unsuccessful can be disastrous. The principal determinants of victory are contained in the advantage parameter, $V = \ln\mu$. The parameters suggested by the Lanchester square law of attrition are good indices of the corresponding real-world phenomena. The attrition coefficient ratio and the advantage parameter depend on initial force ratio. Several factors which might be expected to influence victory in battle (such as force ratios) actually have little influence on it. There is no consistent superiority of one nation over another.

11. Comments and Critique. The findings can be used as a rough general check on the validity of a ground combat model. An example of how this can be done is given in (i) Helmbold, Robert L. "Lanchester's Equations, Historical Battles, and War Games," included in the Proceedings of the Eighth Military Operations Research Symposium, held at the Pacific Missile Range, Point Mugu,

California, 18-21 October 1961, (ii) Helmbold-1964b, and in (iii) Helmbold-1967. Despite their ages, these are still important papers.

HELMBOLD-1964b

1. Document Description. Helmbold, Robert L., "Some Observations on the Use of Lanchester's Theory for Prediction," Journal of the Operations Research Society of America, Vol 12, No 5, 1964, pp 778-781. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To point out that predictions of attrition can be made using the Lanchester square law and historically derived attrition coefficients, even though the form of attrition law may be unknown and may differ from that of the Lanchester square law.

3. Populations Included. Various.

4. Timeframes Included. Various.

5. Casualty Types Included. Various.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. See Helmbold-1961 and Helmbold-1964a.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. By measuring the force ratio at the start of a battle and employing a historically derived prediction equation, a prediction of the defender's relative advantage can be obtained. Although this prediction is too inaccurate for practical use, it is of considerable theoretical interest. It shows that the ratio of the attacker's to the defender's attrition coefficient tends to decrease with the force ratio (attacker's initial strength divided by the defender's initial strength), even though intuition might suggest a different relationship. This finding suggests that victory in battle is primarily determined by factors other than numerical superiority, and challenges the ability of any model of combat which concentrates on numerical force size to yield a practically useful predictor of victory in battle.

11. Comments and Critique. This paper is based on and is supported by Helmbold-1961 and Helmbold-1964a, which provide more data and details. Similar results were obtained earlier by Osipov-1915. Compare these results to those of other works on the form of attrition relationships, where the interpretations differ but the practical results are the same.

HELMBOLD-1965

1. Document Description. Helmbold, Robert L., "A Modification of Lanchester's Equations," Operations Research, Vol 13, no 5, Sep-Oct 1965, pp 857-859. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. Proposes a modification of Lanchester's equations that correctly interpolates between the square, linear, and logarithmic laws.

3. Populations Included. Not used.

4. Timeframes Included. Not used.

5. Casualty Types Included. Not used.

6. Time Intervals Included As. Not used.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. The proposed modification is based on the author's previous research into the historical data on combat.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. A single additional parameter allows one to postulate a differential equation that can correspond to a square, a linear, or logarithmic law of attrition or to various laws intermediate between them.

11. Comments and Critique. Offers a useful generalization of Lanchester's square law formalism, and provides a link among the square, linear, and logarithmic laws.

HELMBOLD-1967

1. Document Description. Helmbold, Robert L., "Some Observations on Validating Combat Models," Presented to the NATO Conference on Recent Developments in Lanchester Theory, Munich, Germany, 3-7 July 1967, 1967, 16 pp. UNCLASSIFIED. Available from the author.

2. Objectives and Scope. To show that certain quantities inspired by Lanchester's theory of combat (such as activity, bitterness, intensity, defender's advantage, *etc.*), together with historical estimates of their values and interrelationships, are valuable clues to the validity or non-validity of large-scale combat models.

3. Populations Included. Participants in battles.

4. Timeframes Included. From early times to World War II.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Uses the data in Helmbold-1961 and Helmbold-1964a.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Demonstrates that the historical data are inconsistent with either the linear, the square, or the logarithmic law of attrition when the coefficients are interpreted as universal constants that do not vary from one battle to another. Argues that the available data are consistent with the square law of attrition in individual battles, which in view of the first finding implies that the attrition coefficients must be allowed to vary from one battle to the next in a manner depending on the initial force ratio. Applies this finding to assessing the validity of several large scale war games involving division to army sized forces.

11. Comments and Critique. This provides a practical method for using historical data to assess the validity of large scale war games.

HELMBOLD-1969

1. Document Description. Helmbold, Robert L., "Probability of Victory in Land Combat as Related to Force Ratio," The RAND Corporation, RAND Paper P-4199, October 1969, 14 pp. UNCLASSIFIED. Available from DTIC (AD-696 489).

2. Objectives and Scope. To examine historical data to determine the extent to which force ratio influences victory in combat.

3. Populations Included. Participants in battle.

4. Timeframes Included. From early times to World War II.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Uses the Helmbold-1961, Helmbold-1964a, and Bodart-1906 data.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Force ratio has an influence on victory on battle, but not nearly as much as might be expected. In fact, a 3-to-1 superiority of force is neither necessary nor sufficient for victory.

11. Comments and Critique. This provides an important empirical test of the relationship of victory to force ratio in land combat operations.

HELMBOLD-1971a

1. Document Description. Helmbold, Robert L., "Air Battles and Ground Battles—A Common Pattern?," The RAND Corporation, RAND P-4548, January 1971, 15 pp. UNCLASSIFIED. Available from DTIC (AD-718 975).

2. Objectives and Scope. To determine whether the historical patterns displayed in historical land combat data (*see*, for example, Helmbold-1961, Helmbold-1964a, Helmbold-1964b, and Helmbold-1967) are also present in historical air combat situations. Data on the Battle of Britain are used for this purpose.

3. Populations Included. Air combat elements of the Battle of Britain.

4. Timeframes Included. World War II Battle of Britain.

5. Casualty Types Included. Aircraft lost.

6. Time Intervals Included As. From start to end of each day during the Battle of Britain.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Primarily Collier, B. "Defense of the United Kingdom," Her Majesty's Stationary Office, London, 1957.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. The same pattern exhibited by land combat battles appears to have been followed by the Battle of Britain's daily engagement results.

11. Comments and Critique. This provides a useful confirmation of the generality of the patterns discovered, and confirms their extension to forms of combat other than land warfare.

HELMBOLD-1971b

1. Document Description. Helmbold, Robert L., "Decision in Battle: Breakpoint Hypotheses and Engagement Termination Data," The RAND Corporation, RAND Report R-772-PR, June 1971, 96 pp. UNCLASSIFIED. Available from publisher and DTIC (AD-729 769).

2. Objectives and Scope. This study was undertaken to examine, through the use of historical data, the validity of breakpoint hypotheses as explanations of the outcomes of land combat battles. The scope of this report is limited to exploring a popular form of assumption regarding the relationship of casualties to the decision to terminate a battle—namely, the assumption that a military force gives up the battle when its personnel casualty fraction reaches a certain level, which may be assigned either deterministically or stochastically. The object of the investigation is to determine the extent to which such a procedure is justified by confronting it with available data on historical engagements.

3. Populations Included. Battle participants.

4. Timeframes Included. From 1600 to 1944.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Various, but principally Helmbold-1961, Helmbold-1964a, and Bodart-1906.

9. Other and Miscellaneous. Table of Contents includes: Introduction, Breakpoint model, Comparison of model with data, Some speculations and suggested approaches. Includes numerous figures and tables.

10. Summary of Findings Regarding Battle Casualties. The principal finding is that the breakpoint hypothesis implies certain relationships that are flatly contradicted by the available battle termination data. Some tentative observations and remarks are offered regarding possible directions for future attempts to devise a model of engagement termination that agrees with the data.

11. Comments and Critique. Until a better theoretical explanation of the battle termination process becomes available, the soundness of models of combat such as war games and computer simulations that make essential use of breakpoint hypotheses is suspect.

HELMBOLD-1986

1. Document Description. Helmbold, Robert L., "Combat History Analysis Study Effort (CHASE): Progress Report for the Period August 1984-June 1985," US Concepts Analysis Agency, 8120 Woodmont Avenue, Bethesda, MD 20814-2797, Concepts Analysis Agency Technical Paper CAA-TP-86-2, August 1986, 249 pp. UNCLASSIFIED. Available from DTIC (AD-F860 122).

2. Objectives and Scope. To carry out the initial phase of the CHASE study, which is aimed at searching for historically-based quantitative results for use in military operations research, concept formulation, wargaming, and studies and analyses. This included preparing the first electronic edition of the CDB90 data base (*see* CAA-1991); assessing its suitability for quantitative analysis; summarizing selected portions of it to facilitate their efficient use in military operations research, concept formulation, war gaming, and studies and analyses; seeking important trends and interrelationships present but hidden in the data; and testing selected hypotheses against the data.

3. Populations Included. Participants in 601 historical battles.

4. Timeframes Included. From 1600 to 1973.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Only a few descriptors were used.

8. Data Sources Used. Uses the Helmbold-1961, Helmbold-1964a, and CAA-1991 data.

9. Other and Miscellaneous. Table of Contents includes: Executive summary; Sources of data on battles and engagements; Descriptive statistics; Factors associated with victory; Analysis of redundancy; Test of a breakpoint hypothesis; Other analyses; and Concluding findings and observations. Numerous tables and figures are used to support the discussion.

10. Summary of Findings Regarding Battle Casualties.

a. Six variables were tested for close association with victory in battle: the force ratio, the casualty exchange ratio, the fractional exchange ratio, a measure of bitterness (total losses to both sides), the defender's advantage parameter, and the residual advantage parameter after the effects of force ratio are eliminated. Of these, the defender's advantage parameter and the fractional exchange ratio are most closely associated with victory in battle. The force ratio and bitterness are least closely associated with victory in battle (*see also* Helmbold-1961, Helmbold-1964a, and Helmbold-1969).

b. It appears that there has been no long-term trend over the last 400 years in the proportion of battles won by the attacker.

c. Battle durations seem to fit a lognormal or Weibull distribution about equally well.

d. Casualty fractions appear to be distributed approximately lognormally.

e. The personnel force ratio, the casualty exchange ratio, and the fractional exchange ratio are all distributed approximately lognormally.

f. There is a high degree of redundancy (*i.e.*, statistical correlation) among some of the items in the CDB90 data base (*see* CAA-1991).

g. When a breakpoint hypothesis similar to those conventionally used to terminate simulations and wargames is tested against the data base, it is found to be inconsistent with the data (*see also* Helmbold-1971b).

11. Comments and Critique. This provides a useful confirmation, using an independent data base, of various findings found earlier using the data in Helmbold-1961, Helmbold-1964a, and Bodart-1906.

HELMBOLD-1987

1. Document Description. Helmbold, Robert L., "Do Battles and Wars Have a Common Relationship Between Casualties and Victory?," US Army Concepts Analysis Agency, 8120 Woodmont Avenue, Bethesda, MD, 20814-2797, Concepts Analysis Agency Technical Paper CAA-TP-87-16, November 1987, 52 pp. UNCLASSIFIED. Available from DTIC (AD-A196 126).

2. Objectives and Scope. To determine whether the relation between casualties and victory in land combat, discovered in the course of earlier research (*see* Helmbold-1961, Helmbold- 1964a, Helmbold-1971a, Anonymous-1985, and Helmbold-1986) holds also for wars.

3. Populations Included. Participants in battles and wars.

4. Timeframes Included. The battle data extend from early days to 1973. The war data extend from 1823 through 1979.

5. Casualty Types Included. As in Singer-1972 and Small-1982, battle-connected deaths of military personnel only are used for interstate wars. For battles, losses were used, as explained in CAA-1991.

6. Time Intervals Included As. From start to end of a war or a battle.

7. Situational Descriptors Defined As. None used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. The relationship of victories to casualties in wars is similar to that for land combat battles. Despite the lack of strict compatibility of the war and the battle data, and despite other obvious differences between battles and wars, they share at least this relationship in common. The key variables involved in this relationship appear to have been remarkably stable from at least the early 1800s to the present day. Since there is no empirical evidence that they will suddenly change in the foreseeable future, it is rational to expect this relationship to persist. Wars characterized by Small-1982 as having high confidence casualty data follow the relationship between victory and casualties more faithfully than those with low confidence data. Accordingly, the apparent deviation of some war data from the general trend of this relationship can reasonably be attributed to inaccurate or incomplete data, compounded by a lack of strict compatibility between battles and wars in the way both casualties and the population at risk are defined, and by the lack of a more extensive data base on wars. In sum, the relationship between victory and casualties seems to be a fundamental one.

11. Comments and Critique. This provides a remarkable confirmation of the relationship of victory to casualties in military actions, discovered to apply to land combat battles, extended to air battles, and then shown to hold for wars.

HELMBOLD-1990

1. Document Description. Helmbold, Robert L., "Rates of Advance in Historical Land Combat Operations," US Army Concepts Analysis Agency, 8120 Woodmont Avenue, Bethesda, MD 20814-2797, Concepts Analysis Agency Research Paper CAA-RP-90-1, June 1990, 142 pp. UNCLASSIFIED. Available from DTIC (AD-A225 635). See also the following companion documents by the same author (not abstracted here):

a. "A Survey of Past Work on Rates of Advance in Land Combat Operations," US Army Concepts Analysis Agency Research Paper CAA-RP-90-3, Feb 1990 (AD-A217 891).

b. "A Compilation of Data on Rates of Advance in Land Combat Operations," CAA-RP-90-4, Feb 1990 (AD-A220 426).

2. Objectives and Scope. To present some original analyses of the statistical data on rates of advance in land combat operations, using a much larger data base than has been used heretofore.

3. Populations Included. As in CAA-1991, *q.v.*

4. Timeframes Included. As in CAA-1991.

5. Casualty Types Included. As in CAA-1991.

6. Time Intervals Included As. As in CAA-1991.

7. Situational Descriptors Defined As. As in CAA-1991 (but none actually used).

8. Data Sources Used. For the relationship of casualties to rates of advance, only the CDB90 database (*see* CAA-1991) was used. The other rates of advance data are unclassified and available on computer diskettes from DTIC as "ROADATA-Rates of Advance Data," Feb 1990, AD-M000 115.

9. Other and Miscellaneous. Much of the information on rates of advance contained in this document does not deal with the influence of casualties on rates of advance. Among the other topics treated are: rates of advance and the speed of the governing mode of transport, rates of advance now and in the past, rates of advance for small and large units, rates of advance for motorized and foot-mobile forces, rates of advance for lightly and heavily engaged forces, rates of advance in summer and winter, rates of advance in campaigns and similar long-duration operations, distribution of rates of advance, and rates of advance and force ratios.

10. Summary of Findings Regarding Battle Casualties. The relationship of casualties to victory in combat, discovered in the course of earlier research (*see* Helmbold-1961, Helmbold- 1964a, Helmbold-1971a, Anonymous-1985, Helmbold-1986, and Helmbold-1987) is also one of the best predictors of rate of advance for forces that are heavily engaged. Force ratio is one of the poorest predictors of rate of advance.

11. Comments and Critique. This improves our understanding of the relationship between advances in land combat operations and the casualties inflicted.

HELMBOLD-1993

1. Document Description. Helmbold, Robert L., "The Constant Fallacy: A Persistent Logical Flaw in Applications of Lanchester's Equations," European Journal of Operations Research, to appear, 1993, pagination to be determined. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. From the Abstract: "A particular logical flaw is continually being made in interpretations of Lanchester's equations. The fallacy will be exposed in this paper. Because of this fallacy, certain applications of Lanchester's N-square law of combat are invalid. Also, a popular method for empirically determining the functional form of the attrition equations is invalid. Correct interpretations of this situation are offered, and a logically sound approach is indicated."

3. Populations Included. Not used.

4. Timeframes Included. Not used.

5. Casualty Types Included. Not used.

6. Time Intervals Included As. Not used.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. None used.

9. Other and Miscellaneous. Similar comments have previously been presented in several venues, including Helmbold-1964b, and "Some Observations on the Choice of Exponent in Lanchester's Law," Presented to the Ad Hoc Working Group on the Theory of Combat, cosponsored by the Defense Nuclear Agency and the Naval Postgraduate School, 1979.

10. Summary of Findings Regarding Battle Casualties. A popular method for determining the form of attrition equations is logically invalid because it commits the "Constant Fallacy." This fallacy is continually being made in interpretations of Lanchester's equations. Because of this fallacy, certain interpretations of Lanchester's N-square law of combat are invalid. Also, a popular method for empirically determining the functional form of the attrition equations is invalid. The nature of the fallacy may briefly be expressed as follows: The Constant Fallacy is committed when particular constants are inadvertently treated as though they were universal constants.

11. Comments and Critique. This provides a useful caution regarding certain arguments about the form of attrition relationship.

HELMBOLD-1994

1. Document Description. Helmbold, Robert L., "Direct and Inverse Solution of the Lanchester Square Law With General Reinforcement Schedules," European Journal of Operations Research, to appear, pagination to be determined. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. To present a simple and efficient method for inferring the attrition coefficients in Lanchester's square law for homogeneous forces with general reinforcement schedules, when the reinforcement schedules and the initial and final strengths are known.

3. Populations Included. Not used.

4. Timeframes Included. Not used.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Although the focus of this paper is on the inverse solution of certain attrition equations, it makes essential use of their direct solution. The distinction between direct and inverse problems is as follows. Direct problems are those of determining the state $x(t)$ of a system as a function of the time t, given the dynamical laws that govern state evolution and enough other basic information to make the problem well posed. Direct problems have been long studied, and general systematic procedures have been developed for dealing with large classes of such problems.

The theory of inverse problems, which are in a sense the opposite of direct problems, is not as well developed. Specifically, we are faced with an inverse problem whenever we are given partial information about the state function $x(t)$, and are asked to infer something about either:

(i) The form of the dynamical laws governing state evolution,

(ii) The values of certain constant parameters characterizing a specific system,

(iii) The values of certain exogenous functions characterizing the system's environment,

(iv) The values of certain boundary conditions characterizing the state of the system at certain points in time, or any conceivable combination of (i) through (iv). It's pretty clear that inverse problems can be harder than direct problems, if only because direct problems usually take more information as given than is normally available for inverse problems.

The specific direct and inverse problems considered involve a combat situation where attrition is governed by the Lanchester square law equations between homogeneous forces with general reinforcement schedules:

$$\begin{cases} x_1' = -Dx_2 + R_1' \\ x_2' = -Ax_1 + R_2' \end{cases}$$

Here the (column) vector $x(t) = [x_1(t), x_2(t)]^{\mathrm{T}}$ gives the force strengths at time t into the battle. Primes denote differentiation with respect to time. It is assumed that the attrition coefficients A and D are constants independent of the time and of the force strengths $x(t)$, while all other quantities are functions of the time t. The direct problem is: find the force strengths $x(t)$ as a function of time, given the following:

(i) The form of the differential equations is as stated.

(ii) The values of the two attrition coefficients A and D, which are considered to be constants independent of the time t and of the force strengths.

(iii) The reinforcement schedule (column) vector $R'(t) = [R_1'(t),\ R_2'(t)]^{\mathrm{T}}$, which gives the rate at which additional forces enter the battle. For ease of reference, $R'(t)$ is called the reinforcement schedule, even though its components may give the rate of exogenous reductions (as well as increases) in force strength. Such exogenous reductions may correspond to losses by administrative detachment of units, by individuals falling sick, and so forth.

(iv) The force strengths at the start of the battle, $x(0)$.

Application of this model to a particular situation of practical interest requires that the attrition coefficient values, A and D, be determined by some means. One approach is to base their values on historical combat data on force strengths and losses. However, this involves the solution of the following inverse problem, which is the main focus of this paper:

(i) Attrition is governed by the Lanchester square law equations for homogeneous forces with general attrition schedules.

(ii) The attrition coefficients A and D are constants.

(iii) The reinforcement schedule R' is a prescribed function of the time t.

(iv) The time T at which the battle ends is known.

(v) The initial and final force strengths, $x(0)$ and $x(T)$ are given.

With this information, we are to infer the values of the attrition coefficients A and D.

This problem arises in the context of validating models of combat, a subject which has attracted considerable attention of late. Historical data are often available in more or less the form given by (i) through (v) above, so that estimates of the historical attrition coefficients can be obtained if our inverse problem can be solved. The validity of a combat model can then be tested in part by comparing its attrition coefficients to those obtained from historical data. In more general terms, it may be broadly asserted that inverse problems of inferring the dynamics of attrition from historical combat data are likely to prove crucial to the development of empirically based quantitative theories of combat.

10. Summary of Findings Regarding Battle Casualties. Methods for solving inverse problems in the theory of attrition are important, and practical methods for doing so are available.

11. Comments and Critique. This provides a useful source of information on the solution of inverse problems in the theory of attrition.

HERO-1967a

1. Document Description. Historical Evaluation and Research Organization (HERO), "Average Casualty Rates for War Games, Based on Historical Combat Data," Historical Evaluation and Research Organization, Unnumbered, 15 February 1967, 192 pp. UNCLASSIFIED. Available from DTIC (Section I is AD-890 546L, Section II is AD-890 547L, Section III is AD-890 548L, and Section IV is AD-458 759).

2. Objectives and Scope. From the Summary: "This study compares casualty figures of both opposing forces in 37 engagements, representing five basic defense postures—defense of a fortified position, defense of a prepared position, defense of a hastily prepared position, delay, and withdrawal—and the corresponding attack postures. ... The data has [*sic*] been analyzed at the level of the division of equivalent."

3. Populations Included. Participants in selected land combat engagements.

4. Timeframes Included. World War II and Korea.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of an engagement.

7. Situational Descriptors Defined As. From the Introduction: "While historical and military judgment have been applied in the interpretation of the records, no effort has been made in this study to evaluate the various qualitative influences on the data derived and presented ... —such influences, for example, as leadership, doctrine, morale, and logistical support."

8. Data Sources Used. From the Summary: "Information on strengths and casualties was derived from US sources entirely for selected operations in Okinawa and Korea and from German as well as US records for selected operations in the European Theater in World War II. Where records were inadequate or ambiguous, available figures have been expanded or modified on the basis of professional military and historical judgment. (This was particularly necessary for German data, since all of the most relevant German records have been returned to West Germany without having been microfilmed.)"

9. Other and Miscellaneous. Remarks on the quality of the data include, from the Methodology: "No Japanese, North Korean, or Chinese Communist records are available. Consequently, figures on casualties and strengths of those forces were procured entirely from the reports of the opposing US units, and must be viewed with considerable caution. Following World War II the major portions of the offic.. records of the Germany Army were brought to Washington. They were retained in what is now the Federal Records Center for several years and available for research to historians and others. It was finally decided, however, that the records should be returned to the German Government. Before their release, many of the documents were microfilmed and the microfilm stored in the National Archives.

Unfortunately for the purposes of this study, no one foresaw the usefulness of the personnel records included in this material, and virtually none of them was microfilmed. ... One serious instance of conflicting and contradictory records for an American division was found, raising some doubts as to the reliability of other records for that division. ... In cases where the only German casualty figures available were those for a stated period, usually ten days or one month ..., a daily breakdown of casualties was estimated, based upon knowledge of the situation existing, the nature of the combat in which the units were engaged throughout the period, the intensity of the combat indicated by casualty figures for US forces, knowledge of the course of operations, and experience with similar forces in similar situations. ... Japanese casualty figures on Okinawa, derived solely from US sources, included only killed, broken down into several categories, including estimated dead as well as counted dead and estimated numbers sealed in caves ... the accuracy of these daily figures is impossible to validate. There are no records at all on Japanese wounded. ... For Korea, we have accepted the FEC [Far Eastern Command] figures ... These evidently do not include prisoners of war. It is not certain whether they include estimates of wounded."

10. Summary of Findings Regarding Battle Casualties. No generalizations regarding battle casualties are offered. However, tabulations of estimated strengths and losses are provided.

11. Comments and Critique. The cautions on the quality of the data available are important and very sound.

HERO-1967b

1. Document Description. Historical Evaluation and Research Organization (HERO), "Comparative Analysis of Armored Conflict Experience," Historical Evaluation and Research Organization, Unnumbered, 12 May 1967, 213 pp. UNCLASSIFIED (except for classified Annex bound separately). Available from DTIC (Vol I is AD-873 137, Vol II Section I is AD-873 138, Vol II Section II is AD-873 139, and the Classified Annex is AD-510 855).

2. Objectives and Scope. From the Summary: "This study ... has surveyed and analyzed selected tank-vs-tank battles with the aim of assessing, on the basis of this analysis, the sensitivity of success in combat to: (1) force ratio advantages, particularly in terms of comparative tank strength; and (2) qualitative differences in opposing items of equipment, particularly tanks."

3. Populations Included. Participants in selected tank battles.

4. Timeframes Included. World War II and the India-Pakistan hostilities of September 1965.

5. Casualty Types Included. Tank losses.

6. Time Intervals Included As. From the Summary: "The battles to be studied were selected on the basis of the following criteria: (1) large number of tanks engaged, preferably an armored division or more; (2) tanks engaged primarily against tanks; (3) relatively open terrain, no jungle or mountainous terrain; (4) records available, preferably for both sides."

7. Situational Descriptors Defined As. Several situational descriptors are included in the accompanying narrative descriptions of the campaigns.

8. Data Sources Used. Various.

9. Other and Miscellaneous. From the Summary: "The actions selected for study, after preliminary investigation of records were the following: (1) three actions in the France-Flanders campaign, May-June 1940; (2) the battle of Alam Halfa in the Egyptian Western Desert, September 1942; (3) action at Chouigi Pass, Tunisia, November 1942; (4) the battle of Targul Frumos, Rumania, May 1944; (5) Operation GOODWOOD, near Caen, France, July 1944; (6) a battle near Arracourt, France, September 1944; (7) the Saar Valley campaign, November-December 1944 and one of its individual engagements; (8) the defense of St. Vith, Belgium, December 1944; (9) several actions in the defense of Bastogne, Belgium, December 1944; and (10) the tank actions of the India-Pakistan hostilities, September 1965."

10. Summary of Findings Regarding Battle Casualties. From the Summary: "The study reached the following major conclusions:

a. "In weighing the combat advantages of superiority of number of tanks against the advantages of quantitative superiority of specific characteristics of tanks, superior tactical mobility is most

important and numerical superiority is next after mobility in influence upon the outcome of armored conflict. Superior numbers have greater influence than individual tank firepower and protection, so long as these latter meet reasonably adequate standards.

b. "It is probably impossible to produce a tank so superior in qualitative characteristics, and to place it on the battlefield in such numbers, that its qualitative and quantitative superiority can compensate for poor leadership, training, and tactics.

c. "In allocating resources available for armored forces, the aim should be as large a number as possible of highly mobile tanks—otherwise adequate in operational characteristics—in combination with effective antitank weapons, artillery, and infantry."

11. Comments and Critique. The stated conclusions obviously go far beyond anything that could rationally have been derived from an analysis, however detailed and intense, of this study's admittedly limited sample of only a few tank actions. It is not at all clear just what additional information or considerations were used to arrive at the stated conclusions, nor is it obvious that they are in fact correct and suitable guidance for future developments. The tabulated data on the limited sample of actions is useful, as far as it goes.

HERO-1975

1. Document Description. Historical Evaluation and Research Organization (HERO), "German and Soviet Replacement Systems in World War II," Historical Evaluation and Research Organization, Prepared for ODASD(M&RA) under Contract No. MDA903-75-C-0137, July 1975, 125 pp. UNCLASSIFIED. Available from DTIC (AD-B959 989L).

2. Objectives and Scope. From the Introduction: "The study is organized in three parts. The first is a brief comparison of the replacement systems developed by the two armies and summarizes the major points made in the study. Parts II and III describe respectively the German and the Soviet replacement systems as they were planned and as they functioned."

3. Populations Included. German and Soviet army troops.

4. Timeframes Included. World War II.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. Various, but usually for periods of a few months. However, Table 6 gives German officer casualties by 10-day periods from October 1942 through March 1945.

7. Situational Descriptors Defined As. Various, and given only in the form of side comments.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. From the Comparison and Comments: "The extent to which the Germans and Soviets replaced their losses is obscured by several factors: (1) records are incomplete, prepared for different purposes, cover different periods of time or conflict; (2) both the Germans and the Soviets reduced the authorized strengths of their units in the course of hostilities, making it impossible to follow through on numbers of unfilled vacancies when many were removed by a readjustment on paper; (3) the withdrawal of depleted units for rehabilitation or dissolution is not reflected in periodic reports of losses and replacements."

11. Comments and Critique. Some of the numerous tabulations in this report may be of use in assessing gross losses and strengths over fairly long periods of time. Also, the comments on data problems are well worth taking to heart.

HERO-1979

1. Document Description. Historical Evaluation and Research Organization (HERO), "The Effects of Combat Losses and Fatigue on Combat Performance," Historical Evaluation and Research Organization, Prepared for US Army Training and Doctrine Command under Contract No. DAAG39-78-C-0048, January 1979, 133 pp. UNCLASSIFIED, except for classified Annex. Available from DTIC (AD-B038 029L, Classified Annex is AD-C017 931).

2. Objectives and Scope. From the Executive Summary: "This study seeks to find relationships between personnel casualties and the loss of major weapons in combat, and the effects on combat effectiveness of fatigue (and losses) in sustained combat. For purposes of this study only casualties and weapon losses due to hostile action were considered."

3. Populations Included. Participants in combat in Northwest Europe.

4. Timeframes Included. World War II.

5. Casualty Types Included. Tank and personnel losses.

6. Time Intervals Included As. Various, but often for a complete campaign.

7. Situational Descriptors Defined As. Occasionally given in narrative form.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Includes numerous tables and figures. Contains several comments on the quality and interpretation of the data. For example, the Introduction states that "In addition to problems of quantity of [the sources of information], there are several significant problems concerning its quality. An Appendix has been included with this report, illustrating some of these problems."

10. Summary of Findings Regarding Battle Casualties. From the Executive Summary: "In Part I of the study data on tank losses is related to personnel losses at crew, battalion, division, and army level. For World War II in Northern Europe the US Army averaged about 2.56 casualties out of a 5 man crew in medium tanks which were damaged sufficiently to sustain casualties. For light tanks there were about 2.64 casualties out of the 4 man crew in similar circumstances. However, many tanks were damaged without their crews suffering casualties; when all damaged tanks are related to all crew casualties, the overall loss is reduced to about 1 crewman per damaged tank, medium or light. The report also presents data relating crew losses to position, and to the weapon causing the damage.

"At the US armored division level personnel loss rates of 0.45 percent per day and tank loss rates of 2.4 percent per day averaged over the length of the operation were recorded. High single day tank losses of 4 to 5 percent were recorded.

"At the army level US tank losses reached as high as 1.5 percent per day during especially heavy fighting like that in the Battle of the Bulge, but in general were below 1 percent per day.

"US loss rates for personnel and tanks, in the examples studied, were considerably lower than those in large British-German and Russian-German battles. For instance, in operation GOODWOOD in Normandy, British losses averaged 1.78 percent per day in personnel and 12.96 percent per day in tanks over a three day period. Soviet tank loss rates in the Orel Operations were 8.7 percent per day. During the Arab-Israeli war in 1973 tank loss rates exceeded US World War II rates, but were similar to the Soviet and British World War II loss rates. While personnel and tank loss rates vary from country to country and war to war the relation of 6 to 1 in percent per day tank losses to personnel losses seems to remain fairly constant."

11. Comments and Critique. This provides a useful compilation of information on tank and personnel losses, and on the relationship between the two. The study contains several cautions regarding the quality and proper interpretation of the data, which are well-taken.

HOEFFLER-1981

1. Document Description. Hoeffler, Dennis F., "Changes in the Distribution of Navy and Marine Corps Casualties from World War I Through the Vietnam Conflict," Military Medicine, Vol 146, Nov 1981, pp 776-779. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To contrast prewar morbidity and mortality with that of the subsequent war time era, and to compare this information for a number of different war time eras.

3. Populations Included. Active duty Navy and Marine Corps personnel.

4. Timeframes Included. World War I through the Vietnam Conflict.

5. Casualty Types Included. Admissions to Navy Hospitals.

6. Time Intervals Included As. From start to end of a war.

7. Situational Descriptors Defined As. The data are for admissions of active duty personnel only and reflect only the total world-wide figures. The influence of outpatient illness and variations between different theaters of operations are not considered. All casualties due to trauma are lumped together (*i.e.*, KIA, WIA, DOW, and nonbattle injuries).

8. Data Sources Used. Annual reports of the Navy Surgeon General, with causes of admission classified by the author according to major ICDA categories (*see* Eighth Revision, International Classification of Diseases, adopted for use in the United States, US Government Printing Office, 1968), and official health statistics of the United States.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Peacetime mortality rates for Navy and Marine Corps personnel during the past 100 years have declined like those of their civilian counterparts. The only exceptions to these steadily declining rates have occurred during periods of military conflict.

a. In World War I, the KIA rate was approximately 4.4/1,000 per year, but the died of disease rate was 11.8/1,000 per year, and DNBI admission rates were 731/1,000 per year as compared to battle wound admissions of 45/1,000 per year (a ratio of about 16 to 1).

b. In World War II, the KIA rate was 3.7/1,000 per year, while the died of disease rate was 0.6/1,000 per year. Admissions for DNBI averaged 534/1,000 per year as compared to battle wound admissions of about 6/1,000 per year (a ratio of about 88 to 1).

c. In Korea, the KIA rate averaged about 1/1,000 per year (although it was about 3/1,000 per year in 1950). Admissions for DNBI averaged 309/1,000 per year as compared to battle wound admissions of 3.7/1,000 per year (a ratio of about 84 to 1).

d. In Vietnam, the KIA rate averaged about 3.2/1,000 per year (peaking at 4.8/1,000 per year during the Tet offensive of 1968). Admissions for DNBI averaged 196/1,000 per year as compared to battle wound admissions of about 11.7/1,000 per year (a ratio of about 17 to 1).

11. Comments and Critique. This provides a useful summary of general information on the trends in nonbattle and battle casualties over the early part of the 1900s.

HOLMES-1985

1. Document Description. Holmes, Richard, "Acts of War: The Behavior of Men in Battle," The Free Press, a Division of Macmillan, Inc., ISBN: 0-02-915020-5, 1985 (first American edition, 1986), 436 pp. UNCLASSIFIED. Available from publisher and libraries (copy in the Pentagon Library under U21.2 H625 1986).

2. Objectives and Scope. The author's aim is to address fundamental questions on the nature of human behavior in battle. In doing this he plumbs the human factors (psychological, sociological, physiological) aspects of combat.

3. Populations Included. Various.

4. Timeframes Included. Various.

5. Casualty Types Included. Various.

6. Time Intervals Included As. Various.

7. Situational Descriptors Defined As. Included in various narrative descriptions.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Pages 167-172 provide some data on the number of rounds needed to inflict a casualty. Pages 348-351 discuss the distribution of casualties by rank. Page 210 gives some figures on the causative agents of casualties. Throughout, there is much information and discussion of the stress placed by combat on morale, fear, and psychophysiological endurance.

11. Comments and Critique. This is an excellent review and analysis of what can be discussed in books about the effects of combat on human beings.

HUTZLER-1989

1. Document Description. Hutzler, Patricia I.; and Frola, F. Ronald, "Disease and Nonbattle Injury Casualty Estimates: Status and Issues," Logistics Management Institute, 6400 Goldsboro Road, Bethesda, MD 20817-5886, Report FP905TR1, October 1989, 45 pp. UNCLASSIFIED. Available from publisher and DTIC.

2. Objectives and Scope. From the Introduction: "In response to increased DoD concern regarding planning and programming for wartime casualties, LMI [Logistics Management Institute] has been tasked to conduct a brief review of the status of DNBI casualty estimates and their use in personnel and medical support programming. This report documents our effort. ... Our work focused on the following specific objectives:

a. "Identifying the data sources and methods used to develop the current DNBI rates.

b. "Determining the status of the DNBI rates used by the Services, including the special studies being conducted by the Services to revise their DNBI rates.

c. "Identifying the major differences between the Services and the theaters in applying DNBI rates.

d. "Evaluating the sensitivity of the major models used by DoD in personnel and medical support programming to DNBI rates.

e. "Developing recommendations as to what further OSD action is warranted."

3. Populations Included. Future US armed services personnel.

4. Timeframes Included. Future.

5. Casualty Types Included. DNBI.

6. Time Intervals Included As. From start to end of a war game scenario.

7. Situational Descriptors Defined As. None used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. From the Findings and Conclusions:

a. "Except for the Marine Corps, the DNBI rates currently used by the Military Services are not well documented. Lack of adequate audit trails renders examination of the basis for the current rates impossible.

b. "All of the Services are revising their DNBI rates. The studies necessary for these revisions are at various stages of completion. ... The basic dissimilarities in the Services' missions and operating environment can result in legitimate differences in determination and use of DNBI rates.

c. "On the basis of limited tests and analysis of the sensitivity of the JOPS III [Joint Operations Planning System] Medical Planning Module (MPM) outputs to changes in DNBI rates, we find that (i) the outputs of MPM vary widely in their sensitivity to DNBI rates, and (ii) medical requirements are probably influenced more by factors, assumptions and data incorporated in the MPM other than DNBI rates."

11. Comments and Critique. This provides a useful summary of information regarding the methods used by the various services to estimate future DNBI rates.

JACOB-1984

1. Document Description. Jacob, Herbert, "Using Published Data: Errors and Remedies," Sage Publications, Beverly Hills, 1984, ISBN: 0-8039-2299-X, 1984, 63 pp. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. From the Introduction: "Although the data are often published in formats that suggest that they are authoritative and trustworthy, they are almost always riddled with errors of one sort or another. This essay seeks to alert the unwary researcher of some of the pitfalls in using them. I shall set out both the problems and some remedies. Readers should not be discouraged. For almost every problem there is a solution or at worst an acceptable compromise. It will sometimes seem that the dangers outrun the remedies; that should give us pause as we undertake research based on these data or rely on analyses that use such sources. But it need not paralyze our research."

3. Populations Included. Does not deal with military casualties.

4. Timeframes Included. Not used.

5. Casualty Types Included. Not used.

6. Time Intervals Included As. Not used.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Table of Contents includes: Introduction; Samples, censuses, and sampling error; Measurement errors and invalidity; Reliability; Conclusion; and an Appendix giving a brief note on sources and critiques of important data sets.

10. Summary of Findings Regarding Battle Casualties. Findings regarding data bases include the following.

a. Perhaps the most important attribute for the user of published data is a large dose of skepticism. ... In every case the analyst should ask, Are these data valid? In what ways might they have been contaminated so that they are unreliable?

b. Researchers must subject published data to as many tests as they can devise.

11. Comments and Critique. This provides a useful summary of the major problems of using published data.

JOHNSON-1981a

1. Document Description Johnson, C. Curtiss, "Analytic Survey of Personnel Replacement Systems in Modern War," Historical Evaluation and Research Organization (HERO), unnumbered, April 1981, about 200 pp (however, pages 90 and above are missing from the DTIC copy). UNCLASSIFIED. Available from DTIC (AD-B100 622L). Prepared for the US Army TRADOC Systems Analysis Activity under Contract No. DABT58-80-C-0064. The results supposedly were used in the General Research Corporation (RAC) study "Personnel Replacement System Policy Analysis," by James M. Wroth, *et al*, RAC Report 1213-01-81-CR, April 1981, Vol I of which is AD-B060 002L.

2. Objectives and Scope. To survey and analyze the wartime replacement systems and experiences of the US and British Armies in World War II and the US Army in the Korean and Vietnam Wars.

3. Populations Included. Personnel.

4. Timeframes Included. World War II, Korea, Vietnam.

5. Casualty Types Included. Battle casualties.

6. Time Intervals Included As. From start to end of a major operation.

7. Situational Descriptors Defined As. A few are given in narrative accounts of the action.

8. Data Sources Used. Various, but mainly the original records of the commands and formations surveyed extensively.

9. Other and Miscellaneous. Includes numerous tables and figures.

10. Summary of Findings Regarding Battle Casualties. Not given in the copy made available by DTIC.

11. Comments and Critique. This provides a useful survey of replacement experience in World War II. Korea, and Vietnam. No doubt many of the problems experienced in the past will plague future replacement system operators.

JOHNSON-1981b

1. Document Description. Johnson, David E.; Crum, John W.; and Lumjiak, Somnuk, "Medical Consequences of the Various Weapons Systems Used in Combat in Thailand," Military Medicine, Vol 146, Sep 1981, pp 632-634. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To report on a random sample of patients evacuated to Phramongkutlao (Royal Thai Army) Hospital with combat injuries.

3. Populations Included. While US ground forces were not actively engaged in Southeast Asia during this period, guerrilla warfare continues to exact casualties there. During a recent 12-month period, combat casualties admitted to the Royal Thai Army Hospital in Bangkok were longitudinally followed to ascertain the frequency of these injuries, their types, degree of medical services required, and the resultant disability of these patients. Patients with combat injuries were identified through evacuation communications. These patients were met in the emergency room and their records tagged for identification with the study.

4. Timeframes Included. Not stated in the document.

5. Casualty Types Included. Wounded. Patients were admitted to the study only if they were injured as a result of the violent actions of an organized group insurgent to established authority in Thailand.

6. Time Intervals Included As. Not stated in the document.

7. Situational Descriptors Defined As. Only a few descriptors are used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. A total of 275 casualties were included in the study. Of these, 223 were soldiers or border policemen, while the remaining 52 were either civilians working for the government or local residents inadvertently involved in combat. Of the 275 casualties, 251 were injured by either (1) rifle (specifically high velocity automatic and semiautomatic weapons fire); (2) fragmentation weapons (usually either home-made or short-range military production mortars); or (3) land mines containing explosives but without shrapnel. The remaining casualties were injured either by more than one of the above; or by other weapons systems (e.g., artillery or pistol), and are omitted from further consideration in this document. The article includes a figure showing length of hospitalization by type of weapon. It also includes tables showing the location of injuries by various agents and the frequency of upper and lower extremity amputations by type of weapon.

10. Summary of Findings Regarding Battle Casualties. "Nearly 50 percent of the personnel were injured as a result of contact with non-shrapneled land mines. The usual result of a lower extremity land

mine injury included amputation and prolonged hospitalization. Rifle injuries accounted for the majority of residual neurological deficits found in these casualties."

11. Comments and Critique. This provides useful data on the kinds of casualties inflicted by modern guerrilla warfare operations.

JTCG-1970

1. Document Description. Joint Technical Coordinating Group (JTCG) for Munitions Effectiveness, "Evaluation of Wound Data and Munitions Effectiveness in Vietnam (WDMEV)," US Department of Defense, Final Report, December 1970, In three volumes (Vol 1 is 406 pp, Vol 2 is 289 pp, Vol 3 is 275 pp), Vols 1 and 3 are UNCLASSIFIED, Vol 2 is SECRET. Available from DTIC (Vol 1 is AD-879 516, Vol 2 is AD-513 342L, Vol 3 is AD-879 517).

2. Objectives and Scope. The Wound Data and Munitions Effectiveness Team (WDMET) was organized on 6 April 1967 to respond to the need for a study in depth of the wounding capability and effectiveness of various weapons used in Vietnam. Its general objectives were to (1) enhance the lethality of present and future weapons, (2) confirm or modify the criteria for estimating weapons and munitions requirements, (3) develop mathematically the dependence of traumatic effects of wounds from a medical point of view upon significant parameters of the causative agent (such as fragment weight and velocity), (4) evaluate and possibly improve protection gear for soldiers, and (5) confirm or modify criteria for estimating medical requirements. The WDMET team concerned itself primarily with the effects of infantry and artillery support systems; to a lesser degree, armored systems , surface-to-air systems, and aerial-delivered systems were included.

3. Timeframes Included. Vietnam War.

4. Populations Included. Personnel in Vietnam.

5. Casualty Types Included. Battle casualties.

6. Time Intervals Included As. The WDMET team operations in Vietnam were conducted from June 1967 through June 1969.

7. Situational Descriptors Defined As. Detailed in the narrative summaries of the action surrounding each casualty incident.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Includes numerous tables and figures. Notes that, although reports and monographs prepared from it are available, all of the raw wound ballistics data from the World War II and Korea field studies has been lost.

10. Summary of Findings Regarding Battle Casualties. Examples of the type of findings are:

a. From 500 autopsies, the distribution of fatal wounds was 36.4 percent from thoracic trauma, 32.6 from head trauma, and 9.2 percent from abdominal trauma. This is similar to the results of other studies.

b. Bullets were responsible for 45.0 percent of the lethalities and fragments for 43.6 of them. The percent of lethalities from bullets is much higher than the percent of all casualties from bullets (30 percent).

c. For head injuries, the frontal, parietal, temporal, and occipital regions, in that order, were the scalp areas most frequently struck in the survivors and fatalities.

d. For thoracic injuries, the upper thorax was struck in 58.64 percent of such cases. The entrance wounds were anterior in 58.13 percent of such cases. The upper anterior thorax was struck in 44 percent of such cases.

11. Comments and Critique. This is no doubt the most ambitious and comprehensive study of wound ballistics and munitions effectiveness in actual combat conditions ever conducted. The digitized data base of approximately 8,000 Vietnam casualties has been preserved, and is maintained by the Casualty Care Research Center, Department of Military Medicine, Uniformed Services University of the Health Sciences, 4301 Jones Bridge Road, Bethesda, MD 20814-4799.

KARIS-1988

1. Document Description. Karis, Daniel G., "Of Blue Badges and Purple Cloth: The Impact of Battle Deaths in a Cohesive Unit," US Army Command and General Staff College, Unnumbered, 18 December 1988, 55 pp. UNCLASSIFIED. Available from DTIC (AD-A208 135).

2. Objectives and Scope. This is an essay on the impact of battle death on unit cohesion, morale, and effectiveness.

3. Populations Included. Small units engaged in combat.

4. Timeframes Included. Not used.

5. Casualty Types Included. Death.

6. Time Intervals Included As. From start to end of a small unit action.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. From the Conclusion: "Military cohesion and motivation are rooted in intensely personal attachments at the small unit level. Casualties occurring to primary group members in the cohesive unit produce more fear than those which occur to members with whom an individual is less closely bound. Of all the causes of breakdown in combat, the death of a soldier's buddy has the most powerful impact." It is also suggested that a three-man buddy system may be better suited to future combat than a two-man system.

11. Comments and Critique. This provides an insightful analysis of the factors that strengthen and loosen unit cohesion under combat conditions.

KEILIG-1956

1. Document Description. Keilig, Wolf, "Das Deutsche Heer, 1939-1945. Gliederung, Einsatz, Stellenbesetzung [The German Army, 1939-1945. Organization, Mission, Employment]," published by Hans-Henning Podzhun, Bad Nauheim, 1956, variously paged. UNCLASSIFIED. Available from Charles C. Wise Library, West Virginia University, Morgantown, WV (US 712.K4). In three volumes. The loss information is in volume 3, section 204.

2. Objectives and Scope. To document certain information concerning the German armed forces in World War II.

3. Populations Included. Werhmacht, Heer, Waffen-SS, Luftwaffe, Kriegsmarine.

4. Timeframes Included. 1939-1943.

5. Casualty Types Included. Deaths, wounded, losses.

6. Time Intervals Included As. As of selected dates.

7. Situational Descriptors Defined As. Not specified.

8. Data Sources Used. Official German records, primarily those of the highest levels of command.

9. Other and Miscellaneous. Table of Contents includes:

a. Einführung, Inhaltsverzeichnis, Abkürzungen, Quellen, Nachträge. [Introduction, contents, abbreviations, sources, appendices.]

b. Übersichten zur Truppenzugehörigkeit. [Overview of troop organizational assignments.]

c. Schlact- und Gefectsbezeichnungen. [Designation of battles and engagements.]

d. Stellenbesestzungen (Gesamtheer). [Employment (total army).]

e. Oberkommando der Wehrmacht (OKW). [Supreme command of the Wehrmacht.]

f. Oberkommando des Heeres (Ob. d. H., OKH). [Supreme command of the army.]

g. Oberbefehlshaber auf Kriegsschauplätzen. [Theater commanders in chief.]

h. Heeresgruppen. [Army groups.]

i. Armeeoberkommandos (auch Pz. Gruppen, Arm. Abt.).

j. Generalkommandos (auch Höh. Kdo., Korpsgr., Res. A.K.).

k. Divisionen (einschl. Div. Kommandos des Ersatzheeres).

l. Höhere Stäbe, Brigaden, selbständige Truppen. [Higher staffs, brigades, independent units.]

m. Abschnittskommandos, Festungen u. ä.

n. Luftwaffen-Feld-Verbände. [Luftwaffe field units.]

o. Kommandobehörden der Waffen-SS.

p. Mil. Befehlshaber, Werm.-Befh., Bevollm. Generale.

q. Kommandanten rückwärtiger Gebiete, Oberfeldkdt. u. ä.

r. *Ersaztheer (stellv. Gen. Kdos. Schulen, u.ä.).*

s. Abwicklungsstäbe nach dem 8. Mai 1945.

t. Lagekarten zo größeren Fronträumen.

u. Documente von besonderer Bedeutung.

v. Die Generalität des Heeres im 2. Weltkrieg.

w. Register. [Index.]

x. Namenverzeichnis. [Index of names.]

10. Summary of Findings Regarding Battle Casualties.

a. All strength and loss figures are at very high level (*i.e.*, at the theater level, such as South-Ukraine, North Ukraine, Center, North, Western Front, Southwest, Southeast, Norway, Denmark, *etc.*).

b. Strength figures are snapshots of status at a particular time. All loss figures are for very long periods of time (*e.g.*, from the beginning of the war to 9 January 1943, *etc.*).

11. Comments and Critique. Probably a unique source of interesting auxiliary information, but of little direct relevance to PAR.

KELLEY-1977

1. Document Description. Kelley, C. T. Jr.; Smith, G. K.; and Matyskiela, W. W., "Quality-Quantity Tradeoffs: A Historical Analysis of Air Combat," The RAND Corporation, RAND Report R-1976-AF, April 1977, 45 pp. UNCLASSIFIED. Available from DTIC (AD-C010 504).

2. Objectives and Scope. From the Abstract: "This study analyzes historical air combat data to understand the sensitivity of aerial combat maneuvering engagement results to variations in fighter aircraft force sizes and compares the data with Lanchester's theory of combat."

3. Populations Included. Participants in air combat maneuvering engagements.

4. Timeframes Included. Korea and Vietnam Wars.

5. Casualty Types Included. Aircraft losses.

6. Time Intervals Included As. From start to end of an air combat maneuvering engagement.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. From the Summary: "The Southeast Asia data of F-4 vs. MiG-21 engagements show that the US-North Vietnamese (NVN) exchange ratio—the ratio of NVN aircraft losses divided by US aircraft losses—decreased somewhat as the initial force ratio increased in the favor of the United States. The Southeast Asia data are not well fitted by either the Lanchester linear or square law or by any form between them. Analysis of the Korean War data (F-26 vs. MiG-15) shows that the US-North Korean exchange ratio increased as the initial force ratio increased in the favor of the United States. The Korean data are best fitted by a form of the Lanchester law that falls between the linear and square laws. It is recommended that an analysis of quality-quantity fighter aircraft tradeoffs include sensitivity tests of aerial combat maneuvering model formulations in addition to the usual sensitivity tests involving air combat variables such as missile kill probabilities."

11. Comments and Critique. The findings regarding Lanchester's equations are wrong, since they are based on the Constant Fallacy (*see* Helmbold-1993). The finding regarding the meager influence of force ratio is similar to the findings in that regard reported by Helmbold, Hartley, Willard, and others. However, the data in this study are for very small forces (for example, a flight of 4 aircraft versus 1 or 2 aircraft), and the resultant losses are also very small (often no losses to either side or just a single loss to one side and none on the other, *etc.*). For such data, an analysis using differential equations is not appropriate. The proper method would be to analyze such data using some stochastic formulation of the attrition equations.

KINGSLEY-1968

1. Document Description. Kingsley, E. H., "A Method for Estimating Ground Combat Attrition Coefficients," Center for Naval Analyses, CNA Research Contribution No. 103, Nov 1968, 54 pp. UNCLASSIFIED. Available from DTIC (AD-501 246).

2. Objectives and Scope. From the cover letter: "This research contribution presents a method for estimating the attrition coefficients of friendly and enemy units. The method employs historical information, weapon lethality, and ammunition usage grates. Formulae are given for computing attrition coefficients when changes are made in the basic parameters."

3. Populations Included. Participants in engaged in land combat battles.

4. Timeframes Included. The historical data cited is primarily from World War II.

5. Casualty Types Included. Battle casualties.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Section I provides the background of this study. Section II describes the technical problem and outlines the proposed solution. Section III offers a method for estimating the Lanchestrian square law attrition coefficients from basic weapon performance data. Section IV presents a method for estimating the attrition coefficients from historical data, and gives some examples of its application to 16 World War II and Korean battles, as well as to 4 World War II amphibious operations. Section V illustrates the method by application to a hypothetical example. Section VI discusses the advantages and disadvantages of the proposed method.

10. Summary of Findings Regarding Battle Casualties. No general conclusions regarding battle casualties are specifically stated, but the author evidently believes his method gives values of the attrition coefficients that are sufficiently accurate for use in war games such as CNA's Tactical Warfare Simulation Program-II (TWSP-II).

11. Comments and Critique. The historical data analyzed in Section IV could be used in other contexts. However, the number of battles considered is not large enough to support general conclusions. The analytical methods in Section III provide, in essence, a proposed form of the attrition relationship.

KIRKPATRICK-1985

1. Document Description. Kirkpatrick, D. L. I., "Do Lanchester's Equations Adequately Model Real Battles?," RUSI (Journal of the Royal United Services Institute for Defence Studies), Vol 130, no 2, June 1985, pp 25-27. UNCLASSIFIED. Available from libraries. See also the subsequent discussion of this paper in (i) Robertson, David, "Lanchester, the Civil War and Military Procurement," RUSI Vol 130, no 4, December 1985, pp 57-58, and (ii) Kirkpatrick, D. L. I., "Lanchester and Real Battles Revisited," RUSI Vol 130, no 4, December 1985, pp 59-60.

2. Objectives and Scope. To present yet another attempt to compare Lanchester's equations to historical combat, in the hope that the result will contribute to a better understanding of the laws and of their relevance too current arguments on quality versus quantity in armaments.

3. Populations Included. Participants in US Civil War battles.

4. Timeframes Included. US Civil War.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Livermore-1900.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. For the US Civil War, setting aside battles not suited to the analysis for one reason or another, on the average the personnel losses are related to personnel strengths according to the following equation:

$$\frac{\text{Confederate losses}}{\text{Union losses}} = 1.01 \cdot \left(\frac{\text{Union strength}}{\text{Confederate strength}} \right)^{0.99}$$

This is derived by linearly regressing the left hand side on the right hand side. This regression uses data from 16 battles in which the number of killed and wounded are known with apparent accuracy, losses can be attributed principally to the effect of firepower, and losses are not significantly influenced by particular circumstances (such as fortifications or surprise) and so depend primarily on the numbers engaged. The regression result is interpreted as implying a form of the attrition relationship that is closer to Lanchester's linear law than to his square law, which in turn is interpreted as "[suggesting] that the effect of superior numbers may be less important than is often claimed by advocates for the procurement of many cheap weapons systems of moderate individual effectiveness."

11. Comments and Critique. The statistical analysis leading to the stated equation appears to be valid. However, the interpretation of the result as implying some form of the attrition relationship is badly mistaken, since it commits the Constant Fallacy (*see* Helmbold-1993). The statement regarding quantity-quality tradeoffs may be correct, but cannot be based on the argument presented.

KLINGBERG-1966

1. Document Description. Klingberg, Frank L., "Predicting the Termination of War: Battle Casualties and Population Losses," Journal of Conflict Resolution, Vol X, no 2, 1966, pp 129-171. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. This paper is concerned with the possibility of predicting the end of a war from a knowledge of the casualties and population losses sustained. Two major hypotheses were considered, without any opinion by the proposers as to whether the study would support them: (i) that there might be a constant ratio for defeated nations between battle casualties and population losses before surrender; and (ii) that certain trends in battle casualties throughout a specific war might be useful in helping to predict the end of that war. The procedure and results for these hypotheses are analyzed in Parts I and II (respectively).

3. Populations Included. Participants in battles.

4. Timeframes Included. From 1618 to 1918.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of a war.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Primarily Bodart-1908 for battle losses. The principal sources consulted for population losses were Dumas-1923 and Friedrich Prinzing's *Epidemics Resulting from Wars* (Oxford, Clarendon Press, 1916).

9. Other and Miscellaneous. This study was originally undertaken in the summer of 1945, in an effort to help understand the conditions under which the Japanese might be induced to surrender. It was suggested by Dr. William B. Shockley (later a joint recipient of the Nobel Prize for the development of transistors), since he felt the need for a historical study of casualties "to determine to what extent the behavior of a nation in war can be predicted from the behavior of her troops in individual battles." Dr. Shockley discussed this with Professor Quincy Wright (*see* Wright-1942), and when advised that no such study had been done, asked Prof. Wright to prepare an outline to be used as a basis for such a project, and Klingberg was brought to Washington to undertake the study. Japan surrendered while the paper was in preparation, but the study was completed. This document describes the procedures and results secured at that time, along with some additional figures and comments. It includes numerous figures and a few tables.

10. Summary of Findings Regarding Battle Casualties. From the Summary and General Conclusions:

a. With regard to the first hypothesis.- "Historical-statistical data from 1618 to 1918 were used in this study to test the hypothesis that a fixed relationship might exist between a nation's casualties in battle defeats and its population losses in lost wars. The results show that there is no general ratio between casualties and population losses, but that there is a marked similarity in these ratios for some major wars at certain historical periods, with a tendency for the ratio to be higher in more recent times."

b. With regard to the second hypothesis.- "A study of statistical trends during long wars indicates that certain shifts in these trends might be used to help predict the approaching surrender of a nation. Four indices which proved particularly significant, when viewed as a whole, were casualty percentage ratios between the opposing belligerents, army-size ratios, proportion of battle defeats, and intensity of fighting. When these indices showed unfavorable trends for two successive periods (as campaign periods), the end of the war was ordinarily at hand. ... An increase in the rate of relative casualties for the defeated nation (as compared to the victor) was also noted near the end of long wars."

11. Comments and Critique. This is a remarkably insightful paper, and provides a unique insight into this study of war conducted to assist US planning near the end of World War II.

KOHN-1932

1. Document Description. Kohn, Stanislas and Baron Alexander F. Meyendorff, "The Cost of the War to Russia," One of the series "Economic and Social History of the World War-Russian Series," printed by the Yale University Press for the Carnegie Endowment for International Peace. Division of Economics and History, 1932, 219 pp. UNCLASSIFIED. Copy held by the Naval History Center (HC56.C4 no.12).

2. Objectives and Scope: The purpose was to investigate the vital statistics of Russia during World War I.

3. Populations Included. Total Russian population.

4. Timeframes Included. 18 July 1914 to April 1917.

5. Casualty Types Included. KIA, WIA, DOW, MIA.

6. Time Intervals Included As. Not specifically broken down by time interval.

7. Situational Descriptors Defined As. Not specified.

8. Data Sources Used. Not specified, but indicated as "official records."

9. Other and Miscellaneous. Table of Contents includes:

a. First Division.

(1) Part I. Direct Influence of the War on the Number and Distribution of the Population: Military Service; and Refugees, Civil Prisoners, and War Prisoners.

(2) Part II. The Natural Growth of the Population During the Years of the War: Marriages: Births; Mortality; and The Natural Increase and Decrease of the Population.

(3) Part III. The War Losses of Russia.

(4) Appendixes: List of Successive Orders Calling Men to the Colors; Estimated Approximate Numbers of Men Called to the Colors in Fifty Provinces of European Russia; Number of Men Mobilized in Rural Districts of Russia and the Number of Allowances Granted to Families of Men on Military Service on September 1, 1917; Pre-War Marriage Rates in European Russia: Number of Marriages in European Russia in the Years 1913-1917; Pre-War Birth Rates in European Russia; Number of Births in European Russian in the Years 1913-1917; Pre-War Death Rates in European Russia; and Number of Deaths in European Russia in the Years 1913-1917.

b. Second Division: The Non-Economic Consequences of the War; The Peasants; Industrial Labor; and The Effects of the War Upon Investments.

10. Summary of Findings Regarding Battle Casualties. An estimated 1,660,000 Russian soldiers died in World War I, either KIA, DOW, MIA/unaccounted for, died in captivity, DNBI, *etc.*

11. Comments and Critique. Frequently remarks that the numbers are rough estimates. Since the values apply to long periods of time, they are of only tangential relevance to the PAR studies.

KOHN-1987

1. Document Description. Kohn, George C., "Dictionary of Wars," Anchor Books, Garden City, New York, ISBN: 0-385-24207-7, 1987, 591 pp. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. Designed to fill the need for a single volume reference work that deals exclusively and concisely with the world's military conflicts, from classical antiquity to the present, emphasizing the major wars, revolutions, revolts, and rebellions. Space limitations preclude comprehensiveness, but coverage is still global. Wars are presented alphabetically by name, well cross-referenced, and with an excellent index.

3. Populations Included. Wars are defined fairly broadly as overt, armed conflict carried on between nations or states or between parties, factions, or people in the same state (civil war).

4. Timeframes Included. From 2000 BC to the present.

5. Casualty Types Included. Various.

6. Time Intervals Included As. From start to end of a war.

7. Situational Descriptors Defined As. Given in the narrative accounts.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. None stated.

11. Comments and Critique. This provides a useful compendium of wars and information on them in brief ready reference form. It can be compared to other dictionaries of battles.

KREMER-1906

1. Document Description. Kremer, W. P., "100 Great Battles of the Rebellion," W. P. Kremer, Hoboken, NJ, 1906, 366 pp. UNCLASSIFIED. Available from libraries (copy available at the library of the University of Northern Cedar Falls, Iowa, as E491 K93). Subtitled "A detailed account of regiments and batteries engaged—casualties, killed, wounded and missing, and the number of men in action in each regiment; all the battles of the Revolution, War of 1812-15, Mexican War, indian battles, American-Spanish War, and naval battles; State rosters from the several northern states, giving the enrollment, number killed, wounded, died and deserted from each organization during the war."

2. Objectives and Scope. Provides a tabulation of personnel losses for several battles and engagements involving US forces.

3. Populations Included. Participants in battles.

4. Timeframes Included. Primarily and almost exclusively those of the American Civil War. However, the more important actions of the American Revolutionary War, the War of 1812, the Mexican War, the Spanish-American War, the Philippine War, the French and Indian War (1754-1760), selected battles from the American Indian Wars, and 15 naval engagements are also represented.

5. Casualty Types Included. Usually killed, wounded, and missing. Sometimes killed, wounded, and captured.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. The official records of the American Civil War.

9. Other and Miscellaneous. For the American Civil War, casualty figures for killed, wounded, and missing are broken down by individual regiment. Where available, the regiment's personnel strength is also given. However, these personnel strength values are usually missing. The author remarks (p 69, in connection with the battle of Chickamauga) that "The reports of this battle are the most complete of any of the engagements during the war. The effective strength carried in action is reported by two-thirds of the regiments." If this document's tabulation of casualties could be combined with information on the regimental strengths (or even with the total command strength), a more useful and valuable compilation would result.

Page 313 gives a tabulation comparing officer figures (on killed, wounded, died, deserted, and number enrolled) to those of soldiers for each of 11 regiments. Pages 314-315 give a tabulation of the various causes of death (killed, died of disease, accidental death, drowned, murdered, killed after capture,

suicide, executed by the enemy, sunstroke, death not classified) by state (Alabama, Arkansas, *etc.*), by arm of the service (Infantry, Cavalry, Artillery), and by troop type (white, colored, and Navy).

10. Summary of Findings Regarding Battle Casualties. No general findings stated.

11. Comments and Critique. This provides a useful tabulation of losses for many of the battles included. Unfortunately, with some exceptions, the corresponding personnel strength information is not provided in this document.

KUHN-1989

1. Document Description. Kuhn, George W. S., "Ground Forces Battle Casualty Rate Patterns: The Empirical Evidence," Logistics Management Institute, 6400 Goldsboro Road, Bethesda, MD, Logistics Management Institute Report FP703TR1, Sep 1989, 252 pp. UNCLASSIFIED (except for Appendix A, bound separately). Available from publisher (not available from DTIC).

2. Objectives and Scope. From the Executive Summary: "This task's purpose is to evaluate the reasonableness of battle casualty rate projections by the Services and theater commands. We will issue three reports on ground forces casualty rates. This first one presents findings about ground forces casualty rates gleaned from a large body of newly developed empirical data, and compares current US Army and U. S. Marine Corps projections for a European scenario to those findings."

3. Populations Included. Battle casualties.

4. Timeframes Included. World War II, Korea, and Arab-Israeli Wars. Some US National Training Center (NTC) data are also included.

5. Casualty Types Included. Battle casualties.

6. Time Intervals Included As. From start to end of a battle (or daily, when available).

7. Situational Descriptors Defined As. Only a few broad characterizations of the tactical situation are used, such as "continuous front" and "disrupted front."

8. Data Sources Used. Various.

9. Other and Miscellaneous. Includes numerous tables and figures.

10. Summary of Findings Regarding Battle Casualties. From the numbered findings given in the document:

a. Casualty rates exhibit pulses and variability (from time to time, from echelon to echelon, and from one sector of the front to another)

b. As casualty rates increase, their duration in [number of] consecutive days decreases dramatically.

c. Daily rate variation increases as the mean rate over time increases.

d. The proportions of a large force that are intensively engaged reflect the effects of daily rate pulsing and variability over time and across the force.

e. The casualty rate for an army over a 10-day period of peak intensity does not necessarily show differences associated with offensive versus defensive postures, or winning versus losing.

f. Casualty rates will reflect whether [the] front remains "continuous" or is "disrupted."

g. Peak casualty rates for Army-level forces are comparable when the operational front remains continuous.

h. The wounded-in-action rate as a proportion of the total battle casualty rate declines significantly with either a disrupted front or a continuous front that experiences rapid loss of territory and confusion.

i. Given the same context, casualty rates for German forces facing Soviet forces and methods were no higher than US rates against German forces and methods.

j. Where direct and appropriate comparisons are possible, empirical evidence shows no significant increase in casualty rates since 1945.

11. Comments and Critique. Many of the findings are reminiscent of those of Berndt-1897, Bodart-1908, and Love-1931, and so are rather trite. A similar study of division casualties was also done by RAC (*see* Robinson-1965), with similar results. So this work's self-characterization as "*The* Empirical Evidence" is much exaggerated. In the sense that this work updates (and in many cases makes more precise) previously-discovered facts with more recent data, it is of value. The value of such research for model validation and analysis is also made clear. However, one of the weaknesses of this treatment is that usually only unilateral losses to one side are considered. This ignores the presence of the other side (in fact, the side that is *causing* those casualties), and as a result pays no attention to that essential aspect of the situation.

KUHN-1990

1. Document Description. Kuhn, George W. S., "Ground Forces Battle Casualty Rate Patterns: Current Rate Projections Compared to the Empirical Evidence," Logistics Management Institute, 6400 Goldsboro Road, Bethesda, MD, Logistics Management Institute Report FP703TR2, May 1990, 304 pp. UNCLASSIFIED (except for Appendix C, bound separately). Available from publisher (not available through DTIC).

2. Objectives and Scope. From the Executive Summary: "This is the second report in this series on ground forces battle casualty rates and rate patterns. ... This report compares recent US and Allied casualty rate projections to the insights into rates and rate patterns that the body of empirical evidence affords." The casualty rate projections addressed are those of the US Army and Marine Corps, the Federal Republic of Germany, the United Kingdom, and the Supreme Headquarters, Allied Powers in Europe (SHAPE).

3. Populations Included. Same as in Kuhn-1989.

4. Timeframes Included. Same as in Kuhn-1989.

5. Casualty Types Included. Same as in Kuhn-1989.

6. Time Intervals Included As. Same as in Kuhn-1989.

7. Situational Descriptors Defined As. Same as in Kuhn-1989.

8. Data Sources Used. Same as in Kuhn-1989.

9. Other and Miscellaneous. Includes numerous tables and figures.

10. Summary of Findings Regarding Battle Casualties. From the Executive Summary:

a. The research confirms our earlier observation of three significant mismatches. First, certain major projections—given their planning scenarios—are at least twice too high for peak-rate (10-day) periods than the evidence from actual operations supports. Such projected peak-rates are usually, in fact, suited only to scenarios in which a theater force suddenly collapses rather than to scenarios (even if pessimistic ones) assumed in planning.

b. Second, the rate projections fail to suggest realistic distributions of rates which are of particular concern to planners attempting to anticipate requirements over the planning timeline. Projections of rate averages over an extended planning timeline should show multiple peak-rate periods where now they generally show only one. And while average divisional rates for an army-size force would be lower for such peaks than now often projected, rates for certain sectors within that force could be far higher than now envisioned.

c. Third, the empirical evidence clearly demonstrates a significant shift in the proportions of casualty types to be expected in certain worst-case defensive scenarios. In real-world operations, those scenarios show a radical increase in missing and captured casualties and a substantial decrease in the proportion of wounded in action. None of the projections takes that shift of casualty proportions into account.

11. Comments and Critique. Several earlier studies by other organizations also found that the wargames generally depict a more rapid pace of operations and a higher average casualty rate than history suggests. The observation that the relative number of missing and captured battle casualties increases when the front line is badly disrupted comes as no surprise, although the quantification of the difference given in this document is useful.

KUHN-1991

1. Document Description. Kuhn, George W. S., "Ground Forces Casualty Rate Patterns: Suggested Planning Considerations," Logistics Management Institute, 6400 Goldsboro Road, Bethesda, MD, Logistics Management Institute Report FP703TR3, Jan 1991, 137 pp. UNCLASSIFIED. Available from publisher (not available from DTIC).

2. Objectives and Scope. From the Preface: "The present report (1) provides ranges and associated distributions of rates that are empirically supportable given certain force sizes and echelons, time periods, and general scenarios and (2) presents these data, and supporting commentary, in a form adaptable to two of the major current US rate projection methodologies [specifically the Medical Planing Module (MPM) and the Patient Flow Model (PFM)]."

3. Populations Included. As in Kuhn-1989.

4. Timeframes Included. As in Kuhn-1989.

5. Casualty Types Included. As in Kuhn-1989.

6. Time Intervals Included As. As in Kuhn-1989.

7. Situational Descriptors Defined As. As in Kuhn-1989.

8. Data Sources Used. As in Kuhn-1989.

9. Other and Miscellaneous. Includes numerous tables and figures.

10. Summary of Findings Regarding Battle Casualties. From the Executive Summary: "At the same time, the widely used US Army Field Manual FM 101-10-1/2, which offers casualty rate planning data, should be amended to incorporate the perspectives afforded in this report (and its two predecessors) on the patterns of casualty rates associated with modern conventional operations. Finally, we suggest that study of the relationships between casualty rate patterns and patterns of modern conventional operations is of such fundamental importance to planning generally that it ought to be instituted for military officers, and for anyone responsible for rate projections in the planning sphere, in the curricula at certain Service Schools. The phenomena that give rise to casualty rates have associated implications across broad areas of planning requirements. Formal attention to the empirically demonstrated character of patterns of rates and operations seems amply justified."

11. Comments and Critique. Certainly more attention should be given to the historical data on casualties and to the development of improved theories for relating casualties to operational factors. This report provides excellent arguments supporting the desirability of such additional research and study.

LAFFIN-1986

1. Document Description. Laffin, John, "Brassey's Battles: 3,500 Years of Conflict, Campaigns and Wars from A to Z," Brassey's Defence Publishers, London, ISBN: 0-08-031185-7, 1986, 484 pp. UNCLASSIFIED. Available from Publisher and libraries.

2. Objectives and Scope. To provide a comprehensive, corrected reference on battles, campaigns, and wars.

3. Populations Included. Lists more than 7,000 battles, campaigns, and wars.

4. Timeframes Included. From 1500 BC to the present.

5. Casualty Types Included. Various.

6. Time Intervals Included As. From start to end of the battle, campaign, or war.

7. Situational Descriptors Defined As. Given in the narrative accounts.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. No findings presented.

11. Comments and Critique. This provides a useful compendium of battles, campaigns, and wars. Erroneously states that Harbottle-1905 was the first to provide a quick-reference dictionary of battles (Berndt-1897 preceded Harbottle's work, as did Livermore-1900). This work can be compared to other dictionaries of battles.

LANCHESTER-1916

1. Document Description. Lanchester, Frederick William, "Aircraft Warfare: The Dawn of the Fourth Arm," Constable & Co., London, 1916. UNCLASSIFIED. Available from libraries. The portion dealing with Lanchester's square law was reprinted in *The World of Mathematics*, James R. Newman (ed), Vol 4, pp 2138-2157, published by Simon & Schuster, New York, 1956.

2. Objectives and Scope. To argue the case for the use of aircraft in warfare.

3. Populations Included. None used.

4. Timeframes Included. None used.

5. Casualty Types Included. None used.

6. Time Intervals Included As. None used.

7. Situational Descriptors Defined As. None used.

8. Data Sources Used. None used.

9. Other and Miscellaneous. The book consists essentially of reprints of articles published in the British journal "Engineering." In particular, Chapters V and VI dealing with Lanchester's attrition relations appeared in that journal in the months of September through December 1914. The famous N-square law first appeared in print in the issue dated 2 October 1914.

10. Summary of Findings Regarding Battle Casualties. Findings are not in evidence, since no explicit comparison to historical battle outcomes is offered. However, the so-called linear and square laws of combat attrition, based on a sort of informal consideration of historical combat, are clearly presented. These attrition equations can be subsumed under a more general case which can be written as

$$\frac{dx}{dt} = -Dx^a y^b$$

$$\frac{dy}{dt} = -Ax^c y^d,$$

where $x \equiv x(t)$ and $y \equiv y(t)$ are the remaining force strengths on sides X and Y as of time t after the start of the battle, the initial strengths $x(0) = x_0$ and $y(0) = y_0$ are given, and it is tacitly understood that once either x or y becomes zero, it remains at that value from then on. The coefficients D and A are known as attrition coefficients. They give the rate of loss of X (respectively Y) per unit value of the quantity $x^a y^b$ (respectively $x^c y^d$).

It is well known that a first integral or state equation can easily be derived from these attrition equations by eliminating t to write

$$\frac{dx}{dy} = \frac{D}{A} x^{a-c} y^{b-d}$$

and then separating variables and integrating to write

$$\frac{A}{c-a+1}(x_0^{c-a+1} - x^{c-a+1}) = \frac{D}{b-d+1}(y_0^{b-d+1} - y^{b-d+1}).$$

Lanchester's square law is the particular case described by $a = d = 0$ and $b = c = 1$. A generalization of the Lanchester square law to the p-power law is described by $c - a = b - d = p - 1$. Note that this corresponds to a single form of the state equation, but to an infinite family of attrition differential equations. The Lanchester linear law is the particular case described by $a = b = c = d = 1$. A generalization of Lanchester's linear law to the so-called p-linear law is the case described by $c = a$ and $b = d$. Note that, as before, this corresponds to a single form of the state equation, but to an infinite family of attrition differential equations.

11. Comments and Critique. Lanchester's equations are famous in the field of military operations research, and have been used and misused ever since a resurgence of interest in them occurred during World War II. For a treatment more in the spirit of the PAR studies and criticisms of the N-square law, see other works on the form of attrition relationships.

LARCHER-1934

1. Document Description. Larcher, "Données Statistiques sur les Forces Françaises 1914-1918," Revue Militaire Française, Vol 104 (new series), no 155, May 1934, pp 198-223 and no 156, June, pp 351-363. UNCLASSIFIED. Available from libraries (copy on microfilm in Library of Congress).

2. Objectives and Scope. To give numerical statistics on the following matters concerning the French forces 1914-1918: effectives and their fluctuations; number of large units; large units committed to action; and losses of large units and in total.

3. Populations Included. French Army forces.

4. Timeframes Included. World War I.

5. Casualty Types Included. Killed, died of wounds, wounded not including deaths, missing, prisoners of war, and died of disease or injury.

6. Time Intervals Included As. From start to end of the war (however, some graphs show variation over time with time resolution of about one month). .

7. Situational Descriptors Defined As. None, except for major campaigns.

8. Data Sources Used. Various, and often unstated (however, the author was at the time a Lieutenant-Colonel in the French armed forces).

9. Other and Miscellaneous. Includes the following major tables and graphs.

a. Tables. Effectives retained outside of the Army; Changes in the number of effectives; Losses by battle; Average losses per division engaged in selected battles; Percentage losses to the various arms of the service (separately for officers and men); Losses by region; Total losses by year; and Total losses (by (i) killed, missing, and prisoners; (ii) died in the Army zone, (iii) evacuated and died in the interior, and (iv) others evacuated to the interior).

b. Graphs. French effectives 1914-1918 (total enrolled, retained in the Army of the North-East, in the French Army of the East, in the interior and in North Africa, discharged for disability, and losses [killed, missing, discharged, retired, and miscellaneous]); Number of divisions of French Infantry and Dragoons; Number of German divisions 1914-1918; Number of divisions of French infantry and cavalry engaged in the principal battles of the war 1914-1918; and Losses of the French Army by month of the war (including those due to sickness).

10. Summary of Findings Regarding Battle Casualties. None explicitly stated.

11. Comments and Critique. This provides a useful overview of French losses in World War I. Its broad figures can be compared to those in Mitchell-1931 and Love-1925.

LETTERMAN-1866

1. Document Description. Letterman, Jonathan, "Medical Recollections of the Army of the Potomac," D. Appleton and Co., New York, 1866, 194 pp. UNCLASSIFIED. Available from US Army William Beaumont Army Medical Center, El Paso, Texas.

2. Objectives and Scope. This is essentially Dr. Jonathan Letterman's personal memoirs of his experiences as chief medical officer of the Medical Department of the Army of the Potomac during portions of the US Civil War. Pages 76 through 78 give for the Union side tables of the total number of wounded and killed by corps and division in the battle of Fredericksburg. Pages 79 through 86 provide for the Union side tables of wounded by site of wound and causative agent.

3. Populations Included. Tables are provided only for the Union forces involved in the battle of Fredericksburg.

4. Timeframes Included. The main battle of Fredericksburg took place on 13 December 1862. According to Letterman, it "began on the morning of the 13th December, and lasted until dark."

5. Casualty Types Included. KIA, WIA, and MIA.

6. Time Intervals Included As. From start to end of the battle.

7. Situational Descriptors Defined As. Not offered.

8. Data Sources Used. Reports of the units involved, or of their medical officers.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. No particular generalizations are offered.

11. Comments and Critique. Provides a useful tabulation of data on losses, site of injury, and causative agent for the battle of Fredericksburg.

LIVERMORE-1900

1. Document Description. Livermore, Thomas L., "Numbers and Losses in the Civil War in America, 1861-65," Kraus Reprint Co., Milwood, NY, 1977 (a reprint of the Indiana University Press edition of 1957, originally published in Boston in 1900), 150 pp. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. To present careful estimates of the personnel strengths and losses for land battles of the American Civil War, based on the Official Records of the US Civil War.

3. Populations Included. Union and Confederate sides in battle in which 1,000 or more were hit (*i.e.*, killed or wounded in action) on at least one of the sides.

4. Timeframes Included. US Civil War (1861 to 1865).

5. Casualty Types Included. Killed, wounded, missing.

6. Time Intervals Included As. Uncertain and variable. For battles, from start to end of the battle.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Official Records of the War of the Rebellion.

9. Other and Miscellaneous. Contents include:

   a. Total number in the Union Army.

   b. Total number in the Confederate Army.

   c. Assaults on fortified lines.

   d. Routs.

   e. Victories.

   f. The following battles are included:

1861–Bull Run, Wilson's Creek;

1862–Fort Donelson, Pea Ridge, Shiloh, Williamsburg, Fair Oaks, Mechanicsville, Gaines's Mill, Peach Orchard to Malvern Hill, Seven Day's Battles, Cedar Mountain, Manassas and Chantilly, Richmond (Kentucky), South Mountain, Antietam, Corinth, Perrysville, Prairie Grove, Fredericksburg, Chickasaw Bayou, Stone's River;

1863–Arkansas Post, Chancellorsville, Champion's Hill, Vicksburg, Port Hudson (May 27), Port Hudson (June 14), Gettysburg, Fort Wagner, Chickamauga, Chattanooga, Mine Run;

1864–Olustee, Pleasant Hill, Wilderness and Spotsylvania (May 5-12), Wilderness (May 5-7), Spotsylvania (May 10), Spotsylvania (May 12), Drewry's Bluff, Atlanta Campaign, Cold Harbor,

Petersburg, The Mine, Deep Bottom, Weldon R.R., Kenesaw Mountain, Tupelo, Peach Tree Creek, Atlanta (July 22), Atlanta (July 28), Jonesborough (August 31), Jonesborough (September 1), Chaffin's Farm, Cedar Creek, Boydton Plank Road, Franklin, Nashville;

1865–Hatcher's Run, Bentonville, Appomatox Camp, Dinwiddie, Petersburg.

10. Summary of Findings Regarding Battle Casualties. The author is very cautious about drawing conclusions from this material, apparently preferring to present the facts, insofar as he is able to discover them, and to leave the interpretation to others.

11. Comments and Critique. This has long been a standard reference for Civil War battle strengths and losses. It has a good discussion of the difficulties of obtaining accurate figures, a clear explanation of how the author arrived at his estimates, and appropriate cautions regarding overly-hasty and superficial interpretation of their meaning.

LOVE-1925

1. Document Description. Love, MAJ Albert G., "Medical and Casualty Statistics," US Army Surgeon General's Office, Volume XV (Statistics), part 2 (Medical and Casualty Statistics), of the series *The Medical Department of the United States Army in the World War* [*i.e.*, World War I], published by the US Government Printing Office, Washington, DC, 1925, 1368 pp. UNCLASSIFIED. Available from US Army Military History Institute (UM24 1917-18 A45 1921 V.15 pt. 2). Part 1 of Volume XV is entitled "Army Anthropology. Based on Observations Made on Draft Recruits, 1917-1918, and on Veterans at Demobilization, 1919," and is not relevant to attrition rate analysis.

2. Objectives and Scope. To document certain medical statistics from US Army experience in World War I.

3. Populations Included. US Army forces.

4. Timeframes Included. World War I (1 April 1917 to 31 December 1919).

5. Casualty Types Included. Deaths, admissions, influenza, nonbattle injuries, battle injuries, discharge for disability, case fatality rates, KIA, wounds by gas and gunshot.

6. Time Intervals Included As. Usually broken down month-by-month.

7. Situational Descriptors Defined As. Not specified.

8. Data Sources Used. From the Introduction to this document "The approximately 12,000,000 individual medical records received by the Surgeon General's Office during World War I." The Preface states in part that "Medical and casualty statistics have been published from year to year in the reports of The Surgeon General for 1918, 1919, and 1920. These contain such statistics for the calendar years 1917, 1918, and 1919, respectively. Many data contained in these reports, with some additional data, will be found in [this document]. Comparison of the tables in The Surgeon General's annual reports for the years mentioned with those in the present volume will reveal some differences. In all such cases, the figures which appear here should be given preference.

"Later, The Adjutant General proposes to publish final casualty statistics which will be based on a careful study of the complete records of all the individuals concerned. These figures also will vary to some extent from those which appear here, due mainly to the fact that they were prepared solely for military purposes while those of the Medical Department had other purposes in mind as well."

9. Other and Miscellaneous. Table of Contents includes:

a. Section I. Methods of collecting and compiling vital statistics: Strength data and estimates; Sick and wounded data; Methods of assembling statistical data in The Surgeon General's Office; and Explanation of terms and methods used.

b. Section II. Tables. (Includes 122 tables.)

c. Plates. (Includes 54 plates.)

d. Appendix. (Describes in some detail the instructions issued for the collection of medical record data and the forms used for this purpose.)

10. Summary of Findings Regarding Battle Casualties.

a. The document gives no summary statement of findings or interpretation of the data.

b. Contains tables giving the number of gas wounded, gunshot wounded, and killed in action each day for each Infantry, Artillery, and Engineer regiment, and for each machinegun battalion.

11. Comments and Critique. Comprehensive account of World War I casualties. Probably the most complete available for US Army forces as a whole.

LOVE-1931

1. Document Description. Love, LCOL Albert G., "War Casualties," US Army Medical Field Service School, Carlisle Barracks, Pennsylvania, The Army Medical Bulletin, Number 24, 1931, 177 pp. UNCLASSIFIED. Available from US Army Military History Institute (UM400 U515, no. 24).

2. Objectives and Scope. From the Preface. "An attempt is made in the following pages to outline a system for estimating, on the basis of our casualty experience in past wars, the requirements for medical service including hospitalization and evacuation of front line casualties; and further to show how intimately the question of replacements for all branches of an army is related to casualty rates, and also to prompt and efficient medical care."

3. Populations Included. US Army forces.

4. Timeframes Included. Not applicable.

5. Casualty Types Included. Average battle and nonbattle casualty rates per day per 1,000. These figures are generally for large forces and long time spans (*i.e.*, the entire American Expeditionary Force for World War I, the entire Union Forces in the Civil War, *etc.*).

6. Time Intervals Included As. Not applicable.

7. Situational Descriptors Defined As. Not specified.

8. Data Sources Used. The earlier work of Love and others described elsewhere as Love–1925, plus additional published and unpublished materials available to the Medical Department.

9. Other and Miscellaneous. Table of Contents includes:

   a. Medical service in war.

   b. Loss of manpower in war.

   c. Medical service in the combat zone.

      (1) Diseases and nonbattle injuries.

      (2) Battle casualties–collection of data.

      (3) Battle casualties–presentation of data.

      (4) Battle casualties–transportation required.

      (5) Battle casualties–disposition of cases in the combat area.

   d. Explanatory notes and development of formulae.

10. Summary of Findings Regarding Battle Casualties.

a. The document gives a detailed but elaborate system for estimating the average rate of loss of personnel due to battle casualties and DNBI, and for estimating the impact of this on medical support planning. However, no simple summary of the system is possible.

b. Points out that the average daily casualty rate for regiments in World War I, which was about 20.36 per 1,000 strength, includes days spent in division reserve. Indicates that medical planning needs to consider high casualty days, and suggests that on 1.74 percent of the combat days regimental casualty rates were greater than 150 per 1,000 strength, and on 0.86 percent of the combat days they exceeded 200 per 1,000 strength.

c. Notes that casualty rates are lower for higher echelons, *i.e.*, division rates are lower than for regiments, corps rates are lower than for divisions, and army rates are lower than for corps.

d. Page 124 gives comparative data on wounding for World War I and the US Civil War.

11. Comments and Critique. The formulae are based on the use of multicomponent exponential decay curves, *i.e.*, on formulae of the form.

$$y(x) = \sum_{k=1}^{n} \epsilon_k e^{(a_k + b_k x)},$$

where $y(x)$ is generally the rate at which personnel enter or leave some designated category as of time x after the start of a period of time, $\epsilon_k = \pm 1$, and $y(0) = \sum \epsilon_k e^{a_k}$ is the rate at the start of the period. However, in a few cases, the author takes y to be the number of personnel remaining in the designated category after the lapse of x time units from the time they entered that category. Also, in most of the situations treated by the author, $n = 1$. In nearly every case he took $\epsilon_k = +1$ for all applicable values of k. However, in a few cases the author chose to take n equal to 2 or 3, and for at least one case with $n = 2$ he elected to put one of the ϵ_k equal to -1.

LOVE-1932

1. Document Description. Love, Albert G., "Casualties and Medical Statistics of the British Forces During the Great War," The Military Surgeon, Vol 70, no 2, February 1932, pp 109-127. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. This is a review of Mitchell-1931, and a comparison of its findings with those of the US Army in World War I.

3. Populations Included. British (and occasionally US) Army forces.

4. Timeframes Included. World War I.

5. Casualty Types Included. Killed, died of wounds, wounded not including deaths, missing, prisoners of war, died of disease or injury, sick and injured, not including deaths.

6. Time Intervals Included As. From start to end of a war (some statistics for divisions over a few days' duration are also given).

7. Situational Descriptors Defined As. None, except for the theater of war.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Includes numerous tables.

10. Summary of Findings Regarding Battle Casualties. None explicitly stated, but it appears that British and US experiences were very similar with regard to the ratio of wounded to killed, the location of wounds, and the general type of causative agent (small arms and hand grenade, artillery, and bayonet).

11. Comments and Critique. This provides a useful review and summary of Mitchell-1931, and a helpful comparison of it to US data.

MacDONALD-1951

1. Document Description. MacDonald, H. W.; Strong, E. D.; Van Royen, W.; Breen, I. J.; Billingslea, C.; Brittain, R. W.; and Johnson, E. A., "The Employment of Armor in Korea," Operations Research Office (ORO), Report ORO-R-1 (FEC), 8 April 1951, Vols I and II. Vol II is 226 pp long, UNCLASSIFIED, and available from DTIC as AD-187 999.

2. Objectives and Scope. From Appendix K of Vol II, "The problem was to identify the damage and the probable primary cause of damage to armored vehicle casualties—enemy and friendly—occurring in the course of UN military action in Korea, to draw preliminary conclusions therefrom, and to indicate, insofar as possible at present, further lines of investigation."

3. Populations Included. From Appendix K of Vol II, "The data upon which this memorandum is based are limited to the period of military activity ending approximately 21 October 1950 and to that part of Korea which is located south of the 39th parallel, the latitude of Pyongyang."

4. Timeframes Included. Korean War.

5. Casualty Types Included. Tank losses.

6. Time Intervals Included As. From start of the Korean War to approximately 21 October 1950.

7. Situational Descriptors Defined As. Only a few descriptors are used.

8. Data Sources Used. From Appendix K to Vol II, "They [the data] were obtained from an analysis of individual reports of seven field parties, which investigated casualties *in situ*, and from casualty reports provided by most of the Eighth Army armored units in the field."

9. Other and Miscellaneous. From Appendix K to Vol II, "The data on tank casualties are in some respects incomplete. ... However, while entirely complete and scientifically accurate data on both enemy and friendly tank casualties have not been obtainable, the present study probably deals, *in toto*, with at least two-thirds of all those casualties that put tanks out of action for periods ranging from more than a day to permanently."

10. Summary of Findings Regarding Battle Casualties. One-third of US tank casualties were attributed to mines, while one-fourth of North Korean tank casualties were attributed to napalm. These were the leading causes among those cited on p 29 of Vol II. Personnel casualties associated with the tank losses are not given in Vol II.

11. Comments and Critique. This provides a useful study of armor losses during the early phases of the Korean War. See also McCrae-1954.

MacLEAN-1990

1. Document Description. MacLean, French L., "German General Officer Casualties in World War II: Lessons for Future War," Military Review, April 1990, pp 45-56. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To show that significant general officer casualties in World War II severely strained the German command and control system, and to draw from that lessons for US forces.

3. Populations Included. German general officers.

4. Timeframes Included. World War II.

5. Casualty Types Included. Killed in action and died of wounds.

6. Time Intervals Included As. From start to end of a war.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Various, but primarily Wolf Keilig, "Die Generale des Heeres," Frieberg, FRG, Podzun-Pallas Verlag, 1983.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. German general officer losses in World War II amounted to 136 killed in action or died of wounds, including 3 army commanders, 23 corps commanders, and 110 division commanders. About 45 percent of those killed were in command for less than 5 months, and about 66 percent were in command for less than 10 months.

11. Comments and Critique. This provides material and references against which general officer losses for other nations can be compared.

MACV-1968

1. Document Description. MACV, "Friendly Casualties From Friendly Fires," HQ, Military Assistance Command, Vietnam, Vietnam Lessons Learned No. 70, 17 Oct 1968, 31 pp. UNCLASSIFIED. Available from US Army History Institute (U742 V5 no. 70).

2. Objectives and Scope. The main purpose of this publication was to encourage personnel to be more conscientious in avoiding friendly casualties from friendly fire.

3. Populations Included. Friendly personnel.

4. Timeframes Included. Vietnam War.

5. Casualty Types Included. Caused by friendly fire.

6. Time Intervals Included As. Emphasis is on calendar years 1967 and 1968.

7. Situational Descriptors Defined As. Several incidents detailed as examples provide illustrative situations. However, these were selected for their training value—not for their statistical significance.

8. Data Sources Used. Official records.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. In calendar year 1967, the bulk of friendly casualties from friendly fire involved artillery errors (fire direction center errors, firing battery errors, faulty ammunition, lack of coordination, unit disorientation, forward observer and forward air controller mistakes, and violations of rules of engagement were also cited, in order from the most to the least prevalent). Mortar fire, fixed wing ordnance, small arms, naval gunfire, and water surface craft were less frequently involved.

11. Comments and Critique. This provides an insight into the friendly fire casualty sources in Vietnam at this particular time.

MARETH-1985

1. Document Description. Mareth, Thomas R.; and Brooker, Alan E., "Combat Stress Reaction: A Concept in Evolution," Military Medicine, Vol 150, no 4, April 1985, pp 186-190. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To review the history of the medical side of psychiatric combat casualties.

3. Populations Included. Various.

4. Timeframes Included. Primarily World War I, World War II, Korea, and Vietnam.

5. Casualty Types Included. Psychiatric.

6. Time Intervals Included As. Various, and largely unspecified.

7. Situational Descriptors Defined As. Seldom given.

8. Data Sources Used. Various.

9. Other and Miscellaneous. The following figures are quoted, although their context and significance is sometimes obscure. During World War I, one-seventh of all British discharges for disability were from mental disorders, although 70 percent of the French and American psychological casualties recovered enough to resume military duties. Some 48.4 percent of the losses sustained by the US Marine 6th Division on Okinawa resulted from combat stress. Typically, in World War II, stress disorders accounted for 30-40 percent of all casualties to US Army forces. During the Korean Conflict, 85 to 90 percent of combat fatigue cases recovered. Of the first 1,500 Israeli casualties during the Yom Kippur War, over 900 suffered from combat stress reactions.

10. Summary of Findings Regarding Battle Casualties. No general statements regarding psychiatric attrition rates are offered. Advice is given on the medical treatment of psychiatric casualties.

11. Comments and Critique. The various statistics quoted in this article are suggestive, but not definitive. They should be confirmed by more authoritative sources before being used in serious work.

MAUGHAN-1970

1. Document Description. Maughan, J. S., "An Inquiry Into the Nature of Wounds Resulting in Killed in Action in Vietnam," Military Medicine, January 1970, pp 8-13. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To describe the author's detailed analysis of 2,600 death certificates on US troops in Vietnam from January through the summer of 1968.

3. Populations Included. US forces.

4. Timeframes Included. Vietnam War (with some comparisons to the Korean War).

5. Casualty Types Included. Killed in action (with some comparisons to wounded in action).

6. Time Intervals Included As. January through the summer of 1968.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Death certificates.

9. Other and Miscellaneous. From the document: "... a review in detail of death certificates was begun in January 1968. From that time, through the summer of 1958, 2,600 death certificates were reviewed ... For greater clarity, certain conditions were imposed. No medical deaths or decomposed remains were included. All were either small arms fire or fragment wounds, and distinctly recognizable. ... Wounds listed as 'multiple' usually had an associated injury, but the most significant and probable lethal area of trauma placed that individual under that particular anatomical classification. Therefore, if an individual had multiple injuries, but was placed under 'thigh' category, the thigh wound was considered the lethal injury ... Each individual was tabulated only once."

10. Summary of Findings Regarding Battle Casualties. The ratio of WIA to KIA has been relatively stable since the time of the Crimean War. The anatomical distribution of fatal wounds in this Vietnam sample is about the same as in the Korean War.

11. Comments and Critique. This provides an important collection of data on the anatomical distribution of wounds in KIAs from Vietnam.

McBRIDE-1991

1. Document Description. McBride, John T.; Hunt, Marjorie M.; Hannon, John P.; Hoxie, Stephen P.; and Rodkey, W. G., "Report and Medical Analyses of Personnel Injury from Operation 'JUST CAUSE'," Letterman Army Institute of Research, Presidio of San Francisco, Division of Military Trauma Research, Institute Report No. 468, December 1991, 89 pp. UNCLASSIFIED. Available from publisher.

2. Objectives and Scope. To document data collection and analysis of a sample of injuries incurred during Operation JUST CAUSE.

3. Populations Included. US Army participants in Operation JUST CAUSE (a few Marine Corps personnel were included).

4. Timeframes Included. Operation JUST CAUSE.

5. Casualty Types Included. Wounded in action and died of wounds.

6. Time Intervals Included As. Mainly those incurred on 20 December 1989 (a very few others scattered over the dates 21-24 December are also included).

7. Situational Descriptors Defined As. Tactical descriptors not used, except for an indication of whether or not the subject was in a hostile environment at the time wounded.

8. Data Sources Used. Medical and Adjutant General records, supplemented by personal interviews.

9. Other and Miscellaneous.

a. The sample included 253 casualties; however, it is stated that this was the number of records available at Brook Army Medical Center and at Wilford Hall Air Force Medical Center, and does not reflect the total number wounded in Operation JUST CAUSE.

b. The document includes numerous tables detailing several items of interest mainly to medical personnel. Included are subject's MOS, organization (company), rank, age, height, weight, date and time injured, environment if known (*e.g.*, urban, jungle), cause of injury, general indication of causative agent (*e.g.*, shrapnel *[sic]*, small arms, or jump injury), details of anatomical location of trauma(s), various medical indicators of patient's condition (*e.g.*, temperature, blood pressure, heart rate, *etc.*) [though without saying when these were measured], whether the patient was ambulatory, in shock, and some indication of the treatment administered.

10. Summary of Findings Regarding Battle Casualties. The authors remark several times that the medical records were not always accurate or complete with respect to the causative agent. To some extent, that information could be gleaned from the Adjutant General's records, or from interviews. The anatomical location of injuries correlated fairly well with data from previous conflicts such as World War II, Korea, and Vietnam. Many jump injuries were recorded.

11. Comments and Critique. From the Summary: "Conspicuously absent is the evaluation of the autopsy reports on the individuals who died of wounds or who were killed in action. Consequently, our data are skewed towards the survivors and the less severely injured. These data have been requested on multiple occasions so that we can gain better insight into the factors responsible for the more severe injuries. Hopefully, at some time in the future we will have these data to supplement our evaluation."

McCONNELL-1987

1. Document Description. McConnell, Robert E., Jr., "Predicting Rear-Area Casualties Using Bayesian Statistics," US Army Soldier Support Center, Proceedings of the 26th Annual Army Operations Research Symposium, held at Fort Lee, VA, Vol 1, 13-15 Oct 1987, pp 243-252. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To develop a method for extrapolating historical casualty data to future conflicts.

3. Populations Included. Originally developed for participants in land combat, but could perhaps be extended to include other types of combat.

4. Timeframes Included. Based on World War II statistical data.

5. Casualty Types Included. Wounded in action and killed in action.

6. Time Intervals Included As. From start to end of a war, but could possibly be modified to handle shorter periods of time.

7. Situational Descriptors Defined As. Characterized by MOS.

8. Data Sources Used. Primarily Beebe-1952 and FM-1987.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Develops a method for estimating losses by MOS in a future conflict by extrapolating from the historical experience. The method requires as inputs estimates of the portion of time the MOS spends in situations akin to those provided by the historical data (*i.e.*, in the future, military policemen in a combat theater will spend 1/3 of their time in situations like those of historical military policemen, but 2/3 of the time in situations like historical combat infantrymen).

11. Comments and Critique. The proposed method is interesting, although, as noted above, requires estimates of the proportion of time spent in various situations. It is not easy to see how such estimates (or their equivalent) can be avoided in extrapolating past experience to the future.

McCREA-1954

1. Document Description. McCrea, Vincent M.; and Coox, Alvin D., "Tank-vs-Tank Combat in Korea," Operations Research Office (ORO), Technical Memorandum ORO-T-278, 8 Sep 1954, 141 pp. UNCLASSIFIED. Available from DTIC (AD-062 803).

2. Objectives and Scope. From the Summary: "To reconstruct the tank-vs-tank actions that occurred in Korea and determine the tactical situations under which the actions occurred, to analyze the effectiveness of the US tank units in these actions, and to determine the variation in effectiveness under different tactical situations."

3. Populations Included. Tanks and tank crews.

4. Timeframes Included. Korean War.

5. Casualty Types Included. Described simply as "casualties."

6. Time Intervals Included As. One hundred nineteen selected tank battles that occurred during the period July to November 1950.

7. Situational Descriptors Defined As. Visibility, time of day, type of tactical action, range to target, and so forth.

8. Data Sources Used. Historical records and interviews.

9. Other and Miscellaneous. Tables 7 and 8 give information on crew casualties.

10. Summary of Findings Regarding Battle Casualties. From p 25: "The probability that a tanker in a US medium tank penetrated by T34 fire would become a casualty was about 0.4; *i.e.*, on the average, two crewmen from a US medium tank became casualties on the inside of the tank when penetrated, and one of these was KIA. The probability of a US tanker becoming a casualty inside any tank not penetrated was negligible (less than 5 percent). ... Among US tank casualties to enemy tank fire, 26 percent of the crews became casualties (99 percent occurring inside the tank)."

11. Comments and Critique. This provides a valuable analysis of Korean War tank and tank crew casualties.

McQUIE-1968

1. Document Description. McQuie, Robert; Cassaday, George; Chapman, Robert; and Montweiler, William, "Multivariate Analysis of Combat," Planning Research Corporation, Report PRC-R-1143, July 1968, 102 pp. UNCLASSIFIED. Available from DTIC AD-673 294.

2. Objectives and Scope. From the Abstract: "This paper evaluates the use of multivariate statistical techniques to analyze combat, and in particular to quantify the relation between firepower and maneuver. Several methods are employed, all of which focus on the differences between success and failure in military engagement. The methods combine mean values, data plots and correlation coefficients with factor analysis and discriminant functions."

3. Populations Included. Participants in 37 United States division-sized engagements during World War II and the Korean War, and from 12 German tank battles in World War II.

4. Timeframes Included. World War II and Korea.

5. Casualty Types Included. Personnel losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Battle date, degree of opposition, duration in days, weather, width of front, distance advanced, number of weapons (separately for small arms, crew-served weapons, mortars), number of artillery pieces (separately for light, medium and heavy artillery), number of tanks (separately for light and medium), planes, number of casualties (separately for personnel, jeeps, and trucks), and personnel strength.

8. Data Sources Used. Various, but primarily the battles in Italy (also contained in CAA-91, which supersedes the data base used by PRC).

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. From the Conclusions: "Finally, success [in battle] was not associated with weapon characteristics of either the firepower force or the maneuver force. Nor in general did casualties appear related to the tangible characteristics of the engagement. The technologically inferior force appeared able to more than compensate for its deficiency by some intangible manipulation of the weapons it had available."

11. Comments and Critique. This is an early study of a combat data base having numerous situational descriptors. Its observations on the kinds of methodological approaches to the study of such data bases are still pertinent. However, since it used too small a sample of battles, many of its factual conclusions have been overtaken by later analyses using much larger data bases [see, for example, Helmbold-1971b, Helmbold-1986, Helmbold-1990, Hartley-1991a, and similar works]. See also Burt-1965.

McQUIE-1988

1. Document Description. McQuie, Robert, "Historical Characteristics of Combat for Wargames (Benchmarks)," US Army Concepts Analysis Agency, 8120 Woodmont Avenue, Bethesda, MD 20814-2797, Research Paper CAA-RP-87-2, July 1988, 60 pp. UNCLASSIFIED. Report available from DTIC as AD-A200 036. Accompanying data base available from DTIC as AD-M000 000 or AD-M000 092.

2. Objectives and Scope. This is an effort to find ways of comparing wargames to historical data.

3. Populations Included. Participants in 260 battles.

4. Timeframes Included. From 1938 to 1973.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Only a few descriptors are used, although several are available in the data base used.

8. Data Sources Used. Essentially the same as CAA-1991, with some modifications.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Although the most likely value of attrition rate in these battles is about 1 percent per day, it is highly variable and not normally distributed.

11. Comments and Critique. This provides one view of how historical data might be used in assessing the validity of wargames. However, the approach presented is not adequate because it considers only the marginal distributions of each quantity separately, which ignores their joint distributions and other important interrelationships. For alternative views on the subject, see the papers listed under Statistical Tabulations; Statistical Analyses; and Influence of Casualties on Breakpoints, Victory, Rate of Advance, *etc.*

MEGGIT-1977

1. Document Description. Meggitt, Mervyn, "Blood is Their Argument," Mayfield Publishing Company, Palo Alto, California, ISBN: 0-87484-394-4, 1977, 223 pp. UNCLASSIFIED. Available from publisher and libraries (copy in Nimitz Library, US Naval Academy, as call number DU 740.42. M4).

2. Objectives and Scope. The major part of the book comprises an ethnography of the traditional military practices of the Mae, a division of the Central Enga people of the western highlands of Papua New Guinea. It describes the modes of warfare undertaken by the local clans, the motives that impel them to fight, the outcomes of their confrontations, and the ways they reestablish peace.

3. Populations Included. Selected clans of the Mae Enga tribes of central Papua, New Guinea.

4. Timeframes Included. Primarily 1900 to 1970.

5. Casualty Types Included. Dead and wounded. Here "dead" includes those who die of wounds shortly after the battle is over as well as those killed in battle.

6. Time Intervals Included As. From start to end of a campaign.

7. Situational Descriptors Defined As. Only a few descriptors are used. However, data on the seasonal distribution of the incidence of war are presented.

8. Data Sources Used. Official Australian records, personal observations, and interviews with various Mae Enga individuals.

9. Other and Miscellaneous. Chapter headings include Traditional Mae Enga Society; Mae Enga Warfare: Preliminary Considerations; Kinds of Fighting Among the Mae; The Mechanics of Mae Warfare; Aspects of Combat; Battle Casualties; Peace-Making and Homicide Compensations; The General Peace; The Return of Violence; and Epilogue. The following tables are provided: Table 4 gives the locations of wound received in Mae warfare; Table 5 gives the frequencies of Mae combat deaths from 1900 to 1950; Table 6 gives the stated causes of death for a sample of Mae men.

10. Summary of Findings Regarding Battle Casualties. General propositions regarding battle casualties are not specifically stated. However, the tables and other descriptions of Mae Enga combat can be compared to those of other times and places, and any similarities will support general propositions.

11. Comments and Critique. This provides a detailed description of warfare among the Mae Enga, who use stoneage weapons and tactics in their combat operations. It can serve as an extremely useful basis of comparison with later warfare.

MELLOR-1972

1. Document Description. Mellor, W. Franklin, "Casualties and Medical Statistics," Her Majesty's Stationery Office, SBN 11 320997 5*, 1972, 898 pp. UNCLASSIFIED. Available from libraries (copy held by Uniformed Service University of the Health Sciences, Bethesda, MD, under UH 258 1939/45 M527c 1972). This is an official medical history.

2. Objectives and Scope. To document the United Kingdom's experience in the Second World War.

3. Populations Included. United Kingdom forces.

4. Timeframes Included. World War II.

5. Casualty Types Included. Battle and nonbattle casualties.

6. Time Intervals Included As. From start to end of a war.

7. Situational Descriptors Defined As. Statistics are grouped by theater of war.

8. Data Sources Used. Official records.

9. Other and Miscellaneous. Includes numerous tables. There are separate sections for the Navy, the Army, the Air Force, and the Medical Services. There is also an addendum on the casualties in the United Kingdom proper caused by enemy bomb and missile attacks. In general, however, there is a very strong focus on disease conditions, with a great deal less attention given to battle casualties.

10. Summary of Findings Regarding Battle Casualties. No general findings specifically stated. This document is primarily a tabulation only. There is a discussion, with accompanying tables, of mental diseases on pp 121-123.

11. Comments and Critique. From page 109, regarding the Army data: "Admissions to, and deaths in, Emergency Medical Service (EMS) Hospitals from the outbreak of war to some time in 1942 are not included. An unknown number of transfers from EMS to Military Hospitals from January 1940 to August 1942 and included in the Hollerith tabulations tends to reduce the overall discrepancy. From September 1944, only ten percent of admissions were coded. There is a strong possibility that the Hollerith tabulations are deficient by at least twenty percent. Deaths were not coded from September 1944. ... Any discussion on the statistics which follow must necessarily be limited by these factors."

MELSOM-1975

1. Document Description. Melsom, M. A.; Farrar, M. D.; and Volkers, R. C., "Battle Casualties," Annals of the Royal College of Surgeons of England, Vol 56, no 6, Jun 1975, pp 289-303. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To describe the experience of a British surgical team detailed to the Salallah surgical center in support of certain actions conducted by the armed forces of the Sultan of Oman.

3. Populations Included. Armed forces of the Sultan of Oman.

4. Timeframes Included. Counterinsurgency operations conducted against enemies of the Sultan of Oman.

5. Casualty Types Included. Killed and wounded in action, and nonbattle injured.

6. Time Intervals Included As. From December 1972 to March 1973.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Personal observation.

9. Other and Miscellaneous. During the $3\frac{1}{2}$-month period covered by this report, 80 cases of wounding occurred. Seven men were killed in action (that is, died before reaching the surgical center), 2 died of wounds (that is, after reaching the surgical center alive), and 71 survived. Of the 80 casualties, 8 suffered miscellaneous trauma (burns, concussions from vehicle accident, and other causes), 16 bullet wounds, and 56 injuries from explosive devices (5 from antipersonnel mines, 5 from vehicle mines, 1 to a flare, and 45 to fragments from mortar and recoilless rifle shells). Of the 73 who reached the surgical center alive, 56 percent had suffered major injuries.

10. Summary of Findings Regarding Battle Casualties. Page 299 presents the table given below on the effects of wounding in different conflicts (in percent of all casualties).

11. Comments and Critique. Other than the figures from Salallah, it is not clear where the values in the table below originate.

Conflict	Evacuation time	Killed in action[a/]	Died of wounds[b/]	Survived[b/]	Died of wounds[c/]
Crimean War	12 h	18.6	13.8	67.6	16.7
American Civil War	12 h	20	11.6	70.4	14.1
Boer War	12 h	20	6.9	73	8.6
World War I	12 h	20.9	6.0	73.1	7.6
World War II	6-7 h	20.3	3.5	75.8	4.5
Korea	6 h	21.2	2.2	76.6	2.5
Vietnam[d/]	40 min	15	1.6	83.4	2.1
Salallah:	30-40 min	8.75	2.5	88.75	2.7
-Bullets		18.75	0	81.25	0
-Mines (personnel & vehicle)		18.8	9.4	71.8	11.1
-Shells (mortar & recoilless)		4.5	2.2	93	2.3
-Miscellaneous		0	0	100	0

[a/] Figures from official reports.
[b/] Figures derived from the last two columns.
[c/] Percent of cases.
[d/] Based on a sample of 7,000 casualties.

MILLER-1978

1. Document Description. Miller, Lester L. Jr., "Military Casualty and Statistical Data Associated With Wars, A Two-Part Bibliography," US Army Field Artillery School, Morris Swett Library, Special Bibliography SB-46, Jan 1978, 8 pp. UNCLASSIFIED. Available from DTIC (AD-A047 811).

2. Objectives and Scope. From the Foreword: "This bibliography presents chronological data on casualties of war and military statistics. Arrangement is in two parts. Part one deals with casualties as a result of war for conflicts dating from the French Wars of 1614 through the Vietnam War concluded in 1975. ...This bibliography represents specific titles selected from the holdings of the Morris Swett Library (US Army Artillery School). ... Part two of this list is on the distinct subject of military statistics. Emphasis is on artillery. ..."

3. Populations Included. Varied.

4. Timeframes Included. From 1614 through 1975 (with some exceptions).

5. Casualty Types Included. From the Foreword: "Military casualties are those losses which incapacitate an individual from performing normal duties and are caused by death, wounds, capture, discharge, desertion, illness, accident, suicide, murder, execution, among others, as they occur on or in support of the field of battle."

6. Time Intervals Included As. Varied.

7. Situational Descriptors Defined As: Not used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Part 1 section headings include: General; French Wars, 1614-1913; Austro-Hungarian Wars, 1618-1913; United States Wars, 1789-1901; United States Wars, 1846-1953; Mexican War, 1846-1849; Sebastopol Siege, 1854-1855; United States Civil War, 1861-1865; Franco-German War, 1870-1871; Spanish-American War, 1898; Russo-Japanese War, 1904-1905; World War I, 1914-1918; World War II, 1939-1945; Korean War, 1950-1953; and Vietnam War, 1961-1975.

10. Summary of Findings Regarding Battle Casualties. From the Foreword: "There is little agreement on how to collect casualty data due to the problems of reporting methods, lack of consensus, or purpose for which accumulated particularly when different countries are involved."

11. Comments and Critique. This provides a useful short bibliography of some material available at the Artillery School library.

MITCHELL-1931

1. Document Description. Mitchell, T. J.; and Smith, G. M., "Casualties and Medical Statistics of the Great War," His Majesty's Stationery Office, number 57-484, 1931, 382 pp. UNCLASSIFIED. Available from libraries (copy held by US Army Command and General Staff College, Leavenworth, KS, under call number 940.4754 1 M 682m). This is the final volume of the *Official Medical History of the War*, which deals with the statistical aspect of casualties. See also Love-1932 for a review and summary of this document, and a comparison of British and US casualty experience in World War I.

2. Objectives and Scope. From the Preface: "This volume records over eleven million casualties sustained by the British Expeditionary Forces at home and in the various campaigns overseas during the Great War. In that total are included both the casualties on the battle field and those occasioned by disease and injury."

3. Populations Included. British forces.

4. Timeframes Included. Boer War and World War I.

5. Casualty Types Included. Killed, wounded, died of wounds, missing, captured, diseased and nonbattle injured.

6. Time Intervals Included As. Usually from start to end of a war, but in a few instances gives data for divisions over the course of a campaign or battle.

7. Situational Descriptors Defined As. Only a few descriptors are used. However, data on the seasonal distribution of the incidence of war are presented.

8. Data Sources Used. Official statistics.

9. Other and Miscellaneous. From the Introduction: "The failure of this [World War I British medical record] system serious affected the preparation of the medical statistics of the war." The Table of Contents lists the following main chapter headings: (i) The strengths of the British Expeditionary Forces from a medical administrative standpoint; (ii) A survey of battle and nonbattle casualties; (iii) The principal causes of non-battle casualties; (iv) Casualties among British and Dominion troops stationed in the United Kingdom, August 1914 to December 1918; (v) Casualties in the British Expeditionary Force in France and Flanders, August 1914 to December 1918; (vi) Casualties in the British Expeditionary Force in France and Flanders, August to December 1914; (vii) Casualties in the British Expeditionary Force in France and Flanders, 1915; (viii) Casualties in the British Expeditionary Force in France and Flanders, 1916; (ix) Casualties in the British Expeditionary Force in France and Flanders, 1917; (x) Casualties in the British Expeditionary Force in France and Flanders, 1918; (xi) Casualties in the British Expeditionary Force in Italy; (xii) Casualties in the British Salonika Force on the Macedonian Front, 1915-1918; (xiii) Casualties in the Mediterranean Expeditionary Force during the Dardanelles Campaign;

(xiv) Casualties in Egypt and Palestine; (xv) Casualties in the Mesopotamian Expeditionary Force, November 1914 to December 1918; (xvi) Casualties in the North Russian Expeditionary Force, 1918-1919; (xvii) Casualties in the Campaign in East Africa, 1914-1918; (xviii) Casualties in the Campaign in South-West Africa, 1914-1915; (xix) Casualties in the South African War, 1899-1902; (xx) Analysis of 1,043,653 British casualties admitted to medical units, 1916-1920; (xxi) Casualties dealt with by the Ministry of Pensions.

10. Summary of Findings Regarding Battle Casualties. Too numerous to summarize here. Many tables are provided.

11. Comments and Critique. Note that some Boer War (Chap xx) and North Russian Campaign (Chap xvi) casualty statistics are also provided. Despite the cautions voiced, this is no doubt the most accurate and complete source available of information on British casualties in World War I, the Boer War, and the North Russian Campaign. See also the review of this work in Love-1932.

MORGENSTERN-1963

1. Document Description. Morgenstern, Oskar, "On the Accuracy of Economic Observations," Princeton University Press, Second edition, ISBN: 0-691-00351-3 (paperback); 0-691-04151-2 (hardcover), 1963, 322 pp. UNCLASSIFIED. Available from libraries (reprinted 1991 by University Microfilms International, 300 N. Zeeb Road, Ann Arbor, MI 48106).

2. Objectives and Scope. From the Preface to the Second Edition: "This book addresses itself to both the general reader and the professional economist. The former will see that decisions made in business and in public service are based on data that are known with much less certainty than generally assumed by the public or the government. The second will discover that even the most widely accepted figures frequently have error components of unexpected magnitude, and consequently cast doubt on many currently accepted analyses in economics. ... We must carefully distinguish between what we think we know and what we really do and can know."

3. Populations Included. Does not deal with military populations.

4. Timeframes Included. Does not deal with military events.

5. Casualty Types Included. Not applicable.

6. Time Intervals Included As. Not applicable.

7. Situational Descriptors Defined As. Not applicable.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. No specific findings regarding battle casualties. However, many of the same considerations affecting the accuracy of economic observations apply to the usual sorts of published casualty data. The most important of these are summarized here to illustrate Morgenstern's point that "At least all sources of error that occur in the natural sciences also occur in the social sciences; or, in other words, the statistical problems of the social sciences cannot possibly be less serious than those of the natural sciences. ... It will be seen later that national income and consumers' spending power probably cannot be known now without an error of ± 10 to ± 15 percent." Among the sources of errors, Morgenstern lists the following, most of which apply with at least equal force to casualty statistics (*emphasis in the original*):

a. Lack of designed experiments. "Many producers of statistics make a considerable effort to inform the reader of the details of composition, stages of classification, and all other characteristics of the statistics. There are too many cases, however, where this description is sketchy and where large gaps remain. Sometimes this is due to negligence and the belief that the authority of the reporting agency is

great enough to inspire full confidence in the statistics. Such authority never exists for scientific purposes."

b. Hiding of information and lies. "There is overly often a deliberate attempt to hide information. In other words, economic and social statistics are frequently based on evasive answers and *deliberate lies* of various types. ... Governments, too, are not free from falsifying statistics. ... History too has to cope with this difficulty. ... It is clear that victors [in battle] have always stated the defeated to have been much stronger that they were in order to make victory impressive, and the losers *vice versa* in order to make defeat excusable; this often creates figures which are impossible for the same occasion. ... Other instances from fields of social statistics or fact-finding are suicide statistics. They are notoriously bad because lay coroners so frequently disagree with medical men, and because great efforts have always been made to keep the fact of suicide secret. This also applies to medical statistics; for generations it was considered improper to have died of cancer, hence little mention of this disease. ... For example, there are many more cases of mental cases in Sweden per 100,000 population than in Yugoslavia. But this is simply due to the fact that in the former country the patient is taken care of in a hospital whereas in the latter case he vegetates as the village idiot and is not recorded as a mental case. Death certificates are very difficult to make out when death is due, as is often the case, to several causes. ... In summarizing, we see that there are three principal sources of false representation: *First*, the observer, by making a selection as to what and how much to observe, introduces a bias which it is impossible to avoid. ... *Second*, the observer may deliberately hide information or falsify his findings to suit his hypothesis or his political purposes. ... *Third*, the observed [interviewee] may deliberately lie to the investigator."

c. The training of observers. "Economic statistics, even when planned in detail, are frequently not gathered by highly trained observers but by personnel collected *ad hoc*."

d. Errors from questionnaires. "Errors can and do derive from the setting up of the questionnaires and from the answers. ... The simple fact is that it is not easy to ask good questions and to insure that intelligent, reliable, and honest answers will be given."

e. Mass observations. "If the data be aggregates, these are necessarily made up from such large masses that this assumes particular significance because, as is often the case, they are usually made by hundreds, thousands, and even tens of thousands of 'observers'."

f. Lack of definition or classification. "There is often lack of definition or classification of the phenomenon to be measured or recorded, and in addition, there is the difficulty of applying correctly even a faultless system of classification. ... Almost everything turns around the question of classification. ... The combination of doubtful classifications and untrained observers gives great scope to possibilities of lying—a very grave issue."

g. Errors of instruments. "The principal 'instruments' [used in econometrics] are still masses of human beings: for recording, interpreting, classifying, counting, questioning. The human limitations and frailties outweigh the faults of the technical instruments used: desk computers, punch cards, sorting machines, coding devices, *etc.* ... [However] anyone familiar with the actual handling of statistical data at the primary level must be aware of the great number of possible errors and mistakes and of the frequency with which they occur. These are so deeply rooted that it is impossible, on purely theoretical-probabilistic grounds, to eliminate all of them all of the time. The problem is to appraise them and to reduce them to a minimum. ... One might also add misprints in printed material ..."

h. The factor of time. "Economic observations cannot be made continuously. They have to be made in successive, discrete intervals of time. When these are far apart, this creates another source of error aside from the fact that there may not even be the same agents and observers in both moments."

i. Observations of unique phenomena. "Many economic observations concern events that are unique and *not* reproducible."

j. Interdependence and stability of errors. "In estimating the value of some specific economic statistic, it would be necessary to account for the possible occurrence of [all of the foregoing] sources of error and to estimate quantitatively the influence of each upon the final figure. ... This estimation is a vast program for most occasions. It is extremely difficult to fulfill ... The notion that errors do cancel [each other] out is widespread ... The world would, indeed, be even more of a miracle than it is if the influence of one set of errors offsets that of another set of errors so conveniently that we need not bother much with the whole matter."

k. Specious accuracy. "For example ... the Army published *enemy* (!) casualties for the Korean war also to 1/1000 of 1 percent—at a time when our own losses were not well known even by the housands of men! ... In [a different] connection, the reader should recall that 10 percent accuracy is a rather average, *i.e.*, common accuracy obtained in physics!"

11. Comments and Critique. This is an outstanding presentation of several of the major considerations affecting the use and interpretation of econometric statistics. Similar observations apply with at least equal force to the kinds of information used in the social sciences generally, and to casualty statistics in particular.

MOTTELAY-1893

1. Document Description. Mottelay, Paul F.; and Campbell-Copeland, T., "The Soldier in Our Civil War," Stanley Bradley Publishing Company, New York and Atlanta, 1893, UNCLASSIFIED. Available from Libraries (copy at Brigham Young University Library under Quarto F 466.7 .M91 1893).

2. Objectives and Scope. To provide a historical overview of the American Civil War.

3. Populations Included. Participants in battles.

4. Timeframes Included. American Civil War.

5. Casualty Types Included. Killed, wounded, captured, and missing.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. See "Other and Miscellaneous" paragraph, below.

8. Data Sources Used. Described as compiled "from 'Official Records of the Federal and Confederate Armies,' the 'Rebellion Record,' 'Phisterer's Statistical Record,' 'Hamersley's Army Register,' the 'Official Army Register,' statistical volumes and pamphlets of the Department of the Interior, 'The Annual Cyclopædia,' 'Twenty Years of Congress,' and such other thoroughly reliable books and documents as have been made available."

9. Other and Miscellaneous. Pages 425 *et seq.* present a "Chronological List of Events (1860-1865)" which is a table with the following column headings: Date; Event; Location; Duration; Force; Composition of Force; Commanders; Killed; Wounded; Prisoners Taken; Missing; Guns Taken; Stands of Arms Taken; and Advantage [*i.e*, which side is awarded the victory in this engagement]. The columns for force size and losses (killed, *etc.*) have subcolumns giving separately the values for the Union and Confederate sides.

10. Summary of Findings Regarding Battle Casualties. No general statements are offered.

11. Comments and Critique. This provides a useful tabulation of many of the lesser known battles and engagements of the American Civil War.

NAISAWALD-1953a

1. Document Description. Naisawald, L. Van Loan, "The Causative Agents of Battle Casualties, World War II," Operations Research Office (ORO), Technical Memorandum ORO-T-241, 17 Jul 1953, 29 pp. UNCLASSIFIED. Available from DTIC (AD-025 637).

2. Objectives and Scope. The problem was to determine the relative incidence of battle casualties from rifle fire, machinegun fire, all small arms, and fragment projectiles.

3. Populations Included. Battle casualties.

4. Timeframes Included. Franco-Prussian War, World War I, and World War II.

5. Casualty Types Included. Battle casualties—identified either as (a) killed in action (KIA); (b) died of wounds (DOW); (c) wounded in action and killed in action (WIA and KIA); (d) wounded in action and injured in action (WIA and IA); (e) living wounded.

6. Time Intervals Included As. From start to end of a major operation.

7. Situational Descriptors Defined As. Only a few descriptors are used. However, data on the seasonal distribution of the incidence of war are presented.

8. Data Sources Used. From the Introduction: "Data were drawn primarily from medical records on file in the Historical Division, Office of the Surgeon General, Department of the Army, Washington, DC. Valuable samples were also available in a published work by Beebe and DeBakey" [*see* Beebe-1952].

9. Other and Miscellaneous. Includes numerous tables.

10. Summary of Findings Regarding Battle Casualties. From the Summary:

a. Small arms fire accounted for between 14 and 31 percent of the total casualties, depending upon the theater of action: the Mediterranean Theater 14.0 percent, the European Theater 23.4 percent, and the Pacific 30.7 percent.

b. Based on limited and uncertain data, there appears to be very little difference in the percentage of casualties to rifle fire and that to machinegun fire. In the European and Pacific theaters, the rifle receives credit for about 4 percent more than the machinegun, whereas in Italy, there is less than 1 percent margin in favor of the machinegun.

c. Artillery and mortar fire together accounted for 65 percent of the total casualties in the Western theaters: 64.0 in the ETO and 69.1 in the Mediterranean. In the Pacific they accounted for 47.0 percent.

d. The initial validity of causative agent data cannot be greatly improved: the testimony of the living victim will always be difficult to assess accurately, the dead and DOW even more so.

e. The classification of causative agent data can be greatly improved by the adoption of a uniform system, greatly facilitating the evaluation of samples, particularly in the subdivision of classes.

11. Comments and Critique. This provides a very useful summary of the state of knowledge of the causative agents of battle casualties as of the time it was written.

NAISAWALD-1953b

1. Document Description. Naisawald, L. Van Loan, "The Cost in Ammunition of Inflicting a Casualty," Operations Research Office (ORO), Technical Memorandum ORO-T-246, 28 July 1953, 23 pp. UNCLASSIFIED. Available from DTIC (AD-028 927).

2. Objectives and Scope. From the Summary: "To determine the direct cost of inflicting a casualty in terms of the cost of ammunition in dollars (exclusive of delivery cost), rounds of ammunition, and weight of metal."

3. Populations Included. Anzio and Okinawa.

4. Timeframes Included. World War II.

5. Casualty Types Included. Battle casualties.

6. Time Intervals Included As. From start to end of an operation.

7. Situational Descriptors Defined As. Only as implied by the name of the operation.

8. Data Sources Used. Not explicitly stated, but apparently from archival records.

9. Other and Miscellaneous. Includes numerous tables. All dollar costs are in 1952 figures, obtained from official publications insofar as possible.

10. Summary of Findings Regarding Battle Casualties. From the Abstract:

a. Ammunition cost in dollars of inflicting a casualty during the Anzio action was between $3,500 and $4,500; in small arms ammunition expended, 11,000 to 18,000 rounds; in fragmenting-type weapon ammunition, 200 rounds; artillery and mortar rounds, 200 to 225; in weight of metal for small arms, 500 to 900 pounds; and for fragmenting weapons, 7,000 to 8,000 pounds.

b. The Anzio data show that in periods of static defense, the ammunition cost in dollars, rounds expended, and metal weight amounts to three times that for periods of active defense.

11. Comments and Critique. This provides a very useful analysis of the cost in ammunition of inflicting a casualty for selected operations.

NEEL-1973

1. Document Description. Neel, Spurgeon, "Medical Support of the US Army in Vietnam 1965-1970," Department of the Army, Vietnam Studies Series, CMH Pub 90-16, 1973 (reprinted 1984), 201 pp. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. From the Preface: "The purpose of this monograph is to provide a meaningful overview of significant medical problems encountered and decisions made, of achievements and mistakes, and of lessons learned in Vietnam. ... Emphasis is placed on perspective rather than detail."

3. Populations Included. US Army forces in Vietnam.

4. Timeframes Included. Vietnam War.

5. Casualty Types Included. Battle and nonbattle.

6. Time Intervals Included As. From 1965 to 1970.

7. Situational Descriptors Defined As. Seldom used.

8. Data Sources Used. From the Foreword: "All monographs in the series are based primarily on official records, with additional material from published and unpublished secondary works, from debriefing reports and interviews with key participants, and from the personal experience of the author. To facilitate security clearance, annotation and detailed bibliography have been omitted from the published version: a fully documented account with bibliography is filed with the Office of the Chief of Military History."

9. Other and Miscellaneous. Includes numerous tables and a few figures. Page 33 has a table showing US Army hospital admission rates (per annum per 1,000 average strength) for battle, nonbattle injuries, and disease in World War I, World War II, Korea, and Vietnam. Pages 53-54 discuss the causative agents responsible for battle casualties in World War II, Korea, and Vietnam. Pages 54-55 discuss the anatomical location of wounds in World War II, Korea, and Vietnam.

10. Summary of Findings Regarding Battle Casualties. From the Summary and Conclusions "The wounded soldier in Vietnam received better care more quickly than in any previous conflict. ... Regardless of the criteria used–survival rates, case fatality rates, return-to-duty rates length of hospital stay, and so forth–the Vietnam experience compares favorably with all military medical experience to date."

11. Comments and Critique. A caution regarding the interpretation of some of the findings will be found in Bzik-1984. See also Thayer-1985.

OSIPOV-1915

1. Document Description. Osipov, M., "The Influence of the Numerical Strength of Engaged Forces on Their Casualties," (In Russian), Military Collection, Numbers 6 through 10, 1915, (No 6, pp 59-74; No 7, pp 25-36; No 8, pp 31-40; No 9, pp 25-37; No 10, pp 93-96). UNCLASSIFIED. Available from libraries. English translation published as US Army Concepts Analysis Research Paper CAA-RP-91-2, September 1991, and available from DTIC.

2. Objectives and Scope. To understand the principal causes or circumstances on which success in battle depends.

3. Populations Included. Uses strength and loss data on 38 battles of the 19th Century.

4. Timeframes Included. From 1805 to 1905.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Primarily G. A. Leyer's "Encyclopedia of Military and Naval Science."

9. Other and Miscellaneous. Includes numerous tables.

10. Summary of Findings Regarding Battle Casualties. Osipov advances the thesis that losses are inversely related to strengths. That thesis translates into modern mathematical notation as follows:

$$\frac{dA}{dt} = -\beta B$$
$$\frac{dB}{dt} = -\alpha A,$$

which are recognizable as the differential equations known in the west as Lanchester's square law. From these, Osipov deduces from it the relationship (valid for $\alpha = \beta$)

$$A_0^2 - A^2 = B_0^2 - B^2,$$

where the strengths of sides A and B are denoted by A and B, strength values at the start of the battle are denoted by subscript 0 and at the end without subscripts. This is known in the west as Lanchester's N-square law of combat power. Introduces the generalized form of this expression

$$A_0^n - A^n = B_0^n - B^n,$$

where n is to be treated as an adjustable parameter, for $n = 1, \frac{3}{2}$, and 2. Determines that, of these three possibilities, the value $n = \frac{3}{2}$ give the best fit to his 38-battle data. Hence, Osipov discovers that Lanchester's N-square law of combat power is in error. He is the first person known to history to

recognize that fact. Osipov discusses various reasons why the value $n = 2$ does not give the best fit, and many other aspects of his attrition equations and of the data used to investigate their validity.

11. Comments and Critique.

Osipov's articles are absolutely outstanding for their time, and are a major contribution to the literature on models of attrition in land combat operations. However, they have in some respects been superseded by later work. For example, he does not develop truly heterogeneous attrition models in our contemporary sense of the term. But he comes close. It is only a small step from Osipov's discussion to the modern heterogeneous attrition law. But Osipov did not take that step.

Also, Osipov used only a small data base of 38 battles. This is not really entirely satisfactory for highly reliable conclusions. But it is a start, and certainly is methodologically correct.

Osipov treats the historical data as though it were absolutely accurate and correct. While recognizing that the historical data might contain errors, he considers that these would be random errors not essential to his main points. Also, I think he did not have the time to question seriously the validity of his data, but instead had to rely upon his source, which was G. L. Leyer's prestigious Military Encyclopedia (in Russian).

Osipov's work could not make use of the great advances in statistical techniques and refinements in concepts since he did his work. As a result, we might be able to improve on his techniques. But we should remember that Osipov did his work at about the same time that Sir Ronald Fisher became interested in statistics.

Finally, other investigators have independently gained a richer understanding of the problems with Lanchester's N-square law of combat power. And they have shown that the breakpoint hypothesis is not consistent with the historical data. Nevertheless, Osipov certainly should be honored for his trailblazing work in these and several other areas. And Osipov's methodological contributions deserve a great deal of respect. They are worthy of emulation even by today's standards of methodological rigor. This is particularly true of Osipov's insistence on empirical verification and validation of the theoretical considerations, and in his clear-headed understanding of how that can be done.

OTIS-1883

1. Document Description. Otis, George A.; and Huntington, D. L., "Surgical History," (Vol II, Pt III, Medical and Surgical History of the War of the Rebellion), Office of The Surgeon General, US Army, 1883, 997 pp. UNCLASSIFIED. Available from libraries (copy held by University Library of North Dakota as 614.0973 U58m, v2, pt 3).

2. Objectives and Scope. This is the concluding volume in the series "The Medical and Surgical History of the War of the Rebellion," and its Chapter XII is "devoted to a general consideration of wounds and complications, in the course of which the endeavor will be made to use, to the best advantage, the large amount of material accumulated during the late war ..."

3. Populations Included. Soldiers in the American Civil War (predominantly Federal troops, but possibly including some Confederate soldiers treated in the Federal medical system).

4. Timeframes Included. American Civil War (with comparative tables for other wars from 1830 to 1877).

5. Casualty Types Included. Wounded in action.

6. Time Intervals Included As. From start to end of a war.

7. Situational Descriptors Defined As. Generally not used, although in a few instances casualties are presented by campaign.

8. Data Sources Used. Various.

9. Other and Miscellaneous. From the letter of transmittal: "It was attempted, from the inception of the work, to give, in the beginning of each chapter, the number of cases to be treated therein. But, as the work progressed, new cases had to be added, duplicates had to be eliminated, or additional information changed the nature of a case, so as to transfer it to a group different from the one to which it had been originally assigned. Thus the total number of cases given in the beginning of a chapter was frequently found to be incorrect at its close, and as the preceding pages had been stereotyped, it was not practicable to make the necessary corrections. The percentages and general deductions, however, were not materially affected by these discrepancies, which have been corrected in the summary of cases given in Chapter XII, in this volume." Includes numerous tables and figures.

10. Summary of Findings Regarding Battle Casualties.

a. Of the 246,712 cases of wounds by weapons of war on record, only 922 were attributed to saber or bayonet. The remainder were attributed to "shot" wounds (defined on page 694 as "All injuries caused directly or indirectly by missiles and projectiles impelled by the force of gunpowder or other explosive compounds," and hence including artillery as well as small arms). A table on p 685 shows that

this proportion of saber and bayonet wounds is in line with the experience of European nations from the Crimean War of 1854-57 through the Franco-Prussian War of 1870-1871. Only in 12 of the 922 cases did the patient die of wounds.

b. Pages 688-690 present tables of the shot wounds to the head, face, and neck; to the trunk; and to the extremities. These tables show by finer gradations of site and nature of the wound the total number of cases on file, whether the patient died of wounds or recovered (or whether the outcome is not recorded), and the percent recorded as dying of wounds. Page 691 gives a table summarizing these results.

c. Page 692 remarks that the Office of The Surgeon General has on file only 1,173 cases in which the site of injury is recorded for soldiers killed on the battlefield. Of these, 487 were of the head and neck, 603 of the trunk, 30 of the upper extremities, and 53 of the lower extremities.

d. Page 693 gives a tabulation of the relative frequency of shot wounds by different regions of the body, not only for the American Civil War, but also for 20 European wars from the Revolution in Paris of 1830 to the Russo-Turkish War of 1876-1877. Unlike many similar tabulations, this one is provided with specific and detailed references to the sources of information used.

e. Page 696 gives a cross-tabulation of the number of cases on file by seat of injury (*e.g.*, scalp, cranium, face, spine, chest, elbow, wrist, hand, foot, *etc.*) and by causative agent (*e.g.*, solid shot, grapeshot, conoidal bullet, ball, *etc.*). Of the 245,790 shot wounds on file, 103,829 had to be placed in the "Nature of missile not ascertained" column of this table. The authors remark that, of the 141,961 cases on file where the missile is recorded, 127,929 (90.1 percent) were attributed to small arms.

11. Comments and Critique. From pp 687-688: "In ... the various sections throughout the work the total number of wounds of the portions of the body under consideration, so far as known at the time, were indicated. Since then additional reports and records of hospitals, especially field hospitals, frequently subjected to the varying fortunes of a successful or unsuccessful campaign, records which in some instances were supposed to have been destroyed, have been received at this Office, as the work on the surgical history progressed, increasing somewhat the total number of injuries. There undoubtedly remain, even at the present time, quite a number of casualties of which there are no histories on file, especially of the early part of the war in 1861, when each regiment and sometimes each detachment of troops, before the establishment of base and general hospitals, continued to find shelter for its more seriously injured patients in tents or buildings temporarily occupied which offered no facilities for keeping records, and when volunteer officers and also enlisted men were allowed to proceed from the battle-fields to their homes to be treated by their family physicians. A few reports of some of the most interesting of these cases have been received at this Office; but undoubtedly quite a large proportion failed to be recorded at all. Furthermore, after general engagements many circumstances interfered with the efforts of medical officers to obtain accurate details of the number of wounded, and no record could

be made of the wounded among those reported as captured and missing." Despite this caveat, this is surely the most careful and authoritative analysis of wounded in the American Civil War. See also Woodward-1875.

OVERHOLT-1970

1. Document Description. Overholt, John L., "Statistical Analysis of Korean War Data—Spring 1951," Vol IX of the *Study of Land/Air Trade-Offs (Short Title: SLAT)*, Center for Naval Analyses (CNA), Control No. 20 006409.00, April 1970, 110 pp. UNCLASSIFIED. Available from DTIC (AD-869 481). See also Overholt, John L., "Fitting Korean War Data By Statistical Methods," Center for Naval Analyses Professional Paper No. 32, 5 May 1970, 11 pp (AD-705 349) for a short summary of some of the results in this document.

2. Objectives and Scope. To describe attempts to relate the strengths of opposing UN and North Korean/Chinese Communist forces, including fire support, to the ground gained and casualties on both sides. The objective is to determine, by statistical techniques, relationships among various kinds of battle data recorded each day by divisions. These were intended to provide guidance in the TWSP (Tactical Warfare Simulation Program) simulation, which rests on the assumption that the Lanchester equations are correct. The methods include plots, a review of the data for validity, formulation of proposed relationships, and testing by multiple regression.

3. Populations Included. United Nations IX and X Corps, and their opposed North Korean forces.

4. Timeframes Included. Korean War.

5. Casualty Types Included. Battle casualties.

6. Time Intervals Included As. From 1 to 31 May 1951.

7. Situational Descriptors Defined As. General descriptors of the broad campaign activity are used (specifically—as explained on p 27—offense and advance by UN forces; offense and advance by enemy forces; and static or patrol periods, including times when either side was patrolling or in assembly areas). In the period studied, there were no large breakthroughs or amphibious landings. Other variables recorded and included in the analysis were the weather, the effects of breakthroughs on adjacent units, and the commander's major operational decisions (advance, withdraw, or hold). Terrain information was inadequate, and data about air interdiction was not tested.

8. Data Sources Used. The basic data are given in in Feldman, L., "Historical Data Base: Vol VII of the Study of Land/Air Trade-Offs (Short Title: SLAT)," Center for Naval Analyses, Naval Warfare Analysis Group, Study 64, May 1970 (AD-869 479). From the Summary: "The data consists of daily friendly and enemy strengths and casualties in the IX and X Corps in central Korea, air and artillery support of US and ROK divisions, and changes in territory. The enemy had no artillery or air support in this sector during this period. The data on small arms, machineguns, mortars, tanks, *etc.*, though not available for either side in division records, is assumed to be proportional to the strengths and to such ordnance expended in World War II. Reserves were introduced continually by UN forces, intermittently

in the form of new divisions by the Communists." All of the data are based on UN records, as no North Korean records were available. Details of the data are in Feldman, L., "Historical Data Base: Vol VII of the Study of Land/Air Trade-Offs (Short Title: SLAT)," Center for Naval Analyses, Naval Warfare Analysis Group, Study 64, May 1970, (AD-869 479).

9. Other and Miscellaneous.

a. A comparison of wargame results to the historical data is in Feldman, L., "The Relation of the Tactical Warfare Simulation Program (TWSP) to Historical Warfare: Vol VIII of the Study of Land/Air Trade-Offs (Short Title: SLAT)," Center for Naval Analyses, Naval Warfare Analysis Group, Study 64, May 1970 (AD-869 480).

b. The following problems with the data are noted in the document:

(1) (p 1) "Though some items are very precise, some data is inexact. The poorest data is concerned with enemy strength, enemy casualties, and attrition inflicted by deep support. ...Some [UN] division records are useless for analysis, or even totally missing ...."

(2) (p 7) "In our calculations the elements of [enemy] divisions were considered full divisions; each was multiplied by 8,000 to give the number of enemy troops."

(3) (p 11) "The enemy strength data was poor. The order of battle was derived from captured prisoners; when the enemy was attacking, little or no data was available because no prisoners were taken. It was often inaccurate ... Simple subtraction of casualties from strength figures led to inconsistencies."

(4) (p xi) "Subsequent investigation ... has shown that some of the strengths reported by [UN] corps were delayed reports from heavily engaged divisions; this data has not been examined adequately."

(5) (p 21) "[Friendly casualty] data is missing for the western and eastern fronts, and casualties were not recorded by the ROK units that were under heaviest attack on May 17 and 18. ...The policy for reporting [enemy] casualties appears to be different for different divisions."

(6) (pp 26-27) "The missions recorded are subjective judgments of the mission by CNA analysts who examined the battle records, and do not, in some instances, agree with the orders of the day. ... These were divided into three groups [*i.e.*, UN advance; enemy advance; or static] because the sample size was not large enough for finer separation. ...The sample sizes are small because of missing data. Data was complete, for these 124 division-days, out of the 205 division-days of Table V. There were 464 division-days on line for the entire battle front."

(7) (Abstract) "Though the work is indicative, it is limited by the poor quality of information about enemy strength."

(8) (p 3) "The poor quality of enemy strength data limits the conclusions, and further study is unlikely to improve it."

10. Summary of Findings Regarding Battle Casualties. (Adapted from the Findings.) There are relationships between casualties, on the one hand, and opposing strengths and firepower, on the other. However, the relationships depend on the intensity of battle, on whether the forces were advancing or retreating, and on the mathematical model used. Any conclusions must be drawn cautiously because changes in the mathematical model or in the data base produce different significant terms. The following findings appear consistently throughout the analysis.

a. According to this analysis, simple Lanchester-type equations—linear, square, or logarithmic—do not appear to work well for units as large as divisions.

b. Different tactical situations require different equations.

c. The equations for casualties show, as expected, that strengths of forces are very important where troops are advancing, but unimportant during static periods.

d. Firepower, expressed in both total tonnages of ordnance delivered and the types of weapons used, is important in the fitting of equations to historical reality.

e. Approximately equal tonnages of ordnance were fired per mile of front in World War II, as exemplified by the battle of Guam, and the Korean War, as represented by the Soyang River battle.

f. Lanchester-type equations are not symmetrically applicable to both sides in the Soyang River battle. The differences can probably be ascribed to differences in available fire support: the enemy had no air or artillery support, relying on manpower and small arms instead; the UN forces, on the other hand, had both artillery and air support.

g. Fire support provided the three forces considered in this volume—United States, ROK, and NKPA/ChiCom—had differing results, as measured in casualties inflicted and ground gained. Empirically derived equations of the Lanchester type, relating ground gained and casualties (suffered or inflicted) to the strengths of the opposing sides, differ according to the amounts of fire support received.

h. The equations for enemy casualties, after classification according to ground gained and firepower, explained more than two-thirds of the variation; artillery and air ordnance and friendly strength were important when the UN was advancing, and artillery ordnance was significant when the enemy attacked.

i. Enemy strength figures alone proved inadequate as a basis for predicting friendly casualties. The reasons may be the poor data about strength, the lack of knowledge about the fraction of friendly forces engaged, and the UN command's general policy of inflicting maximum casualties on the enemy at minimum cost in friendly casualties.

j. Strengths aside, the casualties suffered by enemy forces increased with increases in the amount of UN light artillery ordnance used during heavy enemy attacks. During patrols, however, their casualties increased with heavy artillery and light bomber sorties. The increases in friendly casualties were related to a deficiency of heavy bomber sorties, but there was no evidence of shortages in other ordnance.

k. Ground gained correlated most closely with casualties, and fewer friendly losses occurred during advances than during retreats. Gains by friendly forces were associated with increases in air sorties during both patrols and heavy attacks. The poorer equations (low R^2) for friendly gains may reflect differences in enemy resistance either from dug-in positions or during rapid evacuations. Enemy gains occurred during a deficiency of heavy bomber sorties. They also occurred when our forces were massed and when our forces received the support of light bomber sorties—probably measures of our response to the anticipated attack. A possible program is presented for extending this work to examination of data from smaller units than divisions and to examination of other battles.

11. Comments and Critique.

a. The author has misnamed, seriously misinterpreted, and grotesquely mischaracterized the results of prior work on Lanchester equations. Indeed, he has committed an elementary algebraic mistake in his treatment of them. Hardly any of his statements about them in this document can be trusted.

b. The statistical treatment is seriously defective, as exemplified by the finding: "The equations for enemy casualties, after classification according to ground gained and firepower, explained more than two-thirds of the variation; artillery and air ordnance and friendly strength were important when the UN was advancing, and artillery ordnance was significant when the enemy attacked." First, introducing such "classifications" is tantamount to introducing additional "explanatory variables" into the regression equations, thus reducing the degrees of freedom and artificially enhancing the quality of the "fit." Second, ground gained and firepower are correlated with casualties, but presumably the casualties are the causative agents and ground gained is the effect, rather than *vice versa*.

c. The sample sizes are too small. There are actually only 29 division-day data points for UN offensives, 20 for enemy offensives, and 75 for static situations. Considering that there were some 464 division-days on line for the entire battle front, this is an absurdly small sample, and very likely to have been drastically biased in various ways. Indeed, it is clear that the accuracy and timeliness of friendly casualty reports are much impaired when friendly casualties are high and combat activity is intense. The author makes a huge number of stepwise regression runs trying various explanatory variables, with R^2 as the criterion of goodness-of-fit, and so engages in the dubious practice of "data dredging." The transformations of variables given on p E-10, although characterized as "logarithmic," are certainly not the standard logarithmic transformations commonly used by statisticians.

d. Multicollinearity effects may dominate. As remarked on p 3 of the companion piece cited in paragraph 1 above, "During battles, there is an increase in nearly all the factors measured. Thus, there is a high correlation among the various kinds of fire support, casualties, and ground gained. It is often difficult to decide whether any cause-and-effect relationship should be inferred; it is easier to decide that some relationships are obviously useless, such as the high correlation between friendly casualties and number of light artillery rounds fired. Relationships such as these reflect a common cause, which often was the commander's decision to attack."

e. The level of enemy casualties estimated by UN forces is incredibly and improbably high. It is reported on p 2 of the companion piece cited in paragraph 1i above that "During this period [the enemy attack starting on 15 May] the UN forces inflicted terrific losses; on 38 division-days, enemy losses exceeded 1,000 per division; at times, losses per division mounted to 8,000 or more per day. The median exchange rate in major attacks between enemy and UN forces was 70-to-1 during enemy offensives and 35 to 1 during our counterattacks in the latter part of the month." Since, as mentioned in paragraph 9b above, enemy division strength is assessed at around 8,000, these casualty figures simply are not credible.

PAGE-1954

1. Document Description. Page, Thornton, "The Effects of Counterbattery Fire," Operations Research Office (ORO), Technical Memorandum ORO-T-284, 9 June 1954, 167 pp. UNCLASSIFIED. Available from DTIC (AD-069 456).

2. Objectives and Scope. To address the question: "What are the effects of counterbattery fire in terms of casualties and damage produced, and the psychological results which lead to neutralization or suppression of fire?"

3. Populations Included. Twenty-three US artillery battery positions.

4. Timeframes Included. Korean War.

5. Casualty Types Included. Killed and wounded.

6. Time Intervals Included As. From 1 to 20 June 1953 (the first 10 days of which served as a control period of low enemy activity, while the last 10 days consisted of relatively heavy enemy fire during attacks on Outpost HARRY).

7. Situational Descriptors Defined As. Data were obtained on the number of enemy rounds in each battery area, the general layout, the personnel exposed, the damage and casualties sustained, the fire time lost, and the possible morale effects. The document notes that "Long before June 1953 the Korean conflict had settled down to static warfare in which artillery was of major importance. The Communist Chinese Forces (CCF) made sharp local attacks, preceded and accompanied by counterbattery fire. These 'flaps' were all of approximately the same pattern; in many, the enemy succeeded in capturing an outpost or two, in the HARRY Flap of 10-20 June 1953, he was repulsed."

8. Data Sources Used. Official records and personal observation.

9. Other and Miscellaneous. Includes numerous tables and figures. Table 1 provides a summary of damage and casualties, battery by battery.

10. Summary of Findings Regarding Battle Casualties.

a. The basic data show that 4,290 rounds of CCF fire on 23 US batteries produced 45 casualties (25 of them fatal or evacuated) .... Furthermore, account should be taken of the fortifications which, under surprise conditions, gave absolute protection to all but about 40 of the 140 battery personnel. The casualty rate per 1,000 rounds among those men in the open was 1.3 percent, of whom half were incapacitated (killed or evacuated).

b. Since the purpose of counterbattery fire is to reduce enemy fire, it is somewhat disturbing to find that when friendly units fire more counterbattery rounds, the enemy's batteries fire *more* rounds, not less, on the average. This seems to be the result of averaging over such periods of times and numbers

of batteries that the effect of counterbattery fire on an individual battery is smothered. This reasoning led to a counterbattery experiment ... curtailed by the armistice on 27 July. ... These limited data indicate *no correlation* between the rounds fired by enemy batteries and either the time or the amount of US counterbattery fire against them.

11. Comments and Critique. This provides a masterful analysis of counterbattery fire effects and effectiveness.

PALINKAS-1985a

1. Document Description. Palinkas, Lawrence A.; and Coben, Patricia, "Combat Casualties Among US Marine Corps Personnel in Vietnam: 1964-1972," Naval Health Research Center, San Diego, CA, Report No. 85-11, May 1985, 13 pp. UNCLASSIFIED. Available from DTIC (AD-A160 856).

2. Objectives and Scope. From the Summary: "The objective of this paper is to provide a descriptive account of four distinct aspects of combat casualties among Marine Corps personnel in Vietnam between 1964 and 1972: (i) types of personnel injured in battle; (ii) types of injuries; (iii) wounding agents; and (iv) the flow of patients into and from medical facilities in Vietnam.

3. Populations Included. US Marine Corps personnel stationed in Vietnam.

4. Timeframes Included. Vietnam War.

5. Casualty Types Included. Wounded or injured in combat.

6. Time Intervals Included As. From 1964 to 1972.

7. Situational Descriptors Defined As. Tactical descriptors not used.

8. Data Sources Used. The Marine Corps Inpatient Medical Data File at the Naval Health Research Center.

9. Other and Miscellaneous. Includes tables showing casualties by demographic and service history characteristics, unit assignment, and MOS; casualties by diagnostic group; casualties by mean age and primary diagnosis; casualties by mean pay grade and primary diagnosis; distribution of combat casualties by MOS; combat casualties by wounding agent and primary diagnosis; treatment facilities, type of admission, and disposition of US Marine Corps combat casualties in Vietnam.

10. Summary of Findings Regarding Battle Casualties.

a. For several reasons, these data tell us little about the epidemiology of combat injury. While the data indicate the number of wounded who died while in a medical care facility, they provide an incomplete count of combat deaths because only hospitalized inpatients are included.

b. Most of the Marines wounded in Vietnam were junior enlisted men under the age of 25 with 3 years or less of service.

11. Comments and Critique. This provides a careful analysis of the records on 78,756 Marines who were wounded or injured in combat in Vietnam. Since they accounted for 120,017 battle-related first hospitalizations, it would appear that not more than 41,251 of them (120,017 – 78,756) experienced more than one hospitalizing wound or injury (or else there is something amiss with these data, *i.e.*, some double-counting crept in somewhere).

PALINKAS-1985b

1. Document Description. Palinkas, Lawrence A.; and Coben, Patricia, "Psychiatric Casualties Among US Marines in Vietnam," Naval Health Research Center, San Diego, CA, Report No. 85-47, Oct 1985, 16 pp. UNCLASSIFIED. Available from DTIC (AD-A167 347).

2. Objectives and Scope. From the Summary: "The objective of this paper is to describe psychiatric casualties among US Marine Corps personnel stationed in Vietnam between 1965 and 1972. Included in this description are the following: (i) the population characteristics of those hospitalized while serving in Vietnam; (ii) the relationship between psychiatric casualties and combat-related wounds and injuries; (iii) the types of diagnoses these personnel were given; (iv) possible relationships between demographic and service-related variables and diagnosis; and (v) the disposition of those hospitalized for psychiatric reasons."

3. Populations Included. US Marine Corps personnel stationed in Vietnam.

4. Timeframes Included. Vietnam War.

5. Casualty Types Included. Psychiatric casualties.

6. Time Intervals Included As. From 1965 to 1972.

7. Situational Descriptors Defined As. Tactical descriptors not used.

8. Data Sources Used. The Marine Corps Inpatient Medical Data File at the Naval Health Research Center. The population at risk was obtained from strength figures published in the annual reports of the Secretary of Defense which indicated the numbers from each service assigned to duty in Vietnam.

9. Other and Miscellaneous. Includes tables showing the ratios of psychiatric casualties to wounded in action by demographic and service history characteristics, unit assignment, and MOS; psychiatric casualties by diagnostic group; mean age of psychiatric casualties by primary diagnosis; mean pay grade of psychiatric casualties by primary diagnosis; mean years served by primary diagnosis; distribution of primary psychiatric diagnosis by race; distribution of primary psychiatric diagnosis by occupational group; treatment facility, type of admission, and disposition of psychiatric casualties.

10. Summary of Findings Regarding Battle Casualties.

a. One of the major findings of this study was that crude rates of psychiatric disorders among US Marines were much higher than those reported in other studies.

b. While combat fatigue (symptoms such as uncontrollable crying, hyperventilation, extreme tremulousness, acute incapacitating anxiety, depression, apathy and withdrawal, conversion reactions, agitation and disorganization, and psychosomatic manifestations) accounts for only 3.5 percent of the

psychiatric diagnoses in our study, diagnoses with similar symptoms account for the second largest percentage of psychiatric casualties (16.3 percent).

c. With respect to the treatment of Marine Corps psychiatric casualties, the results of this study indicate that half of the casualties were direct from the battlefield and more than half were returned to duty following treatment.

d. It is conceivable that not all Marines who were treated on an inpatient basis for psychiatric disorders were included in the Naval Health Research Center Inpatient Medical File, resulting in underenumeration of this casualty category.

e. The authors interpret their results as indicating an objective relationship between certain demographic and service-related characteristics and the risk of hospitalization for psychiatric disorders during a military conflict.

11. Comments and Critique. This provides a careful analysis of the records on 8,835 US Marines who were hospitalized for mental disorders while serving in Vietnam between 1965 and 1972. The document carries a caveat that it is a preprint of a paper submitted for publication in the American Journal of Psychiatry and should be cited as a personal communication.

PARKER-1965

1. Document Description. Parker, Richard W. Jr.; Borden, Richard T.; and Ryan, Robert B., "Survey of Casualties, Republic of Vietnam Military Forces, 1962," Research Analysis Corporation (RAC), Technical Paper RAC-TP-167(FOV), August 1965, 90 pp. UNCLASSIFIED. Available from DTIC (AD-366 296).

2. Objectives and Scope. To present data available at the military hospitals of the Republic of Vietnam from admissions records on battle and accident casualties for the year 1962, to establish the validity and define the limits for use of these data, and to analyze these data through comparison with past military casualty experience and through correlation with concurrent military operations.

3. Populations Included. Republic of Vietnam Armed Forces (RVNAF) hospital admissions.

4. Timeframes Included. Vietnam War.

5. Casualty Types Included. Battle casualties (primarily wounded in action, but including some who were killed in action and/or who were wounded but did not survive their evacuation to a hospital and were recorded as dead on arrival), and nonbattle injured.

6. Time Intervals Included As. The year 1962.

7. Situational Descriptors Defined As. From the Summary: "The data provided by the hospital admissions records include for each case: name, rank, unit, service, date of admission, site of mishap, mode of evacuation, causative agent for wound or injury, anatomic location of wound or injury, number of days in hospital, disposition of patient, and hospital identification. Since the Medical Corps of the RVNAF has the responsibility for the care of the dead as well as the injured, data were also recorded for a portion of the killed in action (KIA) which arrived at the hospitals and for casualties dead on arrival at the hospital. This sample of KIA is large, but it remains an uncertain proportion of the total."

8. Data Sources Used. Hospital admissions records of the Medical Corps of the RVNAF.

9. Other and Miscellaneous. Comparisons are made of Vietnamese with US experience in Korea and World War II. For this purpose, US experience as described in Beyer-1962 was used as the principal (and almost exclusive) source.

10. Summary of Findings Regarding Battle Casualties. Selected from the document's Findings:

a. The military casualty experience of the RVNAF displays patterns similar to those reported for US forces in the Pacific and Korea under conditions in which enemy use of field artillery was negligible or nonexistent and the use of enemy mortars was limited.

b. The ratio of RVNAF combat casualties, KIA to WIA, with the best available data, was found to be 1 to 3. This is considered to be significantly different from the historic 1 to 4 for World War II and

Korea. It is similar to selected situations where, as in Vietnam, the proportion of small arms use (bullets) is high in contrast to the use of artillery and other conventional weaponry.

c. Military operations data indicate that the RVNAF (and the paramilitary forces) casualties were taken largely when in a defensive posture. The body exposure associated with such a posture suggests a reason for the apparent high proportion of head wounds.

d. Correlation between the reported level of military operations and casualties recorded in hospital admissions was found to be poor. Hospital admissions records were found to provide more complete wounded casualty data than were reported through military operational channels.

e. A large proportion—nearly one of every four—of the RVNAF casualties admitted to the hospitals resulted from accidents; 55 percent of these accidents involved vehicles.

f. The increased use of helicopter evacuation methods during 1962 did not appear to result in reduced casualty recovery time or fewer deaths from wounds, as might have been expected with a presumed shorter elapsed time from the incurrence of the wound to hospitalization. One effect of mass evacuation was overloading at the hospital resulting primarily from the lack of casualty sorting at the evacuation point.

11. Comments and Critique. This provides a careful and detailed analysis of the casualty experience of the RVNAF in 1962. See also Bzik-1984 in connection with the first part of 10f above.

PEARSALL-1972

1. Document Description. Pearsall, Edward S., "Casualty Rates and Opposed Advance," Institute for Defense Analyses (IDA), Working Paper No. 11 for the Improved Methodologies for General Purpose Forces Planning (New Methods Study), Jan 1972, 26 pp. UNCLASSIFIED. Available from publisher and libraries (copy obtained from US Army Concepts Analysis Agency Technical Library).

2. Objectives and Scope. To fit a simple model of ground combat to the historical data on 97 battles, and to interpret the results.

3. Populations Included. Participants in battle.

4. Timeframes Included. Selected World War II and Korean War campaigns.

5. Casualty Types Included. Battle casualties.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. The data include the engagement name and date, duration, identification of the attacker and defender, terrain (flat, rugged, rolling), defense posture (fortified, prepared, hasty, delay, withdraw), which side won, the attacker's advance rate, and the following for both the attacker and defender: personnel strength, firepower score, and casualty rate.

8. Data Sources Used. Data were obtained from various studies conducted by the Historical Evaluation Research Organization (HERO).

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. The equation that provided the best results for the defender casualty rate was:

$$K_d = \exp\left(A + \sum_{k=1}^{8} \alpha_k Z_k \right) K_a^{\beta_1} F_a^{\beta_2} F_d^{\beta_3} M_a^{\beta_4} M_d^{\beta_5} \quad ,$$

where K_d is the defender casualty rate, K_a is the attacker's casualty rate, F_a and F_d are the attacker's and defender's firepower scores, M_a and M_d are the attacker's and defender's personnel strengths, and the Z_k are categorical or dummy variables defining which of the eight campaigns in the data is being used and which side is attacking, as follows:

$$Z_k = \begin{cases} 1, \text{ if the US or Britain is attacking and the campaign number is } k, \\ -1, \text{ if the US or Britain is defending and the campaign number is } k, \\ 0, \text{ otherwise (\textit{i.e.}, if the action is not from the campaign number } k). \end{cases}$$

Here the campaigns are numbered as follows: 1–Salerno (12 battles); 2–Volturno (21 battles); 3–Anzio (16 battles); 4–Rome (20 battles); 5–Lorraine (2 battles); 6–Okinawa (15 battles); 7–Korea, 1950 (4 battles); 8–Korea, 1951 (7 battles). Actually, because this equation is nonlinear in the parameters, its logarithmic form is used to fit the data. It is claimed that (for the logarithmic form), $R^2 = 0.824$, with a standard error of estimate $\sigma = 0.547$.

11. Comments and Critique. The use of 14 free parameters, 8 of which are fudge factors for different campaign-attack situations, makes this analysis suspect. It would be interesting to repeat it using only the campaign-attack dummy variables, to see if they alone do not provide an apparently useful fit to the data. We further observe that the fitted values of the α_k range from -1.15 to $+1.25$ for the logarithmic form of the equation for K_d, which amounts to a multiplicative factor ranging from about 0.32 to 3.49 for the actual value of K_d itself. We further observe that the validity of the data for some of the Italian and Okinawa Campaign battles has been called into serious question (see Helmbold-1986 and CAA-1991). Finally, we note that the inclusion of the attacker's casualties as an "explanatory variable" for the defender's casualties makes the fitted equation useless in most circumstances, since we usually either know the casualties on both sides, or else know neither side's casualties (in the first case, we do not need any fitted equation to estimate the defender's casualties, and in the second case we lack one of the explanatory variables required to use the fitted equation).

PECKHAM-1974

1. Document Description. Peckham, Edward H., "The Toll of Independence, Engagements and Battle Casualties of the American Revolution," University of Chicago Press, ISBN: 0-226-65318-8, 1974, 176 pp. UNCLASSIFIED. Available from publisher and libraries (copy in the Pentagon Library under E 230 .P35).

2. Objectives and Scope. From the Introduction: "Certain basic statistics about the American Revolution—frequency of engagements, casualties in battle, deaths in camp, prisoners of war, size of the army at any given time, total number of participants, geographical spread or concentration of its actions—have never been compiled. ... This volume offers two kinds of information. It presents the most complete list ever attempted of military and naval engagements involving Americans. Each engagement is briefly described in chronological order. ... Little attempt has been made to determine the size of the opposing forces; when such figures were mentioned, they frequently were wildly unreliable. ... Opposite each descriptive entry is the classification of American casualties suffered according to killed wounded, captured, missing, and deserted, indicated by their initial letters. ... Those persons wounded who died within a day or two have been removed from that column and added to the column of killed. Enemy casualties are indicated in the text, where readily found, but they were not the object of our search; besides, such figures were endlessly complicated by the custom of the British commanders of not reporting German or Loyalist casualties."

3. Populations Included. American soldiers.

4. Timeframes Included. American Revolutionary War.

5. Casualty Types Included. Killed and died of wounds, wounded, captured, missing, and deserted.

6. Time Intervals Included As. From start to end of an engagement.

7. Situational Descriptors Defined As. In various ways, by a sentence or two describing the context.

8. Data Sources Used. Various.

9. Other and Miscellaneous. The Introduction and the section on pp 103-106 discoursing on the naval data both provide careful descriptions of the ambiguities and uncertainties involved in interpreting the original sources. When the number of casualties could not be determined, the entry was left blank. Hence, blank entries correspond to "number unknown," rather than to "number known or estimated to be zero."

10. Summary of Findings Regarding Battle Casualties. The Summations and Implications chapter presents the following estimates for grand total of American battle casualties: 6,824 killed or died of wounds; 8,445 wounded; 18,152 captured; 1,426 missing; and 100 deserted. To these it adds 10,000

Americans estimated to have died in (friendly) camps and 8,500 estimated to have died while being held prisoner, for a grand total of 25,324 estimated to have died in service. Of course, the battle casualty count is incomplete and represents an estimated minimum number. The author points out that the estimated grand total of 25,000 or so died in service represents 0.9 percent of the American population (white and black) in 1780. Estimates of the percent of population deaths for other American wars given by the author are: Mexican War, 0.06; Civil War, 1.6; World War I, 0.12; and World War II, 0.28. In his conclusion, the author remarks that "By reviewing the casualties in relation to the size of the forces engaged, military technicians may be able to estimate the effectiveness of fire power. The expenditure of powder, bullets, and cannon balls seems prodigious, even with the acknowledged deficiencies of aiming."

11. Comments and Critique. This volume has well earned its reputation as the most complete and painstakingly researched work on American casualties in the American Revolutionary War. However, the absence of information on the strengths of both sides, and on casualties to the British, as well as the lumping of died of wounds in with the killed, makes the results of this work difficult to compare with others, or to use in other profitable ways in the PAR studies.

PETERSON-1967

1. Document Description. Peterson, Richard H., "On the 'Logarithmic Law' of Attrition and Its Application to Tank Combat," Operations Research, Vol 15, no 3, May-June 1967, pp 557-558. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To explain the empirical origins of the "logarithmic law."

3. Populations Included. Tanks engaged in small unit actions.

4. Timeframes Included. World War II.

5. Casualty Types Included. Tank losses.

6. Time Intervals Included As. The early parts of the engagement.

7. Situational Descriptors Defined As. Focuses on which side fires first.

8. Data Sources Used. Archival records.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Introduces probabilistic models for the attrition of small units. Specifically, let (m,n) be the current number of survivors on sides M and N, respectively. Then the probability of a transition from state (m,n) to state $(m,n-1)$ is given by the expression

$$p_k = \frac{1}{1+\frac{a}{b}\left(\frac{n}{m}\right)^k} \quad ,$$

where the various attrition "laws" are indexed by k ($k=1$ corresponds to the square law, $k=0$ to the linear law, and $k=-1$ to the logarithmic law). Since this equation can be transformed to the form

$$\log\left(\frac{p_k}{1-p_k}\right) = \log\left(\frac{a}{b}\right) + k\log\left(\frac{n}{m}\right) \quad ,$$

if p_k is known for a number of values of (n/m), then k can be readily determined by a linear least-squares fit. Using data on 1-vs-n engagements, for which it is possible to infer the transition probabilities directly from the initial and terminal states, Peterson estimates that on the first kill k was about -0.95, in good agreement with the logarithmic law. But on the second kill, $k \simeq +1$, which corresponds to the square law. Unfortunately, data on subsequent kills became too sparse to be statistically meaningful.

11. Comments and Critique. This is an interesting paper, and shows quite clearly the theoretical relationships among the square, linear, and logarithmic laws. However, the argument involving linear fits appears to run afoul of the Constant Fallacy [see Helmbold-1993].

PRESTON-1954

1. Document Description. Preston, Harley O., *et al.*, "A Study of Ineffective Soldier Performance Under Fire in Korea, 1951," Operations Research Office (ORO), Technical Memorandum ORO-T-62, 8 Oct 1954, 65 pp. UNCLASSIFIED. Available from DTIC (AD-070 612). Prepared by a team of researchers from the American Institute for Research, led by Harley O. Preston, under contract to ORO, and revised by Lessing A. Kahn of ORO.

2. Objectives and Scope. From the Abstract: "The objective of this study is to examine the psychological effects of weapons fire. This paper deals with the effects of fire on Chinese Communist Forces and North Korean Army personnel, and undertakes to discover the relation between ineffective performance of soldiers in Korea and their exposure to fire from different types of UN weapons."

3. Populations Included. Chinese Communist Forces and North Korean Army personnel, supplemented by brief interviews with small groups of US infantry soldiers.

4. Timeframes Included. Korean War.

5. Casualty Types Included. Captured, surrendered, and ineffectives.

6. Time Intervals Included As. The year 1951.

7. Situational Descriptors Defined As. Type of UN weapon involved; activity of the POW at the time of the ineffective performance; and the age, occupation, literacy, length of service, branch of service, and physical condition, of the POW.

8. Data Sources Used. From p 11: "During August and September 1951, POWs were being sent to a collecting point [Yongdong Po] not far behind the front lines within 24 to 48 hours after their capture or surrender. ... The nonwounded prisoners at the collecting point were registered, tagged, deloused, given haircuts, *etc.*, and kept at Yongdong Po for varying periods before being sent to Pusan where they remained from a few days to a month before being sent to POW compounds on Koje-do ... No problem in the selection of POWs to be interviewed was encountered at Yongdong Po and it was possible to interview practically every prisoner who was not wounded. At Pusan no attempt was made to interview those wounded who were seriously ill or in great pain. With this exception, every POW within any selected hospital ward was interviewed. ... there was no reason to believe that any POW who was missed differed in any important aspect from those who were interviewed." A total of 860 POWs were interviewed.

From p 12: "Interviews with US troops and officers ... took place in groups and virtually all such interviews were conducted within artillery range of the enemy on the battle front north an east of Seoul. ... The US personnel interviewed had recently returned from the front line; none had been off the line for more than 3 weeks, and some for only a few days. ... Company commanders, platoon leaders, and

platoon sergeants were usually interviewed together in small groups varying in size from 2 or 3 to about 6 men. Squad leaders were usually interviewed with the rest of the troops, and these groups would vary from 10 to over 50 men." The 272 US soldiers assembled for these interviews were asked about instances of ineffective performance by North Korean and Chinese Communist soldiers. Although some did not answer or did not correctly interpret the questionnaire, 260 responses were considered valid and used in the analysis.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. From the Summary:

a. Artillery, bombs, napalm, and air strafing were outstanding in producing a significant psychological effect in terms of ineffective performance by enemy soldiers.

b. Those POWs who were (i) seriously wounded before being taken prisoner and so could not avoid it. (ii) were captured without being seriously wounded, and (iii) surrendered without being captured ranked in that order with regard to increasing incidence of ineffective behavior before capture.

c. Mortars and combinations of automatic infantry weapons were the types of weapons most frequently involved in effective enemy fire power against units of US soldiers interviewed in September 1951.

11. Comments and Critique. This provides a unique study of the relationship between ineffective soldier performance and weapons type.

PRIDE-1989

1. Document Description. Pride, David, W., "Technological Alternatives to the Direct Fire Fratricide Problem," Arizona State University, 1 August 1989, 127 pp. UNCLASSIFIED. Available from DTIC (AD-B142 466L). This is a Thesis submitted in partial fulfillment of the requirements for the degree Master of Technology.

2. Objectives and Scope. To investigate viable technologies for reducing the incidence of direct fire fratricide among armored vehicles engaged in future close heavy combat.

3. Populations Included. The emphasis is on armored combat vehicles.

4. Timeframes Included. The emphasis is on future times.

5. Casualty Types Included. Fratricide.

6. Time Intervals Included As. From start to end of an engagement.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Various, but including Goldsmith-1986, Hamza-1987, and Shrader-1982.

9. Other and Miscellaneous. Chapter 2 provides a quick review of the literature on fratricide up to the time of its writing.

10. Summary of Findings Regarding Battle Casualties. No general findings regarding personnel casualties are stated.

11. Comments and Critique. This provides a useful analysis of the causes of fratricide to armored combat vehicles, suggests some technologies that may ameliorate the problem, and presents the results of an opinion survey to rate the likely benefits of those technologies.

REID-1975

1. Document Description. Reid, Robert L., "The British Crimean Medical Disaster—Ineptness or Inevitability?," Military Medicine, Vol 140, June 1975, pp 420-426. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. From the document: "The purpose of this paper is to study these factors [*i.e.*, inadequate medical knowledge of the role of bacteria as a cause of disease, a lack of understanding of antiseptic surgery, and the inability to cope with the wounding power of the rifle] and their relationship to the planning and conduct of the Crimean War."

3. Populations Included. Soldiers in the Crimean War.

4. Timeframes Included. Crimean War (1854-1855).

5. Casualty Types Included. Killed, died of wounds, and diseased.

6. Time Intervals Included As. From start to end of the war.

7. Situational Descriptors Defined As. A few circumstantial factors are described in narrative fashion.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Fig 4 presents the following tabulation of historical "disease rates per 1,000":

Crimean War (1854-1855):	
French	253.5
British	119.3
Russian	161.3
Mexican War (1846-1848)	110
Civil War (1861-1865)	65
World War I	16

Fig 9 presents the following tabulation of deaths in medical facilities, as a percent of admissions:

Crimean (British)	42.0
World War II (US)	4.5
Korea (US)	2.5
Vietnam (US)	2.6

10. Summary of Findings Regarding Battle Casualties. From the document: "The principles of bacteriology, disease prevention, surgical technique of wound management, and the influence of the rifle were all highlighted during the Crimean War."

11. Comments and Critique. This provides a brief, but largely anecdotal, review of the Crimean War. The tabular statistics cited in the article may be correct but should be confirmed using other sources before they are used in serious work. The author's main point is well-taken; namely that medical

knowledge of the causes of disease, antiseptic measures, and techniques of anesthesia made great progress in the late 1800s and that, accordingly, medical practice before that time should be judged in terms of the knowledge it possessed at the time.

REISTER-1969

1. Document Description. Reister, Frank A., "Effects of Type of Operation and Tactical Action on Major Unit Casualty and Morbidity Experience—Korean War," Medical Statistics Agency, Office of the Surgeon General, Department of the Army, May 1969, 74 pp. UNCLASSIFIED. Available from libraries. Subtitled "Numbers and Rates of Killed, Wounded, Diseases and Nonbattle Injury for US Divisions and Separate Regimental Combat Teams, 1950-1953."

2. Objectives and Scope. To expand upon the material and methods used in Beebe-1957, which did not go beyond the classification of ground operation for the entire division and only counted wounded in action who lost time from duty, by including information on the tactical actions of separate regiments and on the total number hit (killed in action plus all of the wounded in action, even those who were slightly wounded and who lost no overnight time from duty and were carded for record only). Statistical tabulations of the causative agent and anatomical location of wounds and nonbattle injuries are also included.

3. Populations Included. Participants in selected operations, which accounted for 93 percent of the total number hit among US troops in the Korean War.

4. Timeframes Included. Korean War.

5. Casualty Types Included. Mainly KIA, WIA, and CRO. However, some information on nonbattle casualties is also included.

6. Time Intervals Included As. From start to end of an operation.

7. Situational Descriptors Defined As. From pp 6-7: "The classification of tactical operations was developed in order to classify all of the killed and wounded in action casualties sustained by each of the eight US Army divisions and the two separate regimental combat teams which served at one time or another in the Korean War. The types of operations and tactical actions reflect the character of US Army divisional experience in Korea, and is, to a certain extent, influenced by the quality of the various after-action reports. The types of divisional operations developed are: Offensive Operations; Pursuit and Mopping-Up; Maintaining Static Defensive Lines; Limited Operations from Main Battle Position; Defensive (Enemy Offensive) Operations; Withdrawal Operations; Redeploying and Regrouping; and Corps or Army Reserve. The types of regimental tactical actions are: Attack, Heavy Resistance; Attack, Light Resistance; Air Drop Attack; Assault River Crossing; Defense, Enemy Attack or Counterattack; Withdrawal and Rearguard Action; Patrolling; Establish, Hold, or Consolidate Defensive Positions; Mopping-Up or Consolidating Gains; Movement or Redeployment; and Reserve."

8. Data Sources Used. Various official records and unit after-action reports.

9. Other and Miscellaneous. Page 4 notes that The Surgeon General's and The Adjutant General's records show the following differences:

Item	Surgeon General	Adjutant General
Killed in Action	18,769	19,585
Wounded in Action	77,788	79,256
Slightly Wounded in Action	14,575	(Not included)

10. Summary of Findings Regarding Battle Casualties. Since the conclusions and implications of the data presented are too numerous and varied to summarize fully here, we limit ourselves to noting the following salient findings. From p 42: "While it has been shown that individual operations and tactical actions produce casualty rates that are specific to a peculiar set of circumstances, nevertheless, certain operations of the same classification are found to be similar, as are certain fo the tactical actions." From pp 73-74: "The relative percentage distributions by causative agent indicate that differences do exist between the relative proportions of wounds for various causative agents when considered by type of tactical operation or for different periods of time. These data show some measure of uniformity in that fragments are the leading cause of both killed in action and wounded in action cases, with the exception of operations of pursuit and withdrawal. ... In the data presented by anatomical location of wound, however, there appears to be no significant variation or major shift between body regions in the relative distribution of wounds, with the exception of the slight increases in head, face, and neck wounds for both the killed in action and wounded in action during static positional type warfare. ... Nonbattle injuries, on the other hand, appear to be affected by the type of tactical operation, largely in relation to the use of equipment such as tanks and other land vehicles and to accidents involving the use of own weapons as well as to the elements–weather, cold, and heat."

11. Comments and Critique. This is an excellent treatment of the Korean War data for the purposes intended. It is a classic in the literature on personnel attrition and deserves to be much better known. Much of it is included, virtually intact, in Reister-1986.

REISTER-1975

1. Document Description. Reister, Frank A., "Medical Statistics in World War II," Office of The Surgeon General, US Army, Library of Congress Catalog Card Number: 75-600004, 1975, 1215 pp. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To document selected medical statistics from World War II.

3. Populations Included. From the document's Chapter I: "The man-years of exposure, used for purposes of computing annual rates per 1,000 average strength in this volume, have been based on the daily average strength served (US Army including Air Corps) as reported monthly on medical summary reports received in the Office of the Surgeon General during the war. These medical statistical reports were consolidated for total Army, continental United States, total overseas and by theater; by rank, sex, and race; and by category of forces."

4. Timeframes Included. January 1942 to December 1945.

5. Casualty Types Included. KIA, WIA, DOW, DNBI.

6. Time Intervals Included As. Monthly.

7. Situational Descriptors Defined As. By theater of operation.

8. Data Sources Used. From the document's Chapter II: "All data relative to admissions, diagnosis, treatment, disposition, days lost from duty are based on tabulations of individual medical records for US Army (including Air Corps) personnel."

9. Other and Miscellaneous. The document contains 92 tables and 2 figures. The Table of Contents includes the following:

a. Part I: Summary Analysis (Introduction and summary; Battle admissions and dispositions; Nonbattle admissions and dispositions; Selected disease and nonbattle injury diagnoses).

b. Part II: Sources, definitions, and methodology.

c. Part III: Reference tables.

10. Summary of Findings Regarding Battle Casualties. Findings are numerous and varied. Only one major point is summarized here, taken from the document's Chapter I: "During times of war before World War II, nonbattle deaths always exceeded battle deaths. In World War I, nonbattle deaths were only slightly higher than battle deaths, and the ratio of battle deaths to nonbattle deaths approximated one for one [for US Army Expeditionary Forces]. In World War II, however, the process was reversed further, and for the first time, battle deaths exceeded nonbattle deaths by a ratio of 3 to 1 [for US Army forces]."

11. Comments and Critique. This is an important study of medical statistics from World War II. However, its concentration on the medical aspects tends to slight other important casualty categories such as KIA and CMIA. Nevertheless, the information it does provide is invaluable.

REISTER-1986

1. Document Description. Reister, Frank A., "Battle Casualties and Medical Statistics, US Army Experience in the Korean War," The Surgeon General, Department of the Army, 1986, 172 pp. UNCLASSIFIED. Available from libraries. First printed in 1973 as Center of Military History Publication CMH Pub 82-5.

2. Objectives and Scope. From the Preface: "These data have been assembled with the planner in mind, based on a knowledge of material considered essential by Systems Analysts engaged in combat development, war-gaming, weapons evaluation, medicologistical problems, and in medical research concerning battle casualties. ... This volume is a compilation of medical statistical data in detail of division versus nondivision comparison, designed for applications in operations research and systems analysis."

3. Populations Included. US Army troops in the Korean War.

4. Timeframes Included. Korean War.

5. Casualty Types Included. KIA, WIA, DNBI.

6. Time Intervals Included As. Mostly from start to end of the war, with some statistics for shorter time periods.

7. Situational Descriptors Defined As. The same descriptors as used in Reister-1969 are used to describe the tactical operations.

8. Data Sources Used. Official records.

9. Other and Miscellaneous. Includes numerous tables and a few figures. Table 72 tabulates the estimated distribution of time from wounding to first medical care, Table 73 from wounding to first hospitalization, Table 74 from wounding to reaching a surgical or medical hospital. The Table of Contents includes the following major chapter headings: Casualty and Morbidity Experience; Effects of Type of Operation and Tactical Action; Lethality of Weapons and Location of Wounds; Hospitalization in Korea; Evacuation of Patients From Overseas; and Surgical, Medical, and Logistic Considerations. The last chapter and Appendix A (Methods of Computation) include methods for projecting bed and other medical requirements from historical casualty data.

10. Summary of Findings Regarding Battle Casualties. Too numerous and too varied to summarize briefly.

11. Comments and Critique. This is the principal source of tabulated casualty data for US forces in the Korean War, and is one of the major classics in this field. It includes, virtually intact, much of Reister-1969.

RICH-1968

1. Document Description. Rich, Norman M., "Vietnam Missile Wounds Evaluated in 750 Patients" Military Medicine, Vol 133, Jan 1968, pp 9-22. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope.

3. Populations Included. US Army soldiers in Vietnam.

4. Timeframes Included. Vietnam War.

5. Casualty Types Included. Admissions (mostly US soldiers) to the 2d Surgical Hospital (MA), located in the central highlands of the Republic of Vietnam.

6. Time Intervals Included As. From January to October 1966.

7. Situational Descriptors Defined As. Only a few descriptors are used.

8. Data Sources Used. Personal observation.

9. Other and Miscellaneous. The sample of 750 patients with missile wounds is a subsample of the 2,048 patient admissions to the 2d Surgical Hospital during the period in question, as shown in the following table, extracted from the document:

Causative agent	Admissions Number	Percent
Missile wounds	750	36.6%
Punji sticks	324	15.8%
Trauma	446	21.8%
Surgical	361	17.6%
Medical	167	8.2%

10. Summary of Findings Regarding Battle Casualties. The regional wound distribution in the 750 admissions for missile wounds is given as follows (counting multiple wounds):

Location	Number	Percent
Lower extremities	430	36%
Upper extremities	317	27%
Head and neck	123	10%
Chest	107	9%
Abdomen	67	6%
Flank, back, genital	134	12%
Totals	1,178	100%

The author notes that the operative mortality rate was 1.2 percent and 61 percent of 729 wounded soldiers were returned to duty in Vietnam.

11. Comments and Critique. This is a useful summary of the operations and experience of one surgical unit in Vietnam during the period under investigation.

RICHARDSON-1960

1. Document Description. Richardson, Lewis Fry, "Statistics of Deadly Quarrels," The Boxwood Press, Pacific Grove, California, ISBN 910286-10-8, 1960, 373 pp. UNCLASSIFIED. Available from publisher and libraries. Edited by Quincy Wright and C. C. Lienau.

2. Objectives and Scope. To collect and analyze data on wars.

3. Populations Included. Various.

4. Timeframes Included. 1820 to about 1950.

5. Casualty Types Included. Deaths (this apparently is the total number of deaths attributed to the war, from whatever cause, including civilians as well as military and including all participating nations or population groups).

6. Time Intervals Included As. War durations.

7. Situational Descriptors Defined As. The document includes a list of the wars used. Each entry is characterized according to an elaborate and somewhat idiosyncratic coding scheme, and normally is accompanied by a short narrative of the circumstances surrounding that war.

8. Data Sources Used. Various.

9. Other and Miscellaneous. The Table of Contents includes the following: Plan for collecting information; Collected information on wars and murders; The distribution of wars in time; Variation with magnitude; Characteristics of named nations; Co-operation, Dominance, and Resentment; Economic causes; Languages and wars; Religions and wars; The number of nations on each side of a war; A preliminary theory of geographical opportunities for fighting; Contiguity and deadly quarrels—the local pacifying influence; References.

10. Summary of Findings Regarding Battle Casualties. Findings are too numerous and varied to summarize here.

11. Comments and Critique. This is a major, classical study of wars. Unfortunately, its data are for wars as a whole rather than for military forces engaged in individual land combat operations, and hence are only tangentially related to the PAR studies. However, the kinds of methods used and the general spirit of the analysis are worthy of emulation.

RICHARDSON-1970

1. Document Description. Richardson, R. P. Jr., *et al.*, "An Analysis of Recent Conflicts," Center for Naval Analyses (CNA), Research Contribution No. 144, 27 Jan 1970, 304 pp. UNCLASSIFIED. Available from publisher and libraries (probably also available from DTIC). A reissue of the original, which was dated January 1966.

2. Objectives and Scope. To present an analysis of 80 conflicts that occurred during the years 1946-1964 in order to (i) confirm or counter assumptions about limited warfare situations in this period so as to provide greater validity in predicting such situations in the future, (ii) to identify the major variables involved in the various kinds of recent conflicts so that these variables will be used appropriately in the analysis of future conflicts of a similar type, and (iii) to provide a data base from which important implications about the nature of recent conflicts may be derived so that the effective processes of deterrence and control may be perceived for future application.

3. Populations Included. Conflicts, defined (p B-14) as "any event involving two or more groups in which the use of force or the threat of force was a significant factor in the event, and the event itself was of at least national significance." General war is specifically excluded, but limited war, border war, blockade, threat or show of force, and unconventional or covert invasion is included. Also included are civil disorder, *coup d'etat*, military revolt or mutiny, insurrection, civil war, and guerrilla war.

4. Timeframes Included. From 1946 to 1964.

5. Casualty Types Included. Deaths.

6. Time Intervals Included As. From start to end of a conflict.

7. Situational Descriptors Defined As. Examples of the sort of descriptors included are: magnitude. location, force size, duration, motivation, outcome, tempo of operations, total fatalities (including civilian as well as military killed as a direct result of the conflict), warning indications, and so forth.

8. Data Sources Used. Chiefly *Keesing's Contemporary Archives* (a semimonthly British publication issued in London that painstakingly attempts to resolve inconsistencies among conflicting journalistic accounts), and *Facts on File.*

9. Other and Miscellaneous. Includes numerous tables and figures from the analysis. However, the original data are not included in this publication.

10. Summary of Findings Regarding Battle Casualties. Because civilian deaths are included in the total, no conclusions regarding battle casualties to military personnel can be drawn.

11. Comments and Critique. This provides valuable analysis of a large segment of 20th century conflicts. It can be compared to Brinkerhoff-1985, which attempted a somewhat similar analysis based on a more detailed description of a lesser number of incidents.

ROBINSON-1965

1. Document Description. Robinson, Richard C., "Casualty Predictions for Medical Workloads from Conventional Weapons," Proceedings of the US Army Operations Research Symposium, 30 March–1 April 1965, 1965, pp 25-38. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To summarize the findings of a RAC report on the subject title.

3. Populations Included. US Army WIA and KIA in divisions involved in selected operations.

4. Timeframes Included. World War I, World War II, and Korea.

5. Casualty Types Included. WIA and KIA.

6. Time Intervals Included As. Daily.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Official records (apparently primarily the monthly division G-1 Journals).

9. Other and Miscellaneous. This presentation to the Army Operations Research Symposium was based on the RAC report RAC-T-439, "Casualty Predictions for Medical Workloads from Conventional Weapons 1965-1970," by Dr. Charles Baker, *et al.*, which was done under contract to USACDCMSA (US Army Combat Developments Command Medical Systems Agency), Fort Sam Houston, Texas [*see* Boyd-1964]. The authors note that "As one would expect, the obtaining of the data was the most difficult part. This aspect alone consumed about two man-years. ... Nevertheless, data were collected on over 1/2 million casualties comprising a total of 96 divisions (28 from World War I, 60 from World War II, and 8 from Korea)."

10. Summary of Findings Regarding Battle Casualties. Slide 4 depicts the distribution of WIA per division combat day as a percent of daily division strength for infantry divisions in World War I, World War II, and Korea. From p 27: "From this graph, there appears to be a trend toward a lower casualty rate." From p 29: "The combined sample of 96 divisions resulted in a 4.05 to 1 ratio [of KIA to WIA]." From p 29: "By just scanning this chronological tabulation, one can spot the development, plateau or peak, and decline of activities in a major engagement. ... the frequency of occurrence of such peaks is small ..." From p 29: "...the expected distribution of wounds on the body ... has remained almost unchanged for the past 3 wars." Slide 8 shows the following tabulation of percent distribution of WIA by region of the body:

Location	Percent of total casualties	Percent of WIA for each body region	WIA as percent of total casualties
Head	22.5	56.5	12.7
Thorax	10.0	62.9	6.3
Abdomen	8.5	60.3	5.1
Upper extremities	25.5	96.1	24.1
Lower extremities	33.5	95.4	32.0
Total	100.0		80.6

Here the column headed "Percent of total casualties" should be interpreted as the probability of a hit on the given body location, "Percent of WIA for each body region" should be interpreted as the conditional probability that a hit on the given body region will result in a WIA (after deducting for KIA). The last column is the product of the first two, and so can be interpreted as the probability that the indicated body region will be hit *and* result in a WIA casualty (as opposed to a KIA).

11. Comments and Critique. This study took a similar approach and arrived at findings similar to those described in Kuhn-1989, although the latter study is based on a substantially larger body of evidence.

ROSENAU-1976

1. Document Description. Rosenau, James N. (ed), "In Search of Global Patterns," The Free Press, a division of Macmillan Publishing Co., New York, ISBN: 0-02-927050-2, 1976, 389 pp. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. From the first Chapter: "Twentieth-century efforts to comprehend the political universe have not been nearly so extensive, conspicuous, or successful as those intended to unravel the secrets of the physical universe ... They have not had the confidence of society enjoyed by the former and the financial support provided for their efforts has thus far been minuscule by comparison. Indeed, probably few persons outside the halls of academe are even aware of the existence of a small community of investigators dedicated to the scientific study of world politics. ... The purpose of this book is to portray that quest—its origins and motivational dynamics, its accomplishments and failures—and to highlight the problems that must be solved if patterns are to be uncovered and knowledge accumulated."

3. Populations Included. Various.

4. Timeframes Included. Various.

5. Casualty Types Included. Various.

6. Time Intervals Included As. Various.

7. Situational Descriptors Defined As. Various.

8. Data Sources Used. Various.

9. Other and Miscellaneous. The Table of Contents lists the following entries: The restless quest; The roots of faith; *Apologia pro vita sua;* Individual achievements rarely sum to collective progress; The researcher in the United Nations: Evolution of a research strategy; The Stanford studies in international conflict and integration; From correlation analysis to computer forecasting: Evolution of a research program; Sizing up a study in simulated international processes; An inside appraisal of the World Event Interaction Survey; War, presidents, and public opinion; Bridging the gap between theory and practice: Foreign policy decisionmakers viewed psychologically: "Cognitive process" approaches; Cumulativeness in international relations; Noticing pre-paradigmatic progress; A contra-Kuhnian view of the discipline's growth; The problem of cumulation; Tribal sins on the QIP [Quantitative International Politics] reservation; The failures of quantitative analysis: Possible causes and cures; Cumulation, correlations, and woozles; Theory for and about policy; Identifying, formulating, and solving puzzles in international relations research; Some suggestions for improving cumulation; Obstacles to the accumulation of knowledge; Environmental fertility and cumulative growth; Cumulation, cooperation, and commitment: The future of comparative studies: An evangelical plea; Optimal control theory: A promising approach

for future research; Some conceptual problems in constructing theories of foreign policy behavior; Comparative foreign policy: Fads, fantasies, orthodoxies, perversities; Laws, explanation, and the $X \rightarrow Y$ syndrome; Reconceptualizing the sources of foreign policy behavior; Epistemology, theory, data, and the future; The case-for-analysis problem; The role of issues; When leader personality will affect foreign policy: Some propositions; Resources in comparative analysis; Politics and ecology, Easton and Rosenau: An alternative research priority; Conceptualizing foreign policy behavior using events data; Targeting behavior: A new direction; Restlessness, change, and foreign policy analysis.

10. Summary of Findings Regarding Battle Casualties. No general findings regarding battle casualties are presented.

11. Comments and Critique. The search for patterns governing the behavior of attrition in combat faces many of the same kinds of problems as confronted by researchers on international relations. This volume contains 40 well-written accounts by practitioners of quantitative international politics of problems and conceptual conundrums they have met when dealing with the data and analytical methods of that field. The difficulties are real and should be appreciated by all who would do serious work in quantitative international politics or in the study of attrition in battle.

ROSS-1992

1. Document Description. Ross, Andrew, "The Analysis of Combat Data for Low Level Contingencies: Some Practical Applications," Australian Defence Studies Centre. This is Chapter 8 of the book *Combat History and Analysis,* edited by Andrew Ross and published in 1992 by the Australian Defence Studies Centre, University College, The University of New South Wales, Australian Defence Force Academy, ISBN: 0-7317-0234-4, 1992, pp 91-109. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. To present various techniques for analyzing the progress of low level contingencies; and as an example to present empirical data from the Confrontation Campaign in North Borneo between Australian Commonwealth and Indonesian forces during April 1963 and August 1966.

3. Populations Included. Commonwealth of Australia forces and Indonesian Raiders in North Borneo.

4. Timeframes Included. From April 1963 to August 1966.

5. Casualty Types Included. Killed, wounded, and captured.

6. Time Intervals Included As. From start to end of an incident or contact.

7. Situational Descriptors Defined As. Figure 8-7 provides a tabulation of casualties by Australian and Raider activity (such as patrolling, ambushing, defensive security, and formal attack) for each calendar quarter and by killed versus wounded and POW. Figure 9-12 tabulates, according to a similar scheme, those casualties for which there was a prior detection.

8. Data Sources Used. Official Australian records.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. The author includes several pertinent comments on the "many research traps in establishing" a data base useful for analysis. No broad generalizations regarding casualties are stated, although it is noted that Raider losses in the average contact tended to be substantially higher than those of Australian security forces.

11. Comments and Critique. This provides what is surely the most accurate and comprehensive statement available in the open literature of casualties inflicted and incurred during the Australia-Indonesia Confrontation. See also Brinkerhoff-1985, Denton-1969, and Richardson-1070.

ROWLAND-1987

1. Document Description. Rowland, David, "The Use of Historical Data in the Assessment of Combat Degradation," Journal of the Operational Research Society (UK), Vol 38, no 2, 1987, pp 149-162. UNCLASSIFIED. Available from libraries. Also published as "Assessments of Combat Degradation" in the Journal of the Royal United Services Institute for Defence Studies (RUSI), June 1986, pp 33-43.

2. Objectives and Scope. Degradation is the reduction in the performance of weapon systems as the environment in which they operate becomes progressively more severe. This paper uses field experiments and combat history to estimate quantitatively the amount of degradation in the performance of rifles and machineguns when they are employed defensively by small units (battalion and below). In this context, performance is defined to be the average number of attacking infantrymen hit per defending weapon system (rifle or machinegun).

3. Populations Included. Combat infantrymen.

4. Timeframes Included. Uses information from the American Civil War, the Franco-Prussian War, the Zulu War, the Boer War, World War I, World War II, and field trials conducted by the United Kingdom during the 1970s and 1980s.

5. Casualty Types Included. "Virtual casualties," *i.e.*, suppression or degradation of effectiveness.

6. Time Intervals Included As. From start to end of an engagement.

7. Situational Descriptors Defined As. Force ratio, number of defense machineguns, density and duration of attacker's preparatory bombardment, number of attacking armored fighting vehicles, and defender's fortification status.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Includes figures and equations.

10. Summary of Findings Regarding Battle Casualties. The performance of rifles and machineguns employed by small units on the defense in actual combat is about one-sixth that which is observed during field trials. Their performance in field trials is, in turn, about one-tenth that observed under firing range conditions. So their performance in actual combat operations is only about 1/60 that observed under firing range conditions. If a preparatory bombardment of about 0.4 pounds of high explosive per square yard continued over a period of 1 hour is delivered against the defending infantrymen, their performance declines by yet another factor of 10. These heavy losses in performance are attributed to degradation caused by the increasing severity of their environmental conditions. It is also observed that the performance of these weapons rises as the attack/defense force ratio increases.

The degradation can be mitigated by providing the defending infantry with antitank weapons and protective fortifications and barriers.

The general expression given in this article for casualties inflicted by the average directfire smallarms weapon employed by the defender is

$$D \cdot G(N_a/N_d)^{0.68}\left[1-\exp(-5.75d/\sqrt{t})\right]\left[1-\exp(-1.1\ t_a/N_s)\right] \quad ,$$

where

D = a factor for prepared/hasty positions

G = a constant for weapon type

N_a = number of attacking infantry

N_d = number of defending infantry

d = density of preparatory bombardment of defending infantry (lb/yd^2)

t = duration of preparatory bombardment (hrs)

t_a = number of attacking armored fighting vehicles

N_s = number of defending machineguns + x × (number of defending antitank guns), where x is a constant whose value depends on the type of antitank gun.

11. Comments and Critique. This study estimates the values of degradation for defending rifles and machineguns, taking into account the effects of armor, artillery, and defensive works. Although many of these degradation factors are larger than some may have expected, their consistency over time suggests that they are governed by some enduring human limitations. The implication is that comparable factors can be anticipated in future actions.

RUSSET-1972

1. Document Description. Russet, Bruce M. (ed), "Peace, War, and Numbers," Sage Publications, Beverly Hills, ISBN: 0-8039-0164-X, 1972, 352 pp. UNCLASSIFIED. Available from publisher and libraries. Copy in CAA Library under 327.07 RUS.

2. Objectives and Scope. To report the results of a September 1970 meeting of the American Political Science Association. The terms of reference were that all papers should: (i) develop specific hypotheses about the causes or conduct of international violence; (ii) test those hypotheses with actual data about international behavior; (iii) indicate the broader relevance of the findings for theory and for policy.

3. Populations Included. Various.

4. Timeframes Included. Various.

5. Casualty Types Included. Various.

6. Time Intervals Included As. Various.

7. Situational Descriptors Defined As. Various.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Table of Contents includes the following: Introduction; Capability distribution, uncertainty, and major power war, 1820-1965; Status, formal organization, and arms control as factors leading to the onset of war; US foreign relations: Conflict, cooperation, and attribute distances; Cooperating to conflict: Sources of informal alignments; American and Soviet influence, balance of power, and Arab-Israeli violence; War power and willingness to suffer; Symbolic involvement as a correlate of escalation: The Vietnam case; Internal and external influences on bargaining in arms control negotiations: The partial test ban; In search of peace systems: Scandinavia and the Netherlands. 1870-1970; Models for the analysis of foreign conflict behavior of states: The revolt of the masses: Public opinion on military expenditures.

10. Summary of Findings Regarding Battle Casualties. No general statements regarding attrition in land combat battles are provided.

11. Comments and Critique. This provides an excellent summary of the state of research on topics within the scope of the conference's terms of reference, as described in paragraph 2 above. The same kinds of problems in dealing with the data and hypotheses described in this document confront analysts attempting to deal with the battle attrition data.

SAMZ-1972

1. Document Description. Samz, Robert W., "Some Comments on Engel's 'A Verification of Lanchester's Law'," Journal of the Operations Research Society of America, Vol 20, No 1, January-February 1972, pp 49-52. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. A recent reexamination of the combat data from the World War II battle of Iwo Jima has yielded some revisions of the data used in Engel's paper (*see* Engel-1954). However, the revised data also fit Lanchester differential and difference equations closely, as Theil's inequality coefficient shows.

3. Populations Included. Combatants.

4. Timeframes Included. World War II.

5. Casualty Types Included. Battle casualties.

6. Time Intervals Included As. From start to end of the battle of Iwo Jima.

7. Situational Descriptors Defined As. None.

8. Data Sources Used. Official US Marine Corps histories of the action at Iwo Jima.

9. Other and Miscellaneous. Corrects a few typographical errors in Engel's paper.

10. Summary of Findings Regarding Battle Casualties. The Lanchester equations, in either differential or difference form, adequately fit the historical data on attrition in the battle of Iwo Jima.

11. Comments and Critique. This provides a useful alternative account of strengths and losses in the battle of Iwo Jima, as well as a confirmation of the fit of Lanchester's square law of attrition to the historical data on the battle of Iwo Jima.

SCALES-1992

1. Document Description. Scales, John R., "Development and Modification of the Lanchester Equations for Land Combat Using Military Planning Factors," University of Alabama in Huntsville, 6 June 1992, 124 pp. UNCLASSIFIED. Available from University of Alabama in Huntsville. Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Industrial and Systems Engineering of the School of Graduate Studies of the University of Alabama in Huntsville.

2. Objectives and Scope. From the Abstract: "This dissertation combines the classical Lanchester equations for attrition in ground combat with an appreciation of traditional military planning factors. ... explicitly modeled in the [proposed] equations are a new model of attrition, a unique expression of terrain, a term for suppression, and command and control. This set of deterministic ordinary differential equations is tested against a data base of 192 post-1940 battles and shown to provide excellent overall agreement. The formulation is extended with a stochastic differential equation, and then with explicit terrain representation, using a set of partial differential equations. ..."

3. Populations Included. Participants in selected battles of the post-1940 period.

4. Timeframes Included. Primarily World War II, with some inclusion of Korean and Arab-Israeli War data. The Battle of 73 Easting is also considered.

5. Casualty Types Included. Battle casualties.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Only those descriptors explicitly modeled in the theoretical formalism are used.

8. Data Sources Used. CAA-1991.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. The final deterministic equations are:

$$\frac{dB}{dt} = -\left[\frac{\alpha_R(t) j_R(t) \gamma_R(t) BR}{\alpha_R(t) j_R(t) + \gamma_R(t) B}\right]\left[1 - \exp\left(-\frac{c_1 \frac{dB'}{dt}}{\frac{dR'}{dt}}\right)\right]$$

$$\left[1 - \exp\left(-\frac{A_{Btarget}}{\pi TLE_B^2(t)}\right)\right]\left[\frac{B}{B_0}\right]^{\exp\left(-\frac{A_{Btarget}}{\pi TLE_B^2(t)}\right)}[fof(R)]$$

$$\frac{dR}{dt} = -\left[\frac{\alpha_B(t) j_B(t) \gamma_B(t) RB}{\alpha_B(t) j_B(t) + \gamma_B(t) R}\right]\left[1 - \exp\left(-\frac{c_1 \frac{dR'}{dt}}{\frac{dB'}{dt}}\right)\right]$$

$$\left[1 - \exp\left(-\frac{A_{Rtarget}}{\pi TLE_R^2(t)}\right)\right]\left[\frac{R}{R_0}\right]^{\exp\left(-\frac{A_{Rtarget}}{\pi TLE_R^2(t)}\right)[fof(B)]} ,$$

with the initial conditions $B(0) = B_0$ and $R(0) = R_0$ and the stopping condition $f(B, B_0, R, R_0)$, where R and B depend on t, the independent variable. All other parameters and functions must be derived from such experimental or historical data as may be available. The symbols are defined as follows, where X takes on the values B or R, and Y takes on the complementary values (*i.e.*, R when $X = B$, and B when $X = R$).

α_X = The number of Y targets lost to one X firer per unit time.
γ_X = Logarithmic law attrition rate for Y targets.
j_X = Command, control, communications, and information efficiency of X.
c_1 = Suppression constant.
dX'/dt = Derivative of X with respect to time without including suppression.
$A_{Xtarget}$ = The area of a side X target element.
TLE_X = Target location error of side Y's firers.
$fof(X)$ = Proportion of $A_{Xtarget}$ actually exposed, *i.e.*, $1 -$ cover.

These equations are fitted to the historical data by first taking $\alpha_R = \alpha_B = \alpha = 74$/day, $j_R = j_B = j = 1$, $A_{Rtarget} = A_{Btarget} = A_{target} = 0.6$ m^2, $TLE_R = TLE_B = TLE = 2$ meters, $fof(R) = fof(B) = fof = 0.5$, $c_1 = 0.03$, and $\gamma_R = \gamma_B = \gamma$. Then γ is adjusted to fit one of the historical data parameters—namely, the slope of the regression line of $\log\left\{\left(R_0^2 - R^2\right) \div \left(B_0^2 - B^2\right)\right\}$ on $\log(R_0/B_0)$.

11. Comments and Critique. The attempt to compare this theory to historical data actually proves little or nothing. In the first place, it uses one adjustable constant to fit one parameter of the historical data—it is not surprising that a reasonable fit is produced. Secondly, the procedure used either commits or comes perilously close to committing the Constant Fallacy (*see* Helmbold-1993) of attempting to determine the form of a differential equation using only information on the initial and final states of the system it is supposed to represent.

SCHAEFER-1977

1. Document Description. Schaefer, Alfred, "Zur Ermittlung Funktionaler Zusammenhänge Zwischen Bewegungsgeschwindigkeit und Verlustraten Militärischer Verbande im Gefecht [On the Determination of the Functional Relationship Between Speed of Movement and Loss Rates of Military Units in Combat]," Hochschule der Budeswehr München, HSBwM-ID03/77, 9 June 1977, 240 pp. UNCLASSIFIED. Available from publisher (Hochschule der Bundeswehr München).

2. Objectives and Scope. English translation of the Abstract: this thesis investigates data on the 1944 Ardennes Offensive compiled by the RMC-Vertex Corporation for the SHAPE Technical Centre (STC) for functional relationships between movement and loss rates of military units in battle. Such relationships cannot be established by using regression analysis on the data provided for American units. However, the data on the German units show that an attacker's willingness to accept risks and higher loss rates definitely determines his movement rate and territorial gain.

3. Populations Included. Selected infantry units in the Ardennes campaign.

4. Timeframes Included. World War II.

5. Casualty Types Included. Battle casualties.

6. Time Intervals Included As. From start to end of an engagement.

7. Situational Descriptors Defined As. As in Cockrell-1974 *(q.v.)*.

8. Data Sources Used. The part of Cockrell-1974 that dealt with the Ardennes campaign.

9. Other and Miscellaneous.

a. English translation of selections from pp 32-33 (Models for Describing the Speed of Movement of Combat Units, and Dependence of the Rate of Advance on to Loss Rates): the losses of attacking tanks are given on 108 days and those of the defending tanks on 99 days. The losses to attacking infantry can be ascertained on 62 days and those of the defending infantry on 51 days. Nevertheless, there are only 6 days on which all of these loss data are provided.

The loss data are missing mostly on those days on which high losses are suspected. Also, if one considers the troop strengths on successive days (insofar as such data are available), then one can establish that the loss data are missing precisely on those days where the difference from the preceding day is high. This is true mainly for the early days of the Ardennes offensive, on which the Americans were on the defensive.

Among other models used in contemporary wargames are those in which the advance rate depends on the attacker's loss rate. Therefore, and because the loss rate of the defender is empirically found to be

less than that of the attacker, a model will be investigated here in which the speed of movement depends only on the loss rate of the attacker.

The basic data contain 73 days in which a German attack occurred (Attack ID Code = 1). The German loss rate is given for 14 of these days. Of the 13 days in the data on which a German attack was combined with an American counterattack (Attack ID Code = 6), no German loss rates are given. Of the 49 days in which American attacks were carried out (Attack ID Code = 0), there were 28 cases in which the loss rate could be ascertained. Finally, loss data is given for 11 of the 15 days in which the American attack was combined with a German counterattack (Attack ID Code = 7). Altogether therefore one can rely on 53 data points in which the loss to the attacker is given. Of these there are 42 days on which a pure attack without a counterattack was conducted. [End of Translation]

b. The tabular representation of all this is as follows (the table entries are in attack days):

ID Code	Description	With ATK loss data	W/O ATK loss data	Total
1	Ger ATK	14	59	73
6	Ger ATK/US counter	0	13	13
0	US ATK	28	21	49
7	US ATK/Ger counter	11	4	15
	Total	53	97	150
0&1	ATK w/o counter	42	80	122
6&7	ATK w/counter	11	17	28
	Total	53	97	150

10. Summary of Findings Regarding Battle Casualties.

a. English translation of the Summary of Results on p 70: unless the number of independent variables is increased still further. Model (4.6) [pp 61-69] is the best model that includes artillery, terrain, and visibility. It gives an estimated constant advance rate of 1.975 km per day. At its lowest level of intensity, the defender's artillery retards the advance by 1.448 km. At its highest level of intensity, the defender's artillery retards the advance by 2.468 km. The quality of the defender's position expresses itself in a difference of land gained amounting to 1.856 km for weak fortifications compared to strong ones. An apparently surprising finding is that the advance rate is lower in higher visibility. This is probably due to the fact that in the Ardennes offensive, the Germans attacked mainly at night, in order to avoid the American material superiority during the advance to contact phase.

In all, if information for the independent variables is obtainable, a good estimate of ground gained can be obtained with Model (4.6), without having to increase still further the number of independent variables, since that would raise the possibility of overfitting the dependent variable.

If one possesses only information on the strength of the attacking infantry and attacking tanks, then one can estimate the ground gained and the losses with the regression equation of the form (4.5) [pp 57-60]. [End of translation]

b. Model (4.6) [pp60-69] is $V_{17} = b_0 + \sum_{i=1}^{16} b_i(V_i - \overline{V}_i)$, where

V_1 = attacking infantry platoons of 40 men each per km of front.
V_2 = defending infantry platoons of 40 men each per km of front.
V_3 = attacking tanks per km of front.
V_4 = defending tanks per km of front.
$V_5 = V_1^2$.
$V_6 = V_2^2$.
$V_7 = V_3^2$.
$V_8 = V_4^2$.
V_9 = attacking artillery rounds per km of front.
V_{10} = defending artillery rounds per km of front.
$V_{11} = V_9^2$.
$V_{12} = V_{10}^2$.
V_{13} = Tank mobility.
V_{14} = Strength of the defensive works.
V_{15} = Percent mechanization of the attacking infantry.
V_{16} = Visibility.
V_{17} = Dependent variable.

NOTES:

1. The b_i are parameters to be fitted to the data. Set $\overline{V}_i = 0$ for $i = 13$, 14, and 16.

2. The dependent variable is taken successively to be: Ground gained by the attacker, losses to the attacking infantry, losses to the defending infantry, losses to the attacking tanks, and losses to the defending tanks. Separate regressions for each case leads to separate regression coefficients for each. Thus, in all, 5 cases (each with 17 adjustable parameters) are treated (for a total of $5 \times 17 = 85$ free parameters).

c. Model (4.5) [pp57-60] is $V_9 = b_0 + \sum_{i=1}^{8} b_i(V_i - \overline{V}_i)$, where

V_1 = attacking infantry platoons of 40 men each per km of front.
V_2 = defending infantry platoons of 40 men each per km of front.
V_3 = attacking tanks per km of front.
V_4 = defending tanks per km of front.

$V_5 = V_1^2$.
$V_6 = V_2^2$.
$V_7 = V_3^2$.
$V_8 = V_4^2$.
V_9 = Dependent variable.

NOTES:

1. The b_i are parameters to be fitted to the data. The dependent variable is taken successively to be: ground gained by the attacker, losses to the attacking infantry, losses to the defending infantry, losses to the attacking tanks, and losses to the defending tanks. Separate regressions for each case leads to separate regression coefficients for each. Thus, in all, 5 cases (each with 9 adjustable parameters) are treated (for a total of $5 \times 9 = 45$ free parameters).

d. Summary of Regression Computations for Model (4.5) [this model contains 9 free parameters and is described on pp 57-60; its regression computations are on pp A76-A116; R is the multiple regression coefficient]:

Dependent variable	No. data points	R	R^2
Advance rate	149	0.36220	0.13
Loss to ATK Inf	61	0.54124	0.29
Loss to DEF Inf	50	0.56447	0.32
Loss to ATK Tks	107	0.40470	0.16
Loss to DEF Tks	98	0.51258	0.25

e. Summary of Regression Computations For Model (4.6) [this model contains 17 free parameters and is on pp 61-69; its regression computations are on pp A117-A168; R is the multiple regression coefficient]:

Dependent variable	No. data points	R	R^2
Advance rate	149	0.63251	0.40
Loss to ATK Inf	61	0.73901	0.55
Loss to DEF Inf	50	0.64590	0.42
Loss to ATK Tks	107	0.46449	0.22
Loss to DEF Tks	98	0.54621	0.30

11. Comments and Critique. Although this is an interesting paper, the results are based on a relatively small sample of data collected during a particular operation. The degree to which it can be used in other contexts is uncertain. Also, the regressions appear to suffer from the statistical problems of overfitting and "data dredging" (*i.e.*, making multiple regression computations and publishing only those that appear to , rovide a good fit). Nevertheless, it would be interesting to pursue the findings to see if they apply to other contexts.

SCHMIDT-1963

1. Document Description. Schmidt, Th. W., "The Necessity for Objective Data From Actual Combat Engagements While Current," US Army Operations Research Symposium Proceedings, 23 March 1963, pp 267-272. UNCLASSIFIED. Available from libraries. At the time, the author was employed at the US Army Research Office-Durham.

2. Objectives and Scope. To argue the case for collecting data from actual combat operations for use in US army research efforts.

3. Populations Included. Various.

4. Timeframes Included. Various.

5. Casualty Types Included. Various.

6. Time Intervals Included As. Various.

7. Situational Descriptors Defined As. Various.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. No general statements regarding battle casualties are presented. However, some selected observations include the following: "No matter how realistic the field testing [of combat systems], some critical constants will still be incompletely determined and can only be obtained under real combat in the theater of war. ... The areas in which critical data from the theater of war are needed should be indicated as soon as a weapon system begins its development. ... Furthermore, besides the equipment and the data to be extracted and stored, the planned design of the combat experiments has to be jointly discussed in closest alliance between the military user and the responsible operations researcher. ... I believe that any agency engaged in operations research which expects to establish field offices in a future theater of war should be given very early attention to the ways and means of data recording under battle conditions and the involved logistics. An institute for military operations research could perhaps even justify a special section in charge of the initiation of new, special equipment, if such equipment is not already available. ... A survey on a much broader basis [than in this paper] and of all the modern weapon systems would be needed to see if the peacetime preparation for data gathering on the battlefield in future wars as input for operations research studies is as complete as possible, so that the constants of the mathematical model, the critical parameter of the war game will reflect the situation of actual combat engagements."

11. Comments and Critique. This paper presents an eloquent appeal for pre-war planning of methods and means for collecting critical information on actual combat operations. It should be heeded by all who use or intend to use such information.

SCHMIEMAN-1967

1. Document Description. Schmieman, William A., "The Use of Lanchester-Type Equations in the Analysis of Past Military Engagements," Georgia Institute of Technology, August 1967, 188 pp. UNCLASSIFIED. Available from publisher and libraries. A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the School of Industrial Engineering, Georgia Institute of Technology.

2. Objectives and Scope. From the Summary: "Using Bodart's *Lexicon* (covering 1,081 land battles fought between 1620 and 1905) [*see* Bodart-1908] as a data source, an analysis of past military engagements was conducted with the following specific objectives:

"a. To determine if Lanchester's square law, Lanchester's linear law, or some other exponential law best depicts the flow of combat.

"b. To develop empirical relationships between the effectiveness ratio and the initial strength ratio.

"c. To develop an advantage parameter to estimate the side possessing the advantage.

"d. To determine the sensitivity of the form of Lanchester's law to the magnitude of the effectiveness coefficients.

"e. To categorize military combat situations according to total force and percent casualties and develop models to estimate the effectiveness ratio and advantage for each category.

"f. To estimate the validity of the models developed by determining the stability of their regression coefficients with time."

3. Populations Included. Those contained in Bodart-1908.

4. Timeframes Included. From 1620 to 1905.

5. Casualty Types Included. Total battle casualties (killed, wounded, missing, and captured).

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Bodart-1908.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. From the Summary: "Based on the results of this study, the following conclusions were obtained:

"a. In general, the battle situations studied were insensitive to the form of Lanchester's law used.

"b. Empirical relationships were established between the effectiveness ratio and the initial strength ratio [*i.e.*, between the ratio of the attrition coefficients in Lanchester's square law of attrition and the force ratio].

"c. The advantage parameter developed was in good agreement with the winner of the battles studied.

"d. A sensitivity analysis, using simulation results supported conclusion 10a above.

"e. A two-way classification of battles by battle size and percent casualties showed that the classification by battle size did not improve the model's ability to estimate advantage. Classification by percent casualties resulted in a 7 percent improvement for those classes in which one side had heavy losses and the other light losses.

"f. Analyses of battles in which one side had light losses and the other heavy revealed that, on the average, the large force has the larger unit effectiveness when the initial strength ratio is less than 3 to 1. The reverse is true for larger ratios of initial strength.

"g. The models developed proved to be time invariant over the time period of the data [*i.e.*, they were insensitive to the date the battle occurred].

"h. The distribution of battles by battle size follows an exponential distribution."

11. Comments and Critique. First, the conclusions regarding the form of attrition relationship are mistaken because they commit the Constant Fallacy (*see* Helmbold-1993). Second, several of the findings had been obtained earlier (*see* Helmbold-1961, Helmbold-1964a, and Helmbold-1964b). In particular, the definition of the advantage parameter, together with its relationship to the attrition coefficients and the initial force ratio, are clearly inspired by Helmbold's papers. That these relationships would be insensitive to battle date and battle size is also clear from Helmbold's prior work. As such, the present thesis can be viewed as confirming Helmbold's results using a different and larger data base. However, subsequent review of the data base has shown that in several respects it is at variance with the data actually contained in Bodart-1908. Moreover, the conclusions would have carried more weight had Schmieman done a comparative analysis using on the one hand total battle casualties (as he did), and only the bloody losses (killed and wounded) on the other hand, and had been able to show that the conclusions were not sensitive to which type of casualty was used.

SHEPHARD-1991

1. Document Description. Shephard, Ronald W.; and Visco, Eugene P., "Injuries to Tank Crews: A New Collection of UK Data from WWII," Thirtieth US Army Operations Research Symposium (AORS) Proceedings, 1991, 24 pp. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. From the Abstract: "This paper describes a compilation of data from UK archives, made for the Model Improvement and Study Management Agency (MISMA), which relates to casualties suffered by tank crews in World War II when their tanks were hit. The aim of the collection has been not only to describe, in detail, the causes and types of injury suffered by each crew member, but also to provide as much information as possible on the role of the tank at the time and on the action in which it was taking part when it was damaged or killed."

3. Populations Included. Tank crews.

4. Timeframes Included. World War II. (But this document notes that a Vietnam data base has also been constructed along similar lines. It is Walker, Stephen K., "Armored Vehicle Weapon Impact Assessment in Southeast Asia," Thesis, AFIT/GOR/EMS, March 1991.)

5. Casualty Types Included. Killed and wounded.

6. Time Intervals Included As. Mainly UK experience in the Mideast and North Africa during the early phases of World War II.

7. Situational Descriptors Defined As. Data are recorded on six standard forms separately for each case (where a case is one tank hit or damaged in action). The six forms are described as follows:

a. Form 1 contains all available information on the identity of the tank, the troop, squadron, and regiment to which it belonged, and a resume of damage sustained by the tank and the severity of personnel casualties.

b. Form 2 gives information about the fate of each crewman, describing in separate tables his injuries (if any), how he exited from the tank, and what happened to him afterwards. Each of his injuries is listed in decreasing order of seriousness, and coded according to the Shephard-Perkins classification which is based on a combination of type of injury, body location, and severity. Based on experience obtained from the classification of air raid casualties, it may be assumed that the severity to be accorded to a casualty overall corresponds to the severity of his most severe wound.

c. Form 3 gives general details about the circumstances in which the tank was hit, including a map reference (copies of the relevant World War II maps are included in the report). The allied and enemy forces involved in the action in which the incident occurred, and the plans they were following, are also described.

d. Form 4 focuses on describing the particular circumstances of the engagement in which the tank was hit, highlighting its role in the action.

e. Form 5 contains what is known about the casualties suffered by both sides, the tank's specific objectives at the time it was hit, and remarks on the repairability of the vehicle.

f. Form 6 records any general remarks or points of interest about the case, and any miscellaneous information of relevance. A list of all the sources used in compiling the case completes the form.

8. Data Sources Used. Official UK records made at the time the losses occurred.

9. Other and Miscellaneous. A total of 183 cases of tank hits involving over 850 crew casualties are included in the data base recorded in dBASE III Plus™ format on five 3.5-inch 730kB floppy diskettes and available from the Director, US Army Model Improvement and Study Management Agency (MISMA), 1725 Jefferson Davis Highway, Suite 808, Crystal Square 2, Arlington, VA 22202. The hard copy of the report, including four volumes and an annex, totals over 1,100 pages.

10. Summary of Findings Regarding Battle Casualties. At the time this document was written, a full research plan had not been developed and only a few preliminary analyses had been done.

11. Comments and Critique. This provides a unique set of data on details of tank crew casualties. It can be compared to other studies of the same subject.

SHRADER-1982

1. Document Description. Shrader, Charles R., "Amicide: The Problem of Friendly Fire in Modern War," Combat Studies Institute, US Army Command and General Staff College, Fort Leavenworth, KS 66027-6900, Research Survey No. 1, Dec 1982, 146 pp. UNCLASSIFIED. Available from DTIC (AD-A211 713).

2. Objectives and Scope. From the Introduction: "This study, by presenting selected examples in their historical settings, is intended only to explain a few of the most obvious types of friendly fire incidents and some of the causative factors associated with them. ... The methodology is primarily historical, narrative, and highly selective. ... Time and resources have also limited the scope of this study to incidents involving US forces in World War II and Vietnam, although some evidence available from other conflicts in the twentieth century has also been considered."

3. Populations Included. US forces.

4. Timeframes Included. World War II and Vietnam.

5. Casualty Types Included. Fratricidal.

6. Time Intervals Included As. Varied.

7. Situational Descriptors Defined As. Variable, and as contained in the narrative accounts. However, the fratricidal incidents are grouped by four broad categories of causative agent (*viz.*, artillery fire, air-delivered weapons, antiaircraft fire, or direct fire weapons), and within those by visibility, type of ground operation, type of air operation, and type of error (as applicable).

8. Data Sources Used. Various.

9. Other and Miscellaneous. Includes tables for each of the four broad categories of causative agent of the number of incidents by visibility, type of ground operation, type of air operation, and type of error (as applicable). Page 110 provides a concluding summary tabulation of the number of casualties per incident, grouped by major category of causative agent.

10. Summary of Findings Regarding Battle Casualties. From the Conclusions: "... We have examined in greater or lesser detail some 269 amicide incidents of all types. ... In terms of the number of casualties produced, air amicide incidents clearly predominate as the most destructive, both in total and per incident. Artillery incidents are nearly as destructive in the aggregate but usually involve only small numbers of casualties per incident. Although frequent, ground incidents are not often heavy casualty producers, even though they can significantly disrupt the flow of combat operations. Antiaircraft amicide is perhaps the least significant type, resulting only in rare incidents of more than a few casualties per incident. ... Fear and the fog of battle have conspired to produce the amicide incidents described in this

study. Surprisingly few incidents can be traced to a genuine misidentification of friendly for enemy troops. Almost always a lack of coordination or some more direct human error was responsible ..."

11. Comments and Critique. This provides a very useful introduction to the subject of fratricide and how it occurred in various historical settings.

SINGER-1972

1. Document Description. Singer, J. David; and Small, Melvin, "The Wages of War: A Statistical Handbook," John Wiley & Sons, Inc, New York, ISBN: 0-471-79300-0, 1972, 419 pp. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. From the document's Purpose and Expectations section (pp 4-5): "The purpose of this volume is to make our war data available to the scholarly community as early as possible, rather than to wait until the project [*i.e.*, the Correlates of War Project, undertaken by the Center for Research on Conflict Resolution and the Mental Health Research Unit of the University of Michigan, that started in 1963] is completed. ... Thus, our intent here is to supply the sort of evidence which will accelerate and strengthen the trend toward rigorous historical research into the causes of international war."

3. Populations Included. From the document's section on Population Identified (pp 37-39): "To summarize, we first had to decide whether a political entity was a member nation of the interstate system; then we had to decide whether it had been sufficiently involved in the war to count as a participant; third, on the basis of which entities participated in the hostilities, and whether a minimum of 1,000 fatalities were sustained by these participants, we decided on whether the event was an interstate war or not; finally, if it did not qualify for the category of interstate war, we classified it as imperial or colonial, depending on the status of the entities which participated."

4. Timeframes Included. From the document's section on Temporal Boundaries (pp 17-19): "Partly for the sake of arithmetical symmetry, but primarily because of the incompleteness and unreliability of information on those wars that are still underway at this writing or have ended in the past few years, we set 31 December 1965 as our terminal date. To make exactly 150 years, we set 1 January 1816 as our beginning date, even though the Napoleonic era ended several months earlier. That is, the Congress of Vienna opened in September of 1814, was dramatically interrupted by Napoleon's landing at Cannes the following March and his restoration of 100 days, and closed on 8 June 1815. But it was late June before the Battle of Waterloo and Napoleon's second abdication, and 20 November 1815 when the second Peace of Paris agreements were finally signed, the Quadruple Alliance renewed, and the so-called 'Concert System' launched."

5. Casualty Types Included. From the document's section on Inclusion Criteria (pp 48-49): "Given this range of considerations, then, we settled on *battle-connected fatalities among military personnel only* [emphasis in the original] as our measure of war's severity. This was defined to include not only those personnel who were killed in combat, but those who subsequently died from combat wounds or from diseases contracted in the war theater. It should also be noted that these figures include not only

personnel of the system member, but native troops from their colonies, protectorates, and dominions, who were fighting alongside them."

6. Time Intervals Included As. From start to end of a war.

7. Situational Descriptors Defined As. Only a few descriptors are used. However, data and discussion on the seasonal and monthly distribution of the incidence of war are presented.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Includes numerous tables and a few figures. The major chapter headings and sections include:

a. Part A: Rationale and procedures (Introduction; Identifying international wars: the inclusion and exclusion problem; Quantifying international war: three sets of indicators).

b. Part B: The wars (The qualifying wars and their quantitative attributes; Comparisons with prior compilations; Ranking the wars by severity, magnitude, and intensity).

c. Part C: The system (Annual amounts of war begun, underway, and terminated; Secular trends in the incidence of war; Cycles and periodicity in the incidence of war; Seasonal concentration in the incidence of war).

d. Part D: The nations (The war-proneness of nations; The war-proneness of regions; Pair-wise war frequencies: traditional enmity and enduring friendship; Victory, defeat, and battle deaths; Summary and Projection).

10. Summary of Findings Regarding Battle Casualties. From the document's Summary [for battle casualties] (pp 370-372): "... it seems quite clear that there is not any absolute or relative battle death threshold at which nations withdraw, or at which wars come to an end. ... We uncover ... no particular threshold at which either the ultimate victors or the ultimate losers appear to modify their expectations and their bargaining positions sufficiently to bring hostilities to a close. ... In sum, the relationship between battle deaths and war termination remains blurred. It seems reasonable to expect that these variables are associated, but it also seems clear that additional variables must be considered ... Another reason for the poor predictive power of combat losses is that, even though they were severe in individual and humanitarian terms, they tended to be negligible from a demographic point of view. In only 7 of the 50 interstate wars did the battle death figure exceed 100,000; and in terms of fatalities per capita, the most severe losses were for all participants in the Chaco War (1932-1935), and for the defeated nations in the World Wars, with average figures of a little more than 4 and 2 percent, respectively."

11. Comments and Critique. This is a major work in the spirit of Richardson-1960 and Wright-1942. However, since it deals with total "battle deaths" for a whole war, it provides information only tangentially related to the PAR studies. We also note that its analysis of war termination depends only on one-sided casualty data, while both sides ought to be considered together.

SMALL-1982

1. Document Description. Small, Melvin; and Singer, J. David, "Resort to Arms: International and Civil Wars, 1816-1980," Sage Publications, Beverly Hills, 1982, ISBN: 0-8039-1776-7, 1982, 372 pp. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. This is essentially a second, revised, and updated edition of Singer-1972, *q.v.* Its objectives and scope are essentially the same as Singer-1972.

3. Populations Included. This document includes *civil* wars that have occurred since the Congress of Vienna, whereas Singer-1972 excluded them.

4. Timeframes Included. This document extends the timeframe of Singer-1972 to include wars up to 1980 (vice 1965).

5. Casualty Types Included. As in Singer-1972, battle-connected deaths of military personnel only are used for interstate wars. However, the document states (p 70) that "On the other hand, no study of civil or guerrilla war could afford to exclude non-military deaths; we thus include such deaths in our civil war tabulations."

6. Time Intervals Included As. From start to end of a war.

7. Situational Descriptors Defined As. Only a few descriptors are used. However, data on the seasonal distribution of the incidence of wars are presented.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Includes numerous tables and a few figures. For Part I on International war, the major chapter headings are nearly the same as those used in Singer-1972. With little change, they are repeated in Part II: Civil War.

10. Summary of Findings Regarding Battle Casualties. Practically word-for-word the same as in Singer-1972.

11. Comments and Critique. This provides a useful update and revision of Singer-1972. However, since its data are always for whole wars, this document provides information only tangentially related to the PAR studies.

SMITH-1955

1. Document Description. Smith, E. G.; and Donovan, G. N., "Trends in Warfare," British Army Operational Research Group, Memorandum No. F.6, April 1955, 38 pp, RESTRICTED, available from United Kingdom Defence Operational Analysis Establishment (DOAE).

2. Objectives and Scope. From the Abstract: "Most of the major trends in warfare are generally appreciated in qualitative terms. In this paper an attempt is made to describe certain trends quantitatively from an examination of the major wars since 1750, most data for wars before this period being considered unreliable."

3. Populations Included. Participants in battles.

4. Timeframes Included. From the Seven Year's War (1756-1763) through World War II.

5. Casualty Types Included. Killed, wounded, or total casualties (used at various time for various purposes).

6. Time Intervals Included As. From start to end of a war.

7. Situational Descriptors Defined As. Hardly any situational descriptors are used.

8. Data Sources Used. Various, but especially Beebe-1952, Bodart-1908, and Harbottle-1905.

9. Other and Miscellaneous. The Table of Contents includes the following: magnitude of war, cost of wars, size of armies in battle, composition of the army, casualties, casualty causative agents, casualties by arms and services, firepower, ammunition expenditure, range of fighting, supply of armies, discussion, and conclusions.

10. Summary of Findings Regarding Battle Casualties. Cites Dumas-1923 to the effect that the ratio of wounded to killed has remained approximately constant at 3.5 to 1 for wars during the last 250 years. Observes that although the casualty rate in battles has declined over time, the average percentage of the total force killed or died of wounds per month shows no pronounced trend. In the past, war was conducted in a few intermittent but sharply fought battles involving heavy casualties, whereas today war is normally conducted more or less continuously, with the attrition rate merely fluctuating around a lower average level. However, the percentage of the population killed in wars has increased with the passage of time, even when only those killed in the armed forces are counted. The percentage of those wounded who died of wounds has decreased substantially since the introduction of modern medical knowledge. Since 1900 or so, the proportion of casualties caused by small arms has declined and that caused by artillery-type weapons has increased. Infantry takes the bulk of the casualties. Ammunition expenditure per death caused has increased sharply since about 1905. The average range at which casualties are caused has tended to increase with the passage of time.

11. Comments and Critique. This is a classic analysis of trends in warfare and deserves to be much more widely known and appreciated than seems to be the case. Unfortunately, as it seldom provides (i) sufficiently specific source citations, (ii) adequate descriptions of how the source data were treated, (iii) the number of data points used, or (iv) exact definitions of terms, its impossible to reproduce (or in some cases even to interpret properly) its results. These shortcomings cause many of its conclusions to lose much of their force.

To give just one of many examples of this, page 7 contains a figure purporting to graph the frequency of occurrence of armies of various sizes in battles for the years 1600 to 1900. These data appear to have been obtained entirely from Bodart-1908, although this is nowhere stated and other possible sources are listed in the bibliography. Furthermore, how is the "size of the battle" defined—is this the sum of the army personnel strengths on both sides? The strength of the largest side? The arithmetic, geometric, or harmonic mean of the two sides? Is *each* side included separately—even though that double-counts the battle as a whole?

SMITH-1969

1. Document Description. Smith, Robert Ross, "Data Requirements and Deficiencies for Historical Purposes," US Army Operations Research Symposium Proceedings, 21-23 May 1969, 431-438 pp. UNCLASSIFIED. Available from libraries. At the time, the author was on the staff of the US Army's Office of the Chief of Military History.

2. Objectives and Scope. To discuss certain characteristics limiting the applicability of the usual sorts of historical data to operations research analyses.

3. Populations Included. Various.

4. Timeframes Included. Various, but primarily World War II and Korea.

5. Casualty Types Included. Not used.

6. Time Intervals Included As. Not used.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Offers no specific findings regarding battle casualties. However, some selected observations include the following: " ... the operations analyst and the military historian often find themselves requiring and employing the same basic source materials. ... Broadly speaking [the sources used by the combat historian] can be broken down into three categories: narrative unit reports prepared in whole or in part to satisfy historical requirements; other types of unit records; and combat interviews. ...We started World War II with no comprehensive Army regulation that would satisfy historical needs, let alone those of operations research. (Indeed, we always seem to be starting wars with inadequate reporting systems, or else we revamp the entire system early on.) ...[After summarizing the changes in reporting requirements and systems from the beginning of World War II through the early phases of the Vietnam War] I am sure you will have noticed that none of the reporting systems I have reviewed ever had as an objective the development of a data base for operations research, and no such regulation is in existence today. ...And have you ever been over a battlefield shortly after a hot infantry fire fight has taken place? You'd see unexpended rounds, clips, boxes, and sometimes even truckloads of machinegun and small arms ammunition left behind and forgotten. You have to take all ammunition expenditure figures with a grain of salt. ...Another major problem for the historian—and for those engaged in operations research as well—entails inconsistency of data categories, by war, by period during a single war, by service, by agency, and by data objectives. ...[regarding official compilations of statistics] in such compilations all the basic data-gathering problems are hidden behind

the solid facade of the final totals. These totals, in turn, represent the end product of many more manhours of work than the historian can hope to spend upon a data-gathering problem. ... we still lack sufficient numbers of trained and competent statisticians and data-processing personnel to assure that the data being spewed forth is both accurate and complete."

11. Comments and Critique. This is a well-written and highly pertinent cautionary note regarding the use and limitations of the usual kinds of statistical data provided in most official tabulations.

STOUFFER-1949

1. Document Description. Stouffer, Samuel A., *et al.,* "The American Solder: Combat and Its Aftermath," Princeton University Press, Princeton, New Jersey, 1949, 675 pp. UNCLASSIFIED. Available from libraries (copy in CAA library under 355.1 STO). This is Vol 2 of a four-volume series on the American soldier in World War II, as follows: Volume I, Adjustment During Army Life; Volume II, Combat and Its Aftermath; Volume III, Experiments in Mass Communication; Volume IV, Measurement and Prediction. Some of these volumes were reprinted in 1977 by Military Affairs/Aerospace Historian Publishing, Eisenhower Hall, Kansas State University, Manhattan, Kansas 66506. In that reprinting, Volume I is ISBN 0-89126-034-X, and Volume II is ISBN 0-89126-035-8.

2. Objectives and Scope. To document for posterity the results of several World War II studies of the attitudes and behaviors of American soldiers during the cycle of induction, training, combat, post-combat service, and post-service status.

3. Populations Included. Various selected groups of American Army and Air Corps personnel.

4. Timeframes Included. World War II.

5. Casualty Types Included. Casualty types *per se* are hardly ever mentioned.

6. Time Intervals Included As. Various.

7. Situational Descriptors Defined As. Various.

8. Data Sources Used. Results of attitude and opinion surveys administered during World War II and assembled by the authors.

9. Other and Miscellaneous. The Table of Contents for Volume 2 includes the following.

a. Combat Attitudes and Behavior (Company attitudes and nonbattle casualty rates in combat, Attitudes of individuals in training as related to performance in combat, Basic data and technical notes on relation of attitudes to behavior in combat).

b. General Characteristics of Ground Combat (Introduction, The place of combat in an active theater, What is a combat outfit?, The combat situation in Europe and the Pacific, General characteristics of combat as a social situation, Combat as a situation of stress, General social characteristics of the combat situation which resist stress, Features which are part of the definition of the combat situation, Institutional features which are primarily brought to the combat situation, Social features which arise primarily within the combat situation, Formal versus informal control of behavior).

c. Combat Motivation Among Ground Troops (Introduction, Role of coercive institutional authority, Attitudes toward combat leaders and combat motivation, The informal group and combat motivation, Masculinity and the role of the combat soldier, Loyalty to outfit and pride in it, Sources of

power and security from the group, Role of convictions about the war and the enemy, Some miscellaneous goals, Prayer and personal philosophies in combat).

d. Problems Related to the Control of Fear in Combat (Introduction, The permissive attitude toward fear and anxiety, The screening of men who are psychologically unfit for combat, Experimental evaluation of an objective psychiatric screening device for paratroop training, Background of the study, The experimental procedures, Results, Precombat training activities related to fear control, Research results on factors related to precombat training, The need for fear-eliciting battle stimuli in training troops for combat, Factors affective fear of enemy weapons).

e. The Combat Replacement (Introduction, The assimilation of replacements to a veteran outfit before combat, The career of a replacement, Combat time and combat effectiveness).

f. Attitudes of Ground Combat Troops Toward Rear Echelons and the Home Front (Introduction, Attitudes of combat troops toward the supporting job done by troops in the rear echelons, Resentment and envy toward the rear echelons, Compensations for combat duty: Status and the "pecking order," Preference for rear-echelon jobs, Attitudes of combat men toward headquarters, Attitudes of combat men toward soldiers still in the United States, Attitudes toward civilians on the home front).

g. Morale Attitudes of Combat Flying Personnel in the Air Corps (Introduction, Characteristic morale attitudes of combat air crew members, Factors related to favorable morale attitudes among combat flying personnel in the air corps).

h. Objective Factors Related to Morale Attitudes in the Aerial Combat Situation (Psychological effects of successive exposures to aerial combat, Attitudes related to rest and recreation between combat missions, Attitudes related to differentials in combat flying conditions for various types of aircraft, Summary).

i. Psychoneurotic Symptoms in the Army (Introduction, The indices of psychoneurotic tendencies, Compositional variations in the incidence of symptoms, Variations in the incidence of symptoms through time, Variations in the incidence of symptoms associated with stages in the Army cycle, The impact of the Army on new recruits, Reactions in the face of overseas service, Reactions in combat).

j. Problems of Rotation and Reconversion (Who were the returnees?, What happened to the returnee?, Early phases of the returnee's adjustment, Finding job assignments for returnees, Returnee's adjustment to their jobs, The desire to be stationed near home, Relations with personnel who had not served overseas, Conclusion).

k. The Point System for Redeployment and Discharge (Research behind the point system, Initial reactions to the point system, Attitudes toward early stages of the actual demobilization process, Attitudes toward post-VJ day revision of the point system, Concluding comments).

l. Aftermath of Hostilities (The forecast, The facts, Attitudes toward the Germans and Germany, Attitudes toward our allies, Attitudes toward the Army and further service, Attitudes toward the home front, Attitudes toward the war and the future, Conclusion).

m. The Soldier Becomes a Veteran (Viewing one's personal future as a civilian, Attitudes toward civilian society, Again in civilian clothes).

10. Summary of Findings Regarding Battle Casualties. Findings specifically related to the incidence or rate of battle casualties are hard to pin down. However, the volume provides excellent general background for understanding the stresses and strains placed on men in combat. Page 439 suggests that, among other things, "[Apparently,] there is little evidence for changes in anxiety symptoms with continuing Army service except for the initial rise after 6 months of service which is consistently present for all groups in both these studies." Some remarks, made almost in passing, on attrition rates in combat are provided on pages 101-104.

11. Comments and Critique. This is a classic work in its field. Other works on stress in combat are provided by R. R. Grinker and J. P. Speigel, *Men Under Stress* and *War Neuroses* (Blakiston, Philadelphia, 1945), E. A. Strecker and K. E. Appel, *Psychiatry in Modern Warfare* (The Macmillan Company, New York, 1945), and Holmes-1985.

SUMMERS-1970

1. Document Description. Summers, Walden M., "Combat Casualties and Mission Accomplishment," US Army Command and General Staff College, Ft. Leavenworth, Kansas, March 1970, 53 pp. UNCLASSIFIED. Available from DTIC (AD-713 373). This is a student paper written for the Individual Research Elective.

2. Objectives and Scope. From the Introduction: "If we exclude those special cases in which a quirk of weather or terrain absolutely blocks an operation, the relevant cause of mission failure is enemy action ...[which] results in casualties inflicted on friendly forces. ... Is there, in fact, the negative correlation between mission success and casualties which conventional wisdom predicts? ...To address [these questions] this study describes an academic reconnaissance in force conducted by selecting a sample of World War II rifle companies, determining their mission accomplishment and associated casualties, and analyzing the results statistically."

3. Populations Included. Rifle companies.

4. Timeframes Included. World War II.

5. Casualty Types Included. KIA, seriously WIA, lightly WIA, and MIA.

6. Time Intervals Included As. Daily.

7. Situational Descriptors Defined As. The general situation is summarized in narrative form.

8. Data Sources Used. Mission accomplishment was assessed by consulting the original regimental unit records on file with the Modern Military Records Division of the National Archives and Record Service. Casualty figures were extracted from the company morning reports on file at the National Personnel Records Center, St. Louis, Missouri.

9. Other and Miscellaneous. The historical period examined is that of the Winter Line Campaign in Italy during the period November 1943 through January 1944. Within that period the records examined included those of the 168th Infantry Regiment, 45th Division for 29 November through 3 December 1943; of the 179th Infantry Regiment, 45th Division for 3-7 December 1943; of the 157th and 179th Regiments, 45th Division for 9-16 December 1943; of the 180th Infantry Regiment, 45th Division for 30-31 December 1943; and of the 135th and 168th Infantry Regiments, 34th Division for 4-13 January 1944. These regimental records in principle span a total of 279 company-days, but sufficient detail to identify company activities could be fc nd on only 229 company-days. Of these, 78 met the criteria that they were rifle company-days on which a rifle company had been assigned a combat mission and had also faced significant enemy action. Of these 78 company-days, 38 were classified as successful and 40 as unsuccessful in terms of mission accomplishment. Casualties were recorded according to the following categories: KIA, seriously WIA, lightly WIA, and MIA.

10. Summary of Findings Regarding Battle Casualties. From the Summary: "This analysis reveals no indication of correlation between incidence of mission success and casualties."

11. Comments and Critique. This is a very interesting and carefully done study. Due to the limited aims of this study, its sample size is rather small; it uses only the raw number of casualties, rather than the casualty fraction; and it does not take into account the unit's recent casualty history. Its weakest aspect is that it considers only one side's casualties and ignores those on the other side. Appendix A tabulates the 78 company-days worth of data collected on casualties by regiment, by company and date within the regiment, by casualty category (KIA, SWIA, LWIA, MIA), and by rank (officers, sergeants, corporals, and privates).

SWEETMAN-1985

1. Document Description. Sweetman, John, "A Dictionary of European Land Battles, From the Earliest Times to 1945," MacMillan, New York, 1985, 309 pp. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. This is a dictionary of European land battles.

3. Populations Included. Battle participants.

4. Timeframes Included. From the earliest times to 1945.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. As given in the narrative accounts.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. None specifically stated.

11. Comments and Critique. This provides a useful compendium of European land battles.

THAYER-1985

1. Document Description. Thayer, Thomas C., "War Without Fronts," Westview Press, Boulder, Colorado, ISBN: 0-8133-7132-5, 1985, 276 pp. UNCLASSIFIED. Available from publisher and libraries.

2. Objectives and Scope. From Chapter 1: "Our commanders and analysts simply had to have some substitute for the front line if they were to understand even the [Vietnam] war's military aspects. ... The answer turned out to be finding the critical patterns of the war. Through quantitative reports to the Joint Chiefs of Staff from the military command in Vietnam about the hundreds of events occurring all over Vietnam every day we found the patterns. ... From these we, in Washington, were able to monitor the war surprisingly well by examining trends and patterns in the forces, military activities, casualties, and population security. This allowed us to judge the importance of events to the progress of the war. ... The following chapters present what we found in doing classified analysis for the Secretary of Defense and other senior officials in Washington and Saigon during the war."

3. Populations Included. Primarily US armed forces in Vietnam, but with frequent reference to the Republic of [South] Vietnam armed forces, and occasional reference to enemy forces.

4. Timeframes Included. Mainly from 1965 through 1972, but with occasional reference to the French experience in Vietnam.

5. Casualty Types Included. KIA, wounded, died of wounds, nonbattle casualties.

6. Time Intervals Included As. Mostly from start to end of the war, but figures occasionally given by shorter time intervals.

7. Situational Descriptors Defined As. Only the descriptors associated with broad general trends are used.

8. Data Sources Used. Various, but the main sources are described in the Appendix as follows: "Fifty issues of the *Southeast Asia Analysis Report* were published from January 1967 through January 1972 by the Southeast Asia office under the Assistant Secretary of Defense (Systems Analysis). ... Articles from this SEA Analysis Report served as the most important source for this book. All articles printed in the Report have been collected and indexed in twelve volumes titled "A Systems Analysis View of the Vietnam War 1965-1972, Vol. 1-12," Thomas C. Thayer, editor. All twelve volumes are available as a group or individually from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161, telephone 703-487-4650. The titles of the twelve volumes are listed below, each with its individual NTIS number ...

   a. Vol 1, The Situation in Southeast Asia, AD-A039 313.

   b. Vol 2, Forces and Manpower, AD-A051 609.

c. Vol 3, Viet Cong-North Vietnamese Operations, AD-A039314.

d. Vol 4, Allied Ground and Naval Operations, AD-A051 610.

e. Vol 5, The Air War, AD-A051 611.

f. Vol 6, Republic of Vietnam Armed Forces (1), AD-A039 315.

g. Vol 7, Republic of Vietnam Armed Forces (2), AD-A051 612.

h. Vol 8, Casualties and Losses, AD-A051 613.

i. Vol 9, Pacification and Security, AD-A039 316.

j. Vol 10, Pacification and Civil Affairs, AD-A039 317.

k. Vol 11, Economics, War Costs and Inflation, AD-A039 317.

l. Vol 12, Construction and Port Operations in South Vietnam, AD-A051 615."

9. Other and Miscellaneous. The Table of Contents includes the following entries—Basic Patterns of This War Without Fronts; The "Main Force" War; The Casualty Toll; Pacification: the "Other War"; Civil Operations; and A Summing Up. Includes numerous tables and few figures.

10. Summary of Findings Regarding Battle Casualties. Table 11.1 summarizes the casualties to each of the US services: Army, Navy, Marine Corps, and Air Force. The footnote to this table states that its figures are "Cumulative from January 1, 1961 through March 31, 1973, plus changes for missing subsequently declared dead." It tabulates the casualties to each of the services according to the following scheme:

- Combat Casualty
  - ▷ Killed
  - ▷ Wounded or injured
    - – Died of wounds
    - – Nonfatal wounds
      - (i) Hospital care required
      - (ii) Hospital care not required
  - ▷ Missing
    - – Died while missing
    - – Returned to control
    - – Missing–declared dead
  - ▷ Captured or interned
    - – Died while captured
    - – Returned to US control
  - ▷ Total combat deaths
- Total Noncombat Deaths
- Total Deaths

Calculating the ratio of seriously wounded (*i.e.*, wounded that died of wounds plus those requiring hospital care) to killed, according to the values given in the table, yields the following values: Army = 3.95, Navy = 3.96, Marine Corps = 4.60, Air Force = 1.95, overall = 4.12. Similarly, calculating the hospital mortality rate from the ratio of those who died of wounds to the seriously wounded, we arrive at the following percentages: Army = 3.51, Navy = 3.38, Marine Corps = 2.75, Air Force = 4.90, overall = 3.26. These values can profitably be compared to similar ones given in Bzik-1984, Neel-1973, and by other works on casualties in Vietnam.

Table 11.3 gives the distribution of combat deaths by rank. Table 11.11 gives their distribution by causative agent. The author notes (p 101) that "The approach centers on combat deaths or KIA (Killed in Action) because prisoners, although they had a large political impact, were a small portion of the American casualties and *every allied force in Vietnam counted its wounded differently so those figures are not comparable among forces* [emphasis added]." In summing up his chapter on casualties, the author remarks that "Tragically, most Americans died in the same places and the same cycles of time as the French troops had died in South Vietnam twenty years before."

The originals from which this work was drawn (specifically Vol 8, Casualties and Losses, AD-A051 613) provide some figures on the friendly personnel killed in action attributed to friendly fire. It appears that those killed in action and attributed to friendly fire stayed close to 5 percent of the total killed in action throughout the main period of the Vietnam War.

11. Comments and Critique. This book, and the references from which most of its data are drawn, are important resources for depicting the broad trends of the Vietnam War. However, they offer little detailed data useful for analyzing attrition rates, and give only sketchy data on enemy attrition rates. See also Neel-1973.

THORNTON-1975

1. Document Description. Thornton, Charles J.; White, William W.; Eyler, Roger C; John, James C.; and Garnett, John H., "BDM/CARAF Feasibility Investigation of Computerized Simulation Methods to Estimate Personnel Loss Rates (Supporting PLRPF Study ACN 21882)," [PLRPF = Personnel Loss Rate Planning Factors], Work performed by BDM Services Company (BDM/CARAF) and its subcontractor, Vector Research Incorporated (VRI) in support of the PLRPF Study, for the US Army Personnel and Administration Combat Developments Activity, ADMINCEN, Fort Benjamin Harrison, Indiana, under Contract No. DAAG39-74-C-0018, Task Order 10-74, BDM/CARAF-FR-75-002, 7 January 1975, (Vol 1 is 162pp; Vol 2 is 232pp). UNCLASSIFIED, distribution limited to US Government agencies only; Test and Evaluation 1 August 75. Other requests for this document must be referred to Dept. of the Army Training and Doctrine Command, Fort Monroe, VA 23651. Available from DTIC (Vol 1 is AD-B006 002L; Vol 2 is AD-B006 003L).

2. Objectives and Scope. To present factual material, qualitative analysis, concepts, limited cost estimates, and other reference materials to help clarify possible solutions to Army needs for improved personnel loss rate planning factors. Primary emphasis is on computer simulation or modeling approaches, but historical data and judgmental approaches are also considered.

3. Populations Included. Various.

4. Timeframes Included. Various.

5. Casualty Types Included. Various.

6. Time Intervals Included As. Not used.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Principally Love-1931, Beebe-1952, and Reister-1975, *q.v.*

9. Other and Miscellaneous. The material of greatest interest to PAR is contained in Section 3-3 and in Appendix H. Among other things, these provide a brief description and discussion of the MEDPLN computerized data base of personnel casualty data for World War II, the Korean War, and the Vietnam War. They also discuss the availability, potential uses, and limitations of historical casualty data. This document notes that the MEDPLN data base contains only WIA and DNBI rates (*i.e.*, no information on KIA or DOW); other than a gross index of "intensity," it gives no information regarding the enemy; and uses a unique set of labels for combat operation types.

10. Summary of Findings Regarding Battle Casualties. No specific summary findings are offered.

11. Comments and Critique. Gives a good discussion of many of the key difficulties and pitfalls of using historical information.

TRAVERSO-1981

1. Document Description. Traverso, L. William; and Fleming, Arthur, "Combat Casualties in Northern Thailand: Emphasis on Land Mine Injuries and Levels of Amputation," Military Medicine, Vol 146, Oct 1981, pp 682-685. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To present the essential points of a retrospective study of combat injuries in northern Thailand.

3. Populations Included. Medical records of 200 combat casualties admitted to the Provincial Hospital of Nan, Northern Thailand.

4. Timeframes Included. Unstated, but apparently post-Vietnam War guerrilla action.

5. Casualty Types Included. Combat casualty patients at the Nan Hospital.

6. Time Intervals Included As. From 1976 through 1979.

7. Situational Descriptors Defined As. Not stated.

8. Data Sources Used. Hospital records.

9. Other and Miscellaneous. The number of cases considered is 200. The causative agent for these was recorded as mine (40 cases), bullet (80 cases), and blast (80 cases). Table VII compares these to the following percentages figures from Vietnam attributed to T. J. Whelan, W. E. Burkhalter, and A. Gomez, "Management of War Wounds," in *Advances in Surgery,* Vol 3, Chicago, Yearbook Medical Publishers, Inc., 1968, pp 227-350:

Period	Rifle	Blast	Other
10/65-06/66	43	50	7
07/66-12/66	27	56	17
01/67-06/67	21	59	20

10. Summary of Findings Regarding Battle Casualties. Argues that mine injuries may be more prevalent in guerrilla warfare than in conventional warfare.

11. Comments and Critique. This provides a limited sample of data from guerrilla actions in Thailand.

UHORCHAK-1992

1. Document Description. Uhorchak, John M., *et al*, "Final Report: Casualty Data Assessment Team Operation DESERT STORM," Letterman Army Institute of Research, Division of Military Trauma Research, Presidio of San Francisco, California 94129, Institute Report No. 469, January 1992, 115 pp. UNCLASSIFIED. Available from publisher and DTIC.

2. Objectives and Scope. From the Introduction: "This report pertaining to the Casualty Data Assessment Team (CDAT) has been compiled for two primary reasons. The first reason is to document the process which the CDAT ... pursued while attempting to gain concurrence and approval to conduct assessment of combat casualties in the eventualities of actual conflict arising from what was then Operation Desert Shield. The second reason for this report is to document the actual findings of the CDAT European Contingency Section's survey of WIA's from Operation DESERT STORM."

3. Populations Included. Wounded personnel arriving at three US Army general hospitals in Germany.

4. Timeframes Included. Operation DESERT STORM.

5. Casualty Types Included. Wounded.

6. Time Intervals Included As. Interviews with wounded conducted from 28 February 1991 through 14 March 1991.

7. Situational Descriptors Defined As. Only a few descriptors are used.

8. Data Sources Used. Personal interviews and inspection of the medical records on 204 wounded soldiers evacuated to US Army general hospitals in Germany.

9. Other and Miscellaneous. This report deals with 204 wounded soldiers, and notes that the Public Affairs Office of the Department of Defense reports a total of 353 WIAs [presumably from all services] from Operation DESERT STORM during the period 22 January to 11 March 1991.

10. Summary of Findings Regarding Battle Casualties.

a. The original CDAT plan was to send a large team to Southwest Asia to survey the wounded soldiers as far forward as possible. Instead, permission was granted only to interview wounded being processed through Army general hospitals in Germany. Accordingly, the team was located too far to the rear to obtain detailed information, which as a result is now irretrievable. The authors note that this same bureaucratic inertia and indifference ruined attempts to provide prompt data collection and analysis in every war since the US Civil War. They observe that "One would expect that [the largest health care system in the world] ... would have a prospective and near real-time analysis of casualties as the military situation and the latest data acquisition technology might allow. ... [Yet] the Army Medical

Department currently does not have a standing system to analyze combat casualties. ... We reiterate that our concept is not new, but unfortunately many of the problems we encountered also are not new." Indeed, after recalling a World War II report of The Office of the Surgeon General noting instances of badly misguided resistance to clinical and laboratory investigations in a theater of war, the authors caustically remark that "This attitude still prevails in some circles."

b. The 204 soldiers interviewed sustained a total of 472 wounds (an average of 2.3 per individual); 36 percent sustained one wound while the remaining 64 percent sustained 2 or more wounds. Of the 204 WIAs, 195 were male and 9 were female. There were 197 enlisted soldiers, 6 officers, and 1 warrant officer. Figure 3 gives their breakdown by MOS. The causative agents of wounds were: fragmentation = 42 percent, spall = 26 percent, SCUD attack = 19 percent, gunshot = 10 percent. Seventy-one percent of the wounds involved the extremities (48 percent to the lower and 23 percent to the upper extremities), while 29 percent involved other locations on the body (7 percent to the face, 4 percent to the head and neck, 4 percent to the ear—mostly eardrums ruptured by the SCUD attack, 2 percent to the eye, 4 percent to the thorax, 4 percent to the abdomen, 2 percent to the pelvis, and 1 percent to the spine). Six incidents of injury to occupants of Bradley Fighting Vehicles are diagrammed to show the injuries separately to each occupant. Several WIA stated that the CDAT interviewers were the first people with whom they could talk about their wounds and "unload" their stories and fears.

c. The authors note that the "medical records generally lack pertinent information" such as blood pressure, heart rate, and so forth. They also note that the category "multiple fragment wounds" (MFW) was used "to describe any wound from a simple 1 to 2 cm fragmentation laceration to a severe traumatic disruption of the popliteal artery."

11. Comments and Critique. This provides a useful source of information on casualties in Operation DESERT STORM, and on the care they received. Of even greater importance, however, is its emphasis on the timely collection and analysis of detailed accurate data from ongoing combat operations, obtained as far forward as possible. Its many suggestions, excellent practical advice, and specific data collection forms could be extremely valuable in any future effort to do that.

VAGTS-1945

1. Document Description. Vagts, Alfred, "Battle and Other Combatant Casualties in the Second World War," Journal of Politics, 1945. UNCLASSIFIED. Available from libraries. This is a two-part article. Part I appeared in J. of Politics, Vol 7 (1945), pp 256-294. Part II appeared in J. of Politics, Vol 7 (1945), pp 411-438.

2. Objectives and Scope. Not specifically stated, but evidently to described the results of an early analysis of such information as was then available on casualties to combatants in World War II.

3. Populations Included. Combatants.

4. Timeframes Included. World War II.

5. Casualty Types Included. To the extent data is available, killed, wounded, and missing.

6. Time Intervals Included As. Various.

7. Situational Descriptors Defined As. Only a few descriptors are used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. No general statements regarding battle casualties are presented. However, nearly every aspect of personnel losses is touched upon, including accidents, disease, treatment of prisoners of war, national differences (especially those of the Japanese and western nations with regard to the ratio of wounded to killed, and of the Germans and Russians with regard to the magnitude of battle losses), differences among the services (land combat forces, air forces, marines, naval, and coast guard), and differences between officers and enlisted personnel.

11. Comments and Critique. The whole is somewhat of a confusing *potpourri* of information. The author either did not have or did not make use of data on the size of the "population at risk"—in other words, raw casualty numbers are provided with no indication of the size of the force involved. No attention is given to the opposing force (which was causing those casualties). Moreover, the whole has to some extent been overtaken by events as substantially more systematic official data has since become available.

VANDIVIER-1990

1. Document Description. Vandivier, Phillip L.; Waldkoetter, Raymond A.; Vandivier, Stella; and Arebalo, Cathy, "Battle Casualties as a Function of Environmental Factors," TRADOC Analysis Command, Fort Benjamin Harrison, Indiana 46216-5000, unnumbered, undated (but presumably circa 1990), 30 pp. UNCLASSIFIED. Available from publisher.

2. Objectives and Scope. From the Synopsis: "The purpose of this study was to investigate the extent to which attack and defensive casualties vary in accordance with differing environmental conditions on the battlefield. More specifically, the authors investigated the extent to which battlefield casualties varied according to changes in battlefield temperatures, humidity, terrain, and cover."

3. Populations Included. Participants in selected battles.

4. Timeframes Included. World War II and subsequently.

5. Casualty Types Included. Battle casualties.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Temperatures described as cold, moderate, and hot. Humidity described as dry, light rain, and heavy rain. Terrain described as flat, rolling, and rugged. Cover described as bare, desert, and mixed trees.

8. Data Sources Used. Used the same data base as in McQuie-1988 (which has now been superseded by CAA-1991).

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. From the "Conclusions and Recommendations:" "Can we say a cause-effect relationship exists between environmental factors and battlefield casualties? No. ... But we can say that casualty figures vary significantly across some of these environmental factors. ... How can these results be used? At least five different ways come to mind: (i) Planners for future battles at all levels should realize that casualties can vary as much as *three to nearly four times per day* [emphasis in the original] according to the prevalence of different environmental conditions. ...(ii) Proponents for doctrine which suggest variability of casualty rates across different environmental conditions should review their guidance in view of these findings. ...(iii) Results underscore the need for more human factors research relevant to performance on the battlefield. ...(iv) Research analysts who work with military models should consider the extent to which casualties differ across environmental factors when writing computerized algorithms which predict combat outcomes. ...(v) Hopefully, results will serve to stimulate interest in research with historical data ..."

11. Comments and Critique. The statistical analyses used essentially varied only one factor at a time. Accordingly, synergistic and interaction effects were not investigated. The results can be compared to those reported in Hartley-1991b and Hartley-1991d, where interaction effects were considered in more detail. Dupuy-1990 and others have also considered the impact of environmental factors. However, additional work needs to be done in this area.

VINEBERG-1965

1. Document Description. Vineberg, Robert, "Human Factors in Tactical Nuclear Combat," Human Resources Research Office (HumRRO), The George Washington University, Technical Report 65-2, April 1965, 90 pp. UNCLASSIFIED. Available from DTIC (AD-463 787).

2. Objectives and Scope. From the letter of transmittal: "This report deals with the reactions that might be expected from men facing nuclear combat. The objectives of the study were to draw together information that would provide bases for predicting human behavior in nuclear warfare, to draw implications for preparing men for such warfare, and to investigate means for estimating the psychological casualties likely to occur under varying conditions of intensity and duration of battle stress. The report summarizes much of the material available in military and research literature describing man's behavior to conditions of extreme stress, including such situations as conventional combat and civil disasters."

3. Populations Included. Primarily military personnel in World War II and Korea, and civilians in notable disasters (including the bombings of Hiroshima and Nagasaki as well as fires, floods, hurricanes, and earthquakes).

4. Timeframes Included. Mainly World War II and Korea for the historical data.

5. Casualty Types Included. Emphasis is on psychoneurotic or battle stress casualties.

6. Time Intervals Included As. Various.

7. Situational Descriptors Defined As. Only a few descriptors are used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Part II contains a specific quantitative model, based on the empirical data, for predicting neuropsychiatric casualty rates.

10. Summary of Findings Regarding Battle Casualties. From "Selected Conclusions and Implications:"

"a. Evidence taken from a wide variety of situations involving severe stress and trauma, and viewed in the light of what is known of man's behavior throughout history, indicates that man can, and generally does, hold up remarkably well under the severest forms of stress.

"b. This evidence has led to the proposition that in general man would act in tactical nuclear combat much as he has always acted in combat.

"c. In general, the effectiveness of a soldier in combat first increases and then decreases. Initial low effectiveness is due both to a lack of knowledge and proficiency in those techniques necessary for operating in battle and to the disruptive effects of emotion. With additional combat experience the

soldier's effectiveness rises because of his gain in combat proficiency. ... After some period of time the soldier reaches maximum effectiveness, and then a period of decreasing effectiveness ensues.

"d. The most important factor affecting the frequency of psychological disorders and the rate at which neuropsychiatric casualties occur is cumulative stress, which arises primarily as a joint function of the duration of man's exposure to battle and the intensity of battle.

"e. Specific factors affecting neuropsychiatric casualty levels that appear to be of particular significance for nuclear combat are: fatigue, isolation, and ambiguity.

"f. The method of management of neuropsychiatric casualties has an effect on the number of casualties and on the likelihood of their returning to combat.

"g. The powerful psychological support provided by a primary combat group (squad, platoon, or company) is perhaps the single most important factor helping to sustain a soldier in the face of severe combat stress.

"h. In general, it seems likely that soldiers would sustain the stresses of nuclear warfare better than would civilians.

"i. In nuclear warfare it is likely that, in general, social control would not break down and civilian populations would not engage in amoral, lawless, and asocial behavior.

"j. The way in which a soldier would act on the nuclear battlefield is likely to depend to a very large extent upon his training, the type and form of information that he had received and retained, and the nature of his beliefs about nuclear combat."

11. Comments and Critique. This is an outstanding summary of the state of knowledge regarding neuropsychiatric casualties and casualty rates at the time of its publication. It does not appear that subsequent data or analyses require a significant change in its conclusions or findings. The predictive model appears to be worthy of serious consideration.

VOEVODSKY-1969

1. Document Description. Voevodsky, John, "Quantitative Behavior of Warring Nations," The Journal of Psychology, Vol 72, 1969, pp 269-292. UNCLASSIFIED. Available from libraries. Much of the material used here appeared earlier and in more detail in the following works, available from the author—copies in Helmbold's personal files.

a. Voevodsky, John, "Quantitative Behavior of Warring Nations," Systems Analysis Division, Office of the Chief of Naval Operations, Department of the Navy, 17 March 1968.

b. Voevodsky, John; and Waleszczak, S. L., "Quantitative Analysis of the Vietnam War Through 30 June 1969," submitted to the Military Operations Research Society for General Session Consideration, 27 February 1970.

2. Objectives and Scope. In general, to demonstrate that warfare is an orderly and repetitive behavioral event. In particular, to show that certain patterns found empirically to be valid for the earlier wars appear to be valid also for Vietnam.

3. Populations Included. Participants in wars.

4. Timeframes Included. US Civil War, World War I, World War II, Korean War, and Vietnam War.

5. Casualty Types Included. Battle casualties and battle deaths (*i.e.*, killed in action and died of wounds).

6. Time Intervals Included As. At various points during the course of a war.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Various, but mainly official or quasiofficial sources.

9. Other and Miscellaneous. Includes several figures.

10. Summary of Findings Regarding Battle Casualties. The following empirical equations are proposed and fitted to the available data.

a. The cumulative battle deaths D and cumulative battle casualties C during the course of a given war are related approximately according to the equation $D = \gamma C^{\delta}$, where γ and δ are constants typical of the particular war. The value of δ is approximately the same for all the wars examined, and the average of its values for the different wars is $\delta_{avg} = 0.855$.

b. The instantaneous personnel strength mobilized or located in a given theater of war at time t, $S(t)$ and the cumulative battle casualties suffered to that time, $C(t)$, are related approximately according to the equation $S = \alpha C^{\beta}$, where α and β are constants typical of the particular war. The

values of β found for the wars considered are: World War I (British experience) $\beta = 0.37$; World War II (US) $\beta = 0.38$; Korea (US) $\beta = 0.57$; Vietnam (US) $\beta = 0.36$.

c. For the relationship between side Y and side X during a given war, the author proposes the relationship $Y = jX^k$, where X and Y are the quantities of interest (*i.e.*, strengths, battle casualties, battle dead, and so forth) and j and k are constants typical of the particular war. For example, if the war in question is World War I and the quantity of interest is battle casualties, and if we take the sides Y and X to be the French and Germans (respectively), then $j = 2.72$ and $k = 0.966$. For other wars and the other quantities mentioned, the exponent k is consistently found to be close to unity, varying only from 0.95 to 1.04.

d. During a given war, the instantaneous personnel strength $S(t)$ mobilized or located in a given theater of war at time t after the initial commitment of strength S_0 at time $t = 0$, is given approximately by

$$\frac{S(t)}{S_\infty} = 1 - \left(1 - \frac{S_0}{S_\infty}\right) e^{-t/\tau},$$

where S_∞ is the ultimate strength mobilized or located in the theater at the end of the war and τ is a time constant. The values of S_0, S_∞, and τ are constants typical of the particular war, estimated by fitting them to the available data. In that way the author arrives at the following estimates:

War	Side	τ	S_∞
World War I	Britain	1.26	2,000,000
World War I	US	0.937	3,660,000
World War II	US	7.25	16,000,000
Korean War	US	0.415	250,000
Vietnam I (1961-64)	US	3.10	20,000
Vietnam II (1965-68)	US	1.56	380,000

11. Comments and Critique. This paper, and those mentioned in paragraph 1, furnish a novel approach to the study of data on wars. The indicated patterns are intriguing, and additional research would be desirable to find out whether they also apply to other wars. It would also be interesting to test their applicability to data on battles and campaigns (as opposed to wars). See also the closely related paper Voevodsky-1972.

VOEVODSKY-1972

1. Document Description. Voevodsky, John, "Crisis Waves: The Growth and Decline of War-Related Behavioral Events," The Journal of Psychology, Vol 80, 1972, pp 289-308. UNCLASSIFIED. Available from libraries. See also Voevodsky-1969 and the background papers cited in its paragraph 1.

2. Objectives and Scope. The quantitative patterns of wars (as expressed in the expenditures, troop commitments, casualties, firepower, and so forth) appear to exhibit a succession of surges, which we call crisis waves. These crisis waves typically involve a rapid rise to a peak, a period during which the peak is sustained, followed by a more or less rapid decline. This paper is directed to proposing a mathematical theory that accounts for this lawfulness by analyzing the mechanism underlying the formation of a crisis wave.

3. Populations Included. Participants in wars.

4. Timeframes Included. US Civil War, World War I, World War II, Korean War, and Vietnam War.

5. Casualty Types Included. Battle casualties and battle deaths.

6. Time Intervals Included As. At various points in time during the course of a war.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. The author argues that the casualties C_i to side i during a given war are governed by differential equations of the (logistic) form

$$\frac{dC_i}{dt} = K_i\left\{1 - \frac{\alpha_i}{S_{\infty i}} C_i^{\beta_i}\right\} C_i^{\beta_i} \quad ,$$

where t is the time from start of the war, $S_{\infty i}$ is the ultimate strength mobilized or located in a theater of war, and K_i, α_i, and β_i are constants typical of the particular war. The author states that at the start of a war, $\beta_i \simeq 1$, and that this is valid up to about 10 percent casualties. However, as the war goes on, β_i decreases and becomes about 1/3 toward its end. Eliminating C_i by using the relation $S_i = \alpha_i C_i^{\beta_i}$, where S_i is the strength at time t after the start of the war, the differential equation can be written as

$$\frac{dS_i}{dt} = \hat{K}_i\left\{1 - \frac{S_i(t)}{S_{\infty i}}\right\} S_i(t)^{2-\rho_i} \quad ,$$

where $\rho_i = 1/\beta_i$ and $\widehat{K}_i$ are also constants typical of the particular war. Solving this last differential equation for the case where $\rho_i = 3$, $S_0(t)/S_{\infty i} \ll 1$, and $S_{\infty i} - S(t) \ll S_{\infty 1}\log(S_{\infty i} - S_i(t))$, the author finds

$$\frac{S_i(t)}{S_{\infty i}} = 1 - e^{-t/\tau},$$

where τ is a constant determined by the values of the constants defined earlier. After fitting the constants to data from the wars mentioned, the author concludes that (as of 30 June 1969) the Vietnam War was very close to a culmination point, at which time the war would be abandoned or would take on a new and very different form.

11. Comments and Critique. This paper, and those mentioned in Voevodsky-1969, furnish a novel approach to the study of data on wars. The indicated patterns are intriguing, and additional research would be desirable to find out whether they also apply to other wars. It would also be interesting to test their applicability to data on battles and campaigns (as opposed to wars). Regarding the latter, it is to be noted that Best-1966 has observed similar surges or waves in loss data for divisions.

WAINSTEIN-1973a

1. Document Description. Wainstein, Leonard, "Some Allied and German Casualty Rates in the European Theater of Operations," Institute for Defense Analyses (IDA), Paper P-989, December 1973, 61 pp. UNCLASSIFIED. Available from DTIC (AD-779 850).

2. Objectives and Scope. From the Preface: "This historical research has been aimed at gaining some new historically based insights into any relationships which might exist among the key simulation elements of force ratios, casualties, and rates of advance. The focus of effort has been on actions at the division level. The paper has two objectives ... The first objective is to examine US and German casualties and casualty rates in the European theater in 1944-45, with prime emphasis on the Normandy-Northern France campaign of June-September 1944. ... The secondary objective of the paper is to describe in some detail the methodological problems encountered in an effort to mine the records of World War II for comparative US-German statistics."

3. Populations Included. Personnel of selected US divisions and German units.

4. Timeframes Included. Primarily World War II (although Table 23 gives some World War I divisional-level casualty data).

5. Casualty Types Included. Variously described as losses or casualties, or indicated by category (killed, wounded, *etc.*). Occasionally nonbattle losses (disease and nonbattle injury) are given.

6. Time Inter[illegible] Included As. Various.

7. Situational Descriptors Defined As. The dependency of attrition rate on the tactical situation is discussed on pp 33-38.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Includes numerous tables and a few figures.

10. Summary of Findings Regarding Battle Casualties.

a. With regard to the difficulties faced in dealing with the records, the author notes that the US microfilms of German World War II records do not include the personnel or quartermaster records, and that few, if any, German division war diaries survived the war. The document also notes that the record-keeping systems used by the various participants often use "strength" and "casualty" in quite different senses, thus making comparisons difficult (for example, US division strengths normally included organic service troops while the Germans usually did not).

b. From Some Summary Comparisons: "Any comparisons between US or Allied and German casualty rates must be heavily qualified. ... It has been shown that the average divisional rate of loss on both sides tended to be fairly similar [daily loss of 3 per 1,000 Table of Organization for the US and at

least 2 per 1,000 for the Germans]. ... There is for both sides the same great difference between average rates and high-intensity rates. ...while average daily losses for armored divisions are one-third smaller than for infantry divisions, the difference increases tremendously during high-intensity combat, with infantry rates soaring."

11. Comments and Critique. This is a careful analysis focusing on some selected data on Allied and German casualties during the latter phases of World War II. It usefully augments other studies of the same subject. It is, however, one-sided in the sense that coordinated data on the casualties to both sides of an action are not provided.

WAINSTEIN-1973b

1. Document Description. Wainstein, Leonard, "Rates of Advance in Infantry Division Attacks in the Normandy-Northern France and Siegfried Line Campaigns," Institute for Defense Analyses (IDA), Paper P-990, December 1973, 22 pp. UNCLASSIFIED. Available from DTIC (AD-779 882).

2. Objectives and Scope. From the Preface: "The research in this paper is in the area of historical combat statistics for possible use as input to simulation models. Historical research was focused on two areas: casualties and advances. ... Data are presented for attacks in which an advance was gained."

3. Populations Included. Participants in 90 selected allied infantry division attacks.

4. Timeframes Included. World War II.

5. Casualty Types Included. Battle casualties.

6. Time Intervals Included As. For the Normandy-Northern France campaign from 13 June to 9 September 1944 (includes 50 actions). For the Siegfried Line campaign from 19 September through 15 December 1944 (35 actions). An additional 5 actions from the final phases of the Ardennes campaign are included (28 January 1945 through 2 February 1945).

7. Situational Descriptors Defined As. Primarily terrain (*e.g.*, open, mixed, close/forest) and degree of enemy resistance (*e.g.*, light, moderate, heavy). These descriptors were taken directly from official and unit histories or after-action reports. A synopsis of the campaigns studied is included.

8. Data Sources Used. Primary historical records and official histories.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Apart from the comment on p 9, made almost in passing, that "It is obvious that no standard measure exists for the relationship between degree of resistance and casualties—any more than for advances ... What is suggested is that there may be no direct correlation between the number of casualties and the degree of resistance the troops *felt* [emphasis in the original] they were encountering," no generalizations regarding casualties are offered. However, Tables 1 and 2 provide estimates of the attacking division's strength and battle casualties (along with the name of the division, the location, the date, the duration of the action, the terrain and degree of resistance descriptors, and the distance advanced).

11. Comments and Critique. This a small but possibly useful sample of data of casualties in division attacks by the western allies during the later phases of World War II. It is, unfortunately, one-sided since it contains no German casualty data.

WAINSTEIN-1986

1. Document Description. Wainstein, Leonard, "The Relationship of Battle Damage to Unit Combat Performance," Institute for Defense Analyses (IDA), Paper P-1903, April 1986, 91 pp. UNCLASSIFIED. Available from DTIC (AD-A170 631).

2. Objectives and Scope. From the Summary: "The purpose of this study is to investigate the historical basis for the assumption that a military formation will cease to be effective after having lost a certain pre-ordained percentage of its strength."

3. Populations Included. From the Summary: "Battles from the First World War to the 1982 Falklands War have been reviewed for insight into the validity of this assumption. The battle cases cited run from Army level to battalion level, from single day engagements to those lasting several months."

4. Timeframes Included. From World War I through the Falklands War.

5. Casualty Types Included. Various, depending on the context.

6. Time Intervals Included As. From start to end of a battle or campaign.

7. Situational Descriptors Defined As. Given in narrative form.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Table 1 gives a summary of the strengths and losses of men and tanks for the British forces in Operation Goodwood (18-24 July 1944). Pages 81-86 summarize in tabular form the 54 actions "in which a unit's performance could be matched against battle damage incurred or in which a badly attrited unit has still managed to maintain an effective defense or attack." The following information is provided for each of these actions: name and date; unit identification and nationality; force size (generic, *i.e.*, battalion, division, army, *etc.*); posture (attack or defense); casualties; outcome; and circumstances or comments.

10. Summary of Findings Regarding Battle Casualties. From the Abstract: "The effect of heavy battle damage on units has been both variable and unpredictable. There is a relationship between losses and the continued willingness to fight, but it defies precise definition."

11. Comments and Critique. This provides an excellent summary and review of selected considerations regarding breakpoints. However, the analysis is one-sided since it does not consider what damage is being done to the opposing unit. All such one-sided attempts to relate casualties to breakpoints have failed to find any consistent or definable pattern.

WALKER-1991

1. Document Description. Walker, Stephen K., "Armored Vehicle Weapon Impact Assessment in Southeast Asia," Air Force Institute of Technology Thesis, AFIT/GOR/ENS/91M-20, March 1991, 290 pp. UNCLASSIFIED/LIMITED. Available from DTIC as AD-B156 495.

2. Objectives and Scope. From the abstract: "The goal of this study was to determine the relationship between battlefield physical insults, levels of protection, and the number and severity of casualties sustained by armored vehicle crews as a result of battlefield physical insults on armored vehicles in the Vietnam conflict. In addition, this study sought to establish the relationship between battle field physical insults, levels of protection, and vehicle mission vulnerability."

3. Populations Included. Vehicle crewmen.

4. Timeframes Included. Vietnam War.

5. Casualty Types Included. KIA, WIA, DOW, and MIA. Casualties are also classified as Not Wounded, Lightly Wounded (self-aid required), Moderately Wounded (unit aid man required), Severely Wounded (evacuation required), Dead, and Position Not Manned. [However, in the second classification scheme the Lightly and Moderately Wounded categories were combined because the data did not permit distinguishing them.]

6. Time Intervals Included As. The data cover the period from July 1969 to July 1970. The date and time of day of each incident are recorded whenever available.

7. Situational Descriptors Defined As. Each data base record consists of 72 fields. Several descriptors are provided when available, including such items as country where the incident occurred (South Vietnam or Cambodia), unit and branch of service to which the vehicle was assigned, vehicle speed, number of hits on the vehicle, azimuth and elevation of incoming rounds, effect of the hits on mission completion, and several others.

8. Data Sources Used. The data base was generated from historical data on 706 vehicle damage incidents recorded in the document files associated with the GNVEHSEADB data base maintained at the Survivability/Vulnerability Information Analysis Center (SURVIAC). These data were originally collected in the field by US Army teams as part of the Battle Damage Assessment Reporting Program (BDARP). Since each hit of a multiple hit was recorded separately, the final dBASE^{TM} data base contains 737 records.

9. Other and Miscellaneous. The data base includes 104 incidents involving the M48 tank, 345 involving the M113 Armored Personnel Carrier, 89 involving the M551 Armored Reconnaissance/Airborne Assault Vehicle, 77 involving 9 different types of trucks, and 91 involving 24 other assorted vehicle types such as the M132 Flamethrower, M577 Command Post, M43 Duster,

D7 Bulldozer, arc-welders, and cement mixers. The data covers equipment assigned to the 25th, 1st, and 4th Infantry Divisions, the Americal Division, and the 11th Armored Cavalry Regiment.

10. Summary of Findings Regarding Battle Casualties. The goals of the study were achieved. Detailed findings are too numerous to detail here.

11. Comments and Critique. The author notes several considerations bearing on the interpretation of his findings. Among them are the following.

a. Classified sources were intentionally excluded in order to keep the study report unclassified.

b. Although variants of two of the vehicles studied in this work are still in service in the US Army, none of these vehicles is exactly like those studied. Further, the materials currently used in US vehicles and the spectrum of threats they face can be quite different from those in the population studied.

c. Data on the use or presence of body armor was rarely collected by the BDARP teams, except for crewmen who were injured. This possible bias was considered in the author's analysis and should be considered in any subsequent analysis.

WEISS-1963

1. Document Description. Weiss, Herbert K., "Stochastic Models for the Duration and Magnitude of a 'Deadly Quarrel'," Journal of the Operations Research Society of American, Vol 11, No 1, January-February 1963, pp 101-121. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To propose models for the distribution of the duration and number of deaths in a tabulation of 315 wars.

3. Populations Included. Participants in wars.

4. Timeframes Included. From 1820 to 1949.

5. Casualty Types Included. Deaths (this apparently is the total number of deaths attributed to the war, from whatever cause, including civilians as well as military and including all participating nations or population groups).

6. Time Intervals Included As. From start to end of a war.

7. Situational Descriptors Defined As. None used.

8. Data Sources Used. A selection of 315 wars from Richardson's tabulation (see Richardson-1960).

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. The distribution of the number $N(x)$ of wars with x casualties approximately follows the Pareto distribution $N(x) = ax^{-\alpha}$. Values of the parameter α, based on Richardson's data, range from 1.37 to 1.68, depending on the timeframe and whether small wars are included or not. The parameter $a = 1/\zeta(\alpha)$, where $\zeta(\ )$ is the Riemann zeta-function.

11. Comments and Critique. This is a remarkable and very ingenious paper. However, since it uses Richardson's data, the same comments offered in Richardson-1960 apply. Other investigators have found that other distributions may fit the data as well or better, or have found little reason to believe that casualties alone affect war termination. See (among others) Singer-1972; Small-1982; Wright-1942; Yengst-1982; Voevodsky-1969; Voevodsky-1972; Horvath, William J., "A Statistical Model for the Duration of Wars and Strikes," Behavioral Science, Vol 13, 1968, pp 18-28; Lawrence, R. J., "The Lognormal Distribution of the Duration of Strikes," J. R. Statist. Soc. A, 1984, vol 147, Part 3, pp 464-483; and Klingberg-1966. See also other works on the influence of losses on breakpoints.

WEISS-1966a

1. Document Description. Weiss, Herbert K., "Combat Models and Historical Data: The US Civil War," Journal of the Operations Research Society of America, Vol 14, September-October 1966, pp 759-790. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. From the Abstract: "In this paper, combat data on the US Civil War is examined to determine the extent to which it can be explained by simple mathematical relations, and some support, as well as problems, for such modeling is developed."

3. Populations Included. Combatants in battles of the US Civil War.

4. Timeframes Included. US Civil War.

5. Casualty Types Included. Variously described as hits (killed and wounded), losses, or casualties.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. The author distinguishes "meeting engagements" from "assaults" [on fortified lines].

8. Data Sources Used. From Sources of Data: "Three principal sources of data were used for this paper. They are Phisterer's *Statistical Record*, Livermore's *Numbers and Losses in the Civil War*, and Bodart's *Kriegs-Lexicon*."

9. Other and Miscellaneous. Not used.

10. Summary of Findings. From the Conclusions and other selected passages.

a. Total losses on both sides cumulated at a fairly uniform rate after the first full year of active hostilities.

b. On the average, the Confederate forces were able to secure a much more favorable local force ratio in individual battles than the overall sizes of the respective armies would suggest. This battle force ratio deteriorated as the war progressed.

c. Casualties on both sides were remarkably equal, both on the whole and in battles other than assaults on fortified lines.

d. In battles other than attacks on fortified lines, the casualty ratios appeared to be independent of force ratios. The probability of winning was clearly a function of the force size in these cases, a 2:1 advantage corresponding to about an 0.87 probability of winning. Casualties on both sides were equal within a factor of two. As a result, the winner tended to have smaller percent casualties than the loser.

e. The larger the battles, measured in total casualties, the lower the variability in casualty ratios observed across many battles.

f. In assaults on fortified lines, the losses of the attacker were proportional to the force size of the defender. In meeting engagements, battles of all sizes included in the class, casualty ratio showed no dependence on force ratio.

g. In attacks on fortified lines, there was great variability in the casualty ratio. The probability of a successful attack increased with the ratio of attacker's force to that of the defender. With a favorable force ratio, the probability of a successful attack increased with the size of the total force involved. The principal determinant of success was the fractional loss sustained by the attacker.

h. The phenomenon of losses increasing with force committed was observed by Richard H. Peterson at the Army Ballistic Research Laboratories about 1950, in a study of tank battles. It was again observed by Willard-1962, and Weiss has also noticed it in the Battle of Britain data.

i. Lanchester's linear law states that the exchange ratio (casualty ratio) should be independent of force ratio; his square law, that it should vary inversely as force ratio. Since the Civil War data used in this article do not display any notable trend, it is inferred that the linear law is more strongly supported by the data than the square law.

j. A footnote on p 763 observes that in the First Battle of Manassas, both sides expended between 8,000 and 10,000 bullets for every man killed or wounded.

11. Comments and Critique. The author's assertions quoted in 10i regarding what Lanchester's laws state are wrong, because they commit the Constant Fallacy (*see* Helmbold-1993). Accordingly, the author's inferences regarding what attrition models are or are not supported by the data are baseless. However, apart from this slip, the article as a whole is a masterful display of the author's usual ingenuity and perspicacity, and is well worth thoughtful study and consideration. It is interesting that two equations are used to represent the probability of a Union victory: the first expresses it as a function of the force ratio and the second as a function of the fractional exchange ratio (which the author terms fractional loss ratio). Since for the data used in this paper the fractional exchange ratio is approximately proportional to the force ratio, it is not suited to determining whether force ratio or fractional exchange ratio is the better predictor of victory. However, subsequent research with much larger samples of data has demonstrated that the key parameter is indeed the fractional exchange ratio, rather than the force ratio (*see* Hartley-1989b, Hartley-1990, Hartley-1991a, Helmbold-1969, Helmbold-1971b, Helmbold-1986, Helmbold-1987, and Helmbold-1990).

WEISS-1966b

1. Document Description. Weiss, Herbert K., "Systems Analysis Problems of Limited War," Proceedings of the 5th Reliability and Maintainability Conference, Annals of Reliability: Achieving System Effectiveness, American Institute of Aeronautics and Astronautics, New York, 1966, pp 295-309. UNCLASSIFIED. Available from libraries. Only the portion on air-to-air combat is considered here.

2. Objectives and Scope. To analyze data on the survival rate of fighter pilots engaged in air-to-air combat.

3. Populations Included. Fighter pilots.

4. Timeframes Included. World War I, World War II, and Korea.

5. Casualty Types Included. Killed in action.

6. Time Intervals Included As. Throughout an air campaign.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Uses data to support the argument that fighter pilots can be divided roughly into "Hawks" and "Doves" where an encounter between a Hawk and a Dove will end in loss of the Dove, one between two Hawks has a 50-50 chance of ending with the loss of either Hawk, and one between two Doves ends with no losses to either side.

11. Comments and Critique. The possibility of similar Hawk and Dove effects in land combat battles does not seem to have been much explored.

WILLARD-1962

1. Document Description. Willard, Daniel, "Lanchester as Force in History," Research Analysis Corporation (RAC), Technical Paper RAC-TP-74, November 1962, 37 pp. UNCLASSIFIED. Available from DTIC (AD-297 375L).

2. Objectives and Scope. From the Summary: "Specifically, the goal of the investigation reported here was to determine, by an examination of historical military data, the extent to which Lanchester's equations are an expression of a general property of battle."

3. Populations Included. Participants in land combat battles.

4. Timeframes Included. From 1618 to 1905.

5. Casualty Types Included. Losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Bodart-1908.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. From the Summary: In general, force ratio has had little to do with determining the outcome of the battles studied. Lanchester's square law is the poorest among poor alternative choices of deterministic laws. By elimination it is presumably the exchange ratio E that has controlled the outcome of these battles and is in some fashion responsible for the extent to which a stochastic form of the theory explains [the observations].

11. Comments and Critique. The conclusion regarding Lanchester's square law is wrong because it is based on the Constant Fallacy (*see* Helmbold-1993). The finding that the exchange ratio E has controlled the outcome of these battles is essentially the same as the conclusion in several papers of Helmbold, Schmieman, Dunn, Hartley, and Weiss that the advantage parameter is closely associated with victory in land combat battles–these results mutually support each other.

WILLIAMS-1978

1. Document Description. Williams, W. H., "How Bad Can 'Good' Data Really Be?", The American Statistician, Vol 32, No 2, May 1978, pp 61-65. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. This is essentially an essay on the effects of bias in ostensibly high quality data bases.

3. Populations Included. Does not deal specifically with military casualties.

4. Timeframes Included. Not used.

5. Casualty Types Included. Not used.

6. Time Intervals Included As. Not used.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. Findings regarding data bases are that they are far more prone to errors of various kinds, including biases, than is generally appreciated. Potential errors are created by technical bias (meaning that an estimator's expected value differs from the true parameter value), measurement error, and selection bias. The paper concludes that the magnitude of such errors can be substantial, and that their effects are often difficult to detect or to overcome.

11. Comments and Critique. This provides a useful cautionary note on the use of published data.

WILTSE-1965

1. Document Description. Wiltse, Charles M., "The Medical Department: Medical Service in the Mediterranean and Minor Theaters," Office Chief of Military History, US Army, 1965, 664 pp. UNCLASSIFIED. Available from libraries.

2. Objectives and Scope. To document the history of the Medical Department activities in the Mediterranean and minor theaters.

3. Populations Included. Hospitalized patients in the Mediterranean and minor theaters.

4. Timeframes Included. World War II.

5. Casualty Types Included. Wounded in action, diseased, and nonbattle casualties treated at Army hospitals.

6. Time Intervals Included As. From the early days of World War II through the North African, Sicilian, Italian, and Southern France campaigns.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. Official and semiofficial records and interviews.

9. Other and Miscellaneous. Not used.

10. Summary of Findings Regarding Battle Casualties. No general findings regarding battle casualties are presented. However, certain other useful information is included. For example, the Prologue (The Gift of Life) is an exceptionally clear and understanable description of how US Army wounded in action were cared for during most of World War II. Various tables show the disposition of hospital admittees in the Mediterranean and minor theaters. Table 14 shows the disposition of neuropsychiatric cases in the Fifth Army for May-August 1944. Additional information on neuropsychiatric cases is provided on pages 21-22, 96-98, 256, 284-285, 316, and 452. Appendix C offers some brief comments on the French medical system as it existed at that time, and Appendix D includes a description of the German medical establishment as it was at that time.

11. Comments and Critique. The Prologue and the information in Appendices and D regarding the French and German medical systems are very useful introductory accounts. As usual, little or no consideration is given to the connection between medical care and other forms of personnel wastage.

WOODWARD-1875

1. Document Description. Woodward, J. J., "The Medical and Surgical History of the War of the Rebellion (1861-65)," United States Army, Office of The Surgeon General, 1875, 726 pp (plus separately numbered appendix of more than 300 pages). UNCLASSIFIED. Available from the Medical Library, Brooke Medical Center, Fort Sam Houston, Texas, under call number REF UH 2224.A5 UN C1. This is the second issue, in which obvious typographical errors have been corrected, but no thorough revision of the whole has been attempted.

2. Objectives and Scope. From the Introduction: "The Medical Volume of the First Part of the Medical and Surgical History of the War of the Rebellion consists of a series of statistical tables presenting a summary view of the facts embodied in the monthly reports made to the Surgeon General with regard to the Sickness of the Army, the Deaths, and the Discharges from service on surgeon's certificate of disability."

3. Populations Included. Union solders.

4. Timeframes Included. US Civil War.

5. Casualty Types Included. Wounded, died of wounds, discharged for disability, diseased, and nonbattle injury.

6. Time Intervals Included As. From start to end of the war, and at various intermediate points in time.

7. Situational Descriptors Defined As. Not used, although tabulations are given separately by Military Department (*e.g.*, Department of the Ohio, Department of the Gulf, Military Division of the Mississippi, *etc.*).

8. Data Sources Used. Official records.

9. Other and Miscellaneous. Pages xxviii-xxix specifically note that "It must further be explained in this place that the tables in this volume do not embrace those Killed in Action, those dead of Wounds or Disease while Prisoners of War, or those who died while on Furlough, Leave of Absence, Absent Without Leave, or after Discharge from service on surgeon's certificate of disability. ... the number of Wounded was intended to embrace all the Wounded among the mean strength given, [but circumstances sometimes prevented this being carried out] so that the figures in the tables representing the number of Wounded, and especially the number of Gunshot Wounds, must be regarded as probably less than the real number occurring in the mean strength represented."

10. Summary of Findings Regarding Battle Casualties. No general findings regarding battle casualties are offered. However, the tabular data could be used to obtain values of the number of cases of gunshot wounds treated that died. Also, the number of cases treated by hits on various portions of the body during selected engagements is given in the appendix on its pages 11, 20-22, and 258. The number of Confederate troops engaged, wounded, killed, surrendered, and missing/escaped in the Union's capture of Fort Donelson is tabulated in the appendix on its page 36.

11. Comments and Critique. This provides a useful source of information on the medical services provided during the US Civil War. It is, however, difficult to extract from it information of value to PAR. See also Otis-1883.

WRIGHT-1942

1. Document Description. Wright, Quincy, "A Study of War," University of Chicago, 1942 (revised edition 1965), (Vol I is 678 pp; Vol II is 873 pp). UNCLASSIFIED. Available from CAA Library as 355.02 WRI.

2. Objectives and Scope. To record the results of the University of Chicago's project to study war, which was initiated in 1926.

3. Populations Included. Various.

4. Timeframes Included. Basically from 1480 to 1940.

5. Casualty Types Included. Losses, not further identified.

6. Time Intervals Included As. Duration of the war or battle.

7. Situational Descriptors Defined As. Not used.

8. Data Sources Used. For battles, the sources used were mainly Bodart-1908, Harbottle-1905, and Charles Oman, "The Art of War in the Sixteenth Century," E. P. Dutton & Co., New York, 1937, plus a scattering of others.

9. Other and Miscellaneous. The document contains 77 tables and 51 figures. The Table of Contents includes the following:

a. Introduction (Objectives of the study; Scope and organization of the study).

b. The history of war (History and war; Origin of war; Animal warfare; Primitive warfare; Historic warfare; Character of modern civilization; Fluctuations in the intensity of modern war; Functions of modern war; Drives of modern war; Technique of modern war; Theory of modern war; Contradictions of modern civilization; Changes in war through history).

c. The analysis of war.

(1) Method of analysis (Scientific method and the study of war; The meaning of war; The social disciplines and war; Analysis of the causes of war).

(2) Governments and the struggle for power (The balance of power; Foreign policy and armament; Conditions of government and war).

(3) States and the divergencies of law (Law and violence; Sovereignty and war; International procedures and war).

(4) Nations and the rivalry of cultures (The family of nations; Nationalism and war; Social integration and war; International organization and war).

(5) Peoples and the competition for a living (Public opinion and war; Population changes and war; The utilization of resources and war; Human nature and war).

(6) Factors influencing the incidence of war (Influence of the point of view; Measurement of international relations; The probability of war; The causes of war).

d. The control of war (Synthesis and practice; The prevention of war; Toward a warless world).

10. Summary of Findings Regarding Battle Casualties. Various and scattered throughout the document. However, hardly any of them are relevant to PAR.

11. Comments and Critique. This is a classic work on the study of war. However, it is very uneven in its quality, as might be expected from the fact that it is, in essence, a collection of master's and doctor's theses prepared under the direction of the study leaders. The author's preface states, in part, that "To trace with any precision the influence upon world-stability of any incident, invention, discovery, personality, institution, or movement in the immediate or more distant future lies beyond our present power. Suggestions of probabilities and of methods for reducing their margins of error is the most that this study hopes to do." Also, there is nothing in it that PAR can use directly.

WSEG-1975

1. Document Description. Weapon Systems Evaluation Group (WSEG), "Data From the October 1973 Middle East War," WSEG Report-237, July 1975, (in seven volumes, of which Vol I is 13 pp; Vol II is 652 pp; and Vol III is 776 pp), SECRET-NOFORN, available from DTIC (Vol I is AD-C003 740L, Vol II is AD-C003 741L, Vol III is AD-C00 205L). The seven volumes are as follows: Vol I, Index; Vol II, Overview-Chronology; Vol III, Israeli Defense Forces (IDF) Ground Forces; Vol IV, Air Operations; Vol V, Naval Operations; Vol VI, Structural Engineering Report; and Vol VII, Combat Vehicle Assessment Report.

2. Objectives and Scope. The following is paraphrased from the letter of transmittal. This report is in response to the direction of the Director of Defense Research and Engineering that the Weapons Systems Evaluation Group undertake the task of systematic collection, organization, and distribution of data having to do with the details of the interactions between opposing weapons and weapons systems utilized in the October 1973 Middle East War. This report includes all data available to WSEG's Data Acquisition Team and is compiled mainly from Israeli sources. It is a compilation of data, *not* an evaluation of the war or the equipment employed in it.

3. Populations Included. Mainly Israeli Defense Forces.

4. Timeframes Included. Middle East October War of 1973.

5. Casualty Types Included. Does not appear to contain casualty data.

6. Time Intervals Included As. From start to end of the war.

7. Situational Descriptors Defined As. So many situational descriptors are used that it is impossible to summarize them here.

8. Data Sources Used. Interviews with Israeli combat participants.

9. Other and Miscellaneous. Includes extensive tables.

10. Summary of Findings Regarding Battle Casualties. Does not appear to contain casualty data.

11. Comments and Critique. This provides a massive and comprehensive collection of data on various aspects of the 1973 Middle East October War. However, it apparently does not include casualty data of the type that would be useful in PAR.

YENGST-1982

1. Document Description. Yengst, William C., "War Termination and 'How Much is Enough'," Science Applications, Inc., 1200 Prospect Street, PO Box 2351, La Jolla, CA 92037, June 1982, 75 pp. UNCLASSIFIED. Available from the author—copy in Helmbold's personal files.

2. Objectives and Scope. To explore some of the factors that influence the decision of a country to terminate a war or major campaign. Specifically, this was an exploratory investigation of the practicality and promise of a macroscopic approach to war termination based on cumulative effort expended and cumulative casualties suffered.

3. Populations Included. Military personnel in wars or major campaigns.

4. Timeframes Included. World War I to the October War of 1973.

5. Casualty Types Included. Cumulative total casualties, and cumulative dead and missing.

6. Time Intervals Included As. From start to end of a war or major campaign.

7. Situational Descriptors Defined As. Treated only sketchily and qualitatively.

8. Data Sources Used. Various.

9. Other and Miscellaneous. Includes numerous tables and figures.

10. Summary of Findings Regarding Battle Casualties. Cumulative casualties are proportional to the man-years of effort devoted to the campaign or war. There appears to be a maximum level of cumulative total casualties for a given level of man-years of effort. The loser suffers more casualties than the winner, in relation to their respective effort in man-years. The spread between the loser and the winner is much greater for small conflicts (low levels of effort in man-years) than for large, protracted wars (involving high levels of effort).

11. Comments and Critique. Although exploratory in nature, this is an interesting and provocative study. Consideration of its findings in the light of additional evidence appears to be a worthwhile endeavor.

YOUNG-1977

1. Document Description. Young, Peter; and Calvert, Michael, "A Dictionary of Battles (1816-1976)," New English Library, London, ISBN: 0-8317-2260-6, 1977, 606 pp. UNCLASSIFIED. Available from libraries. First American edition published 1978 by Mayflower Books, Inc., New York.

2. Objectives and Scope. From the author's preface: "This work, which will eventually comprise four volumes, has been planned as a comprehensive study of military operations, on land, by sea and in the air, since the earliest times. The word 'battle' has been give a fairly wide interpretation, for sieges, amphibious landings, single-ship actions, and a variety of other operations are included."

3. Populations Included. Participants in battles.

4. Timeframes Included. From 1816 to 1976.

5. Casualty Types Included. Various, but mostly characterized as losses.

6. Time Intervals Included As. From start to end of a battle.

7. Situational Descriptors Defined As. Given in the narrative descriptions.

8. Data Sources Used. Various.

9. Other and Miscellaneous. In four volumes published from about 1977 through 1979.

10. Summary of Findings Regarding Battle Casualties. None offered.

11. Comments and Critique. This provides a useful compendium of battles.

APPENDIX E

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GLOSSARY

GLOSSARY-1. Some of the abbreviations and special terms used in this document are listed below. If the definition given is an official one, the organizations that have adopted it are given in parentheses; otherwise no indication of its adoption are given. Note that the definitions used by other countries or by the US in earlier times may differ more or less from those given below, and may be interpreted in various ways even within the US Department of Defense.

GLOSSARY-2. Definitions of terms and abbreviations:

Battle casualty: (DOD) Any casualty incurred in action. "In action" characterizes the casualty status as having been the direct result of hostile action, sustained in combat or relating thereto, or sustained going to or returning from a combat mission provided that the occurrence was directly related to hostile action. Included are persons killed or wounded mistakenly or accidentally by friendly fire directed at a hostile force or what is thought to be a hostile force. However, not to be considered as sustained in action and thereby not to be interpreted as battle casualties are injuries due to the elements, self-inflicted wounds, and, except in unusual cases, wounds or death inflicted by friendly forces while the individual is in absent-without-leave or dropped-from-rolls status or is voluntarily absent from a place of duty. See also died of wounds received in action; nonbattle casualty; wounded.

Bloody losses: The sum of the KIA and WIA.

Casualty: (DOD, IADB) Any person who is lost to the organization by reason of having been declared dead, wounded, injured, diseased, interned, captured, retained, missing, missing in action, beleaguered, besieged or detained; see also battle casualty; nonbattle casualty; wounded.

CMIA: Captured or missing in action. *See* POW and MIA.

CRO: Carded for record only. (Adapted from Beebe, Gilbert W.; and De Bakey, Michael E., "Battle Casualties: Incidence, Mortality, and Logistic Considerations," Charles C. Thomas (publisher), 1952) Basically, admissions to a medical treatment facility 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).

DNBI: Disease and nonbattle injury. Personnel treated for diseases and for injuries not received in action. *See* Nonbattle casualty.

DOW: Died of wounds received in action (DOD, NATO). A battle casualty who dies of wounds or other injuries received in action, after having reached a medical treatment facility. See also killed in action.

DTIC: Defense Technical Information Center.

KIA: Killed in action (DOD, NATO, IADB). A battle casualty who is killed outright or who dies as a result of wounds or other injuries before reaching a medical treatment facility. See also died of wounds received in action.

Losses: (Adapted from FM 101-10-1/2, Staff Officers' Field Manual Organizational, Technical, and Logistical Data Planning Factors, October 1987). A personnel loss is any reduction in the assigned strength of a unit. Personnel losses are recorded in three general categories: battle, nonbattle, and administrative.

- Battle losses are those incurred in action. They include wounded or injured in action (including those who died of wounds and died of injuries received in action), killed in action, and missing in action or captured by the enemy.

- Nonbattle losses are those not directly attributable to action regardless of when sustained. They include nonbattle dead, nonbattle accident/injury, nonbattle missing, and illness/disease.

- Administrative losses are those resulting from transfer from the unit, absence without leave, desertion, personnel rotation, and discharges.

LWIA: Lightly wounded in action (*cf.* Slightly Wounded).

MIA: (adapted from FM 101-10-1/2, Staff Officers' Field Manual Organizational, Technical, and Logistical Data Planning Factors, October 1987). Missing in action describes battle casualties whose whereabouts or fate cannot be determined and who are not known to be in an unauthorized absence status (desertion or absence without leave). Missing in action (MIA) casualties are not usually included in medical statistical records or reports received by The Surgeon General, but are reportable to The Adjutant General.

Nonbattle casualty: (DOD, NATO, IADB) A person who is not a battle casualty, but who is lost to his organization by reason of disease or injury, including persons dying from disease or injury, or by reason of being missing where the absence does not appear to be voluntary or due to enemy action. See also battle casualty; wounded.

Nonbloody loss: Battle casualties other than KIA and WIA; includes (for example) MIA, POW, absent without leave, stragglers, and deserters.

NP: Neuropsychiatric.

POW: Prisoner of war. Detainee (DOD). A term used to refer to any person captured or otherwise detained by an armed force. (According to FM 101-10-1/2, Staff Officers' Field Manual Organizational, Technical, and Logistical Data Planning Factors, October 1987, captured describes all battle casualties known to have been taken into custody by a hostile force as a result of and for reasons arising out of any armed conflict in which US armed forces are engaged. Captured casualties are not usually included in medical statistical records or reports received by The Surgeon General but are reported to The Adjutant General.)

Seriously wounded: (DOD, IADB) A stretcher case. See also WIA.

Slightly wounded: (DOD, IADB) A casualty that is a sitting or walking case. See also WIA.

SWIA: Seriously wounded in action (*cf.* Seriously Wounded).

WIA: Wounded in action (DOD, NATO, IADB). A battle casualty other than "killed in action" who has incurred an injury due to an external agent or cause. The term encompasses all kinds of wounds and other injuries incurred in action, whether there is a piercing of the body, as in a penetrating or perforated wound, or none, as in the contused wound; all fractures, burns, blast concussions, all effects of biological and chemical warfare agents, the effects of exposure to ionizing radiation, or any other destructive weapon or agent.