Understanding Combat Casualty Care Statistics

John B. Holcomb, MD, Lynn G. Stansbury, MD, Howard R. Champion, FRCS, Charles Wade, PhD, and Ronald F. Bellamy, MD

Maintaining good hospital records during military conflicts can provide medical personnel and researchers with feedback to rapidly adjust treatment strategies and improve outcomes. But to convert the resulting raw data into meaningful conclusions requires clear terminology and well thought out equations, utilizing consistent numerators and denominators. Our objective was to arrive at terminology and equations that would produce the best insight into the effectiveness of care at different stages of treatment, either pre or post medical treatment facility care. We first clarified three essential terms: 1) the case fatality rate (CFR) as percentage of fatalities among all wounded; 2) killed in action (KIA) as percentage of immediate deaths among all seriously injured (not returning to duty); and 3) died of wounds (DOW) as percentage of deaths following admission to a medical treatment facility among all seriously injured (not returning to duty). These equations were then applied consistently across data from the WWII, Vietnam and the current Global War on Terrorism. Using this clear set of definitions we used the equations to ask two basic questions: What is the overall lethality of the battlefield? How effective is combat casualty care? To answer these questions with current data, the three services have collaboratively created a joint theater trauma registry (JTTR), cataloging all the serious injuries, procedures, and outcomes for the current war. These definitions and equations, consistently applied to the JTTR, will allow meaningful comparisons and help direct future research and appropriate application of personnel.

Key Words: Combat, Casualty, Statistics.

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Accurate understanding of the epidemiology and outcome of battle injury is essential to improving combat casualty care, but combat trauma data are acquired under notoriously difficult circumstances and involve degrees and contexts of injury and care unfamiliar to many practitioners, civilian or military. Further, the ready availability of raw battle casualty data on the Internet invites misinterpretation by those not familiar with its pitfalls. Much of the potential for such misinterpretation boils down to familiar epidemiologic problems of consistency of numerators and denominators.

The United States Department of Defense (DoD) maintains two Internet Websites providing information on battle casualties.[1,2] The Defense link website has data on return to duty casualties (RTD)[1] white the site maintained by the Directorate for Information Operations and Reports (DIOR)[2] provides information from the current and past conflicts in sufficient detail for calculation of proportional mortality (that is, the fraction of an exposed group—those injured in combat—who die, expressed as a percent), suggesting that battle mortality for injured United States forces has dropped from 30% in World War II to 24% in Vietnam to less than 10% in the current conflict.[3] These conclusions assume that the data presented on these three conflicts are comparable. They are not. However, they do provide a basis for illustrating the major pitfalls in interpreting military casualty data and their derived statistics.

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From the US Army Institute of Surgical Research, Fort Sam Houston, Texas (L.G.S., J.B.H. C.W.); and Uniformed Services University of the Health Sciences, Bethesda, Maryland (H.R.C., R.F.B.).
Disclaimer: The opinions or assertions expressed herein are the private views of the authors and are not to be construed as official or as reflecting the views of the United States Army or the Department of Defense.
Address for Reprints: COL John B. Holcomb, MD, US Army Institute of Surgical Research, 3400 Rawley E. Chambers Avenue, Fort Sam Houston, TX 78234; email: John.Holcomb@amedd.army.mil.
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THE PROBLEM OF DEFINITIONS

Even the term "casualty" must be approached with caution when reviewing military medical data. "Casualty" in customary military usage means active duty personnel lost to the theater of operations for medical reasons.[4] The term therefore includes illness and noncombat injuries as well as combat injuries. For this discussion, we focus on battle injuries sustained in combat, i.e. during hostile engagement with a military enemy. However, even using this definition, sub-groups of casualties may be included or excluded from a given set of summary statistics, depending on the definitions in use at the time, with important effects both on the results and the inferences that are made from these results, when compared with other data sets.[5–7]

Beebe and DeBakey, in their review of World War II combat casualties, wrote: "The proportion of deaths among *all men hit* is fundamental. . . although perhaps greatest interest attaches to the proportion of the *wounded* (excluding those designated as killed) who die of their wounds."[8] In this statement, the authors contrast the overall concept of *all men hit*, to three groups: *killed*, *wounded*, and, as a sub-set of *wounded*, those "who die of their wounds." In the discussion of definitions that follows, it will be useful to keep in mind to which of these groups the modern terms refer.

A key term used to define combat-injured casualties is the number of wounded in action (WIA) and is the sum of three subgroups.

1. Died of Wounds (DOW, vide infra)
2. Those admitted to a medical treatment facility (MTF) and survived/evacuated
3. Returned to duty within 72 hours (defines minor wounds)

Conventionally, the subgroup of surviving WIAs who return to duty within 72 hours, the RTD, is excluded from denominators when proportional statistics are presented. This is significant because this group traditionally represents about 50% of all wounded in action, and in the current conflict represents 51% of all wounded.

The number and classification of wounded and deaths from combat is classically used to provide insights into the lethality of the battle, the effectiveness of the systems of care and evacuation, and focus attention on required areas of research. The following definitions, taken from Bellamy,[4] standardize the numbers to allow a reasonable retrospective comparison between conflicts.

Case Fatality Rate (CFR)

CFR refers to the fraction of an exposed group—all those wounded in action including all those who die (at any level), expressed as a percent.

$$\text{CFR} = \frac{\text{KIA} + \text{DOW}}{\text{KIA} + \text{WIA}} \times 100$$

This summary statistic provides a measure of the overall lethality of the battlefield in those who receive combat wounds. It includes the RTDs that are excluded in the denominator of DOW and killed in action (KIA) rates defined below. However, this statistic has been used both with and without the RTD population, creating a major source of confusion when comparing data sets. Insufficient detail is provided by a CFR for detailed medical planning for reasons discussed below. The CFR is not a total mortality rate that would describe all deaths relative to the entire deployed population at risk.

Killed in Action (KIA)

KIA refers to the number of combat deaths that occur before reaching an MTF (battalion aid station, forward surgical, combat support and higher levels of hospital care), expressed as a percent of the Wounded in Action minus the RTDs.

$$\%\text{KIA} = \frac{\text{Deaths before MTF}}{\text{KIA} + (\text{WIA} - \text{RTD})} \times 100$$

This statistic provides a measure of (1) the lethality of the weapons (82% of KIAs are near-instant deaths from nonsurvivable injuries that result from the massive destructive nature of military weapons); (2) the effectiveness of point-of-wounding and medic care; and (3) the availability of evacuation from the tactical setting.

Died of Wounds (DOW)

DOW is the number of all deaths that occur after reaching an MTF, expressed as a percentage of total wounded minus the RTDs.

$$\%\text{DOW} = \frac{\text{Died after reaching MTF}}{(\text{WIA} - \text{RTD})} \times 100$$

This statistic provides a measure of the effectiveness of the MTF care and perhaps also of the appropriateness of field triage, initial care, optimal evacuation routes and application of a coordinated trauma systems approach in mature combat settings. Deaths that occur at anytime after admission to an MTF are included in this category.

It is important to note that the above two statistics, %KIA and %DOW, have different denominators. The latter does not include deaths before reaching a medical treatment facility (or those who are dead on arrival at an MTF). This focuses %DOW as a measure of MTF care. However, both denominators use the same definition of a battle injury: the first two subgroups of WIA. The main difference is that the KIAs are excluded from the DOW calculations. The %KIA and %DOW cannot be summed to obtain a case fatality rate.

Over the past century, the %KIA has consistently remained between 20 and 25%. The %DOW dropped significantly toward the latter half of World War II when improved evacuation, anesthesia, antibiotics, blood transfusion, and surgical techniques all coalesced to bring the %DOW to less than 5%, where it has stayed for the latter half of the 20th century.[4]

Numerators and Denominators

As noted above, the inclusion or exclusion of the numbers of lightly wounded from the denominators of calculations of proportional mortality can have huge effects. The Surgeon General's 1981 revised report on the Vietnam War (covering 1965–1974), summarized by Bellamy,[4] shows KIA for the Army as 27,129, DOW as 3,529, wounded requiring hospital care but surviving as 96,924 and RTD (using the definitions current at the time) as 44,858.[4] Similar casualty data for the Marines are 11,152; 1,454; 51,399; and 37,234 respectively.[5] Using the formula shown above, these data result in a KIA rate of 20.0% when the RTD are excluded from the denominator. For World War II, it has been less easy to distinguish the cohort of RTD, but their existence is recognized.[8,9] These raw data are summarized in Table 1.

What is included in the numerator can be a source of confusion. The most striking example of this is World War II. The overall case fatality rate for World War II using the data available on the DIOR Website is 30%, however, the case

Table 1 U.S. Military Combat Casualties, Afghanistan and Iraq, October, 2001–October 2005, Data from the Department of Defense[1,2,4,5]

	WW II*	Vietnam†	Iraq/Afghanistan
KIA	152,359	38,281	1,266
DOW	20,810	4,983	383
Admitted & Evacuated‡	581,586	148,323	7,548
RTD†	~150,000	82,092	8,304
WIA*	752,396	235,398	16,235
TOTAL	904,755	273,679	17,501

KIA, Killed in Action; DOW, Died of Wounds; RTD, Returned to Duty in 72 hours; WIA, Wounded in Action (WIA = RTD + Evacuated + DOW).

* Does not include air combat wounded.

† Does not include 653 MIA or air combat wounded.

‡ Admitted and Evacuated = Not RTD in 72 hrs.

fatality rate for the individual services in World War II calculated from the same website is 49% for Navy, 26% for Army (including both Air Corps and ground troops), and 22% for Marines. Air Corps mortality for World War II is not given on the DIOR Website but has been calculated by Beebe and DeBakey as roughly 66%.[8] This high rate, like that for sailors, is clearly associated with the environments (air, ocean) in which battle is joined, i.e. larger numbers go into the numerator, and small numbers in the denominator. This same source shows a case fatality rate for what is variously described as "infantry" or "ground troops" as ~23%. This is less than the overall number, 30% used by Gawande,[3] and is the more legitimate comparison with mortality for Vietnam, Iraq, and Afghanistan.

The Problem of Samples

Another critical problem in battle casualty epidemiology is that of nonrepresentative samples of casualties of variable sizes being represented as theater-wide experiences. Beebe and DeBakey, writing about World War II, expressed this problem very clearly:

> "At this writing [1952], as was true throughout the combat period, one must perforce rely upon a multitude of source-materials of varying excellence, often without assurance as to their comparability or even essential accuracy. . . . "[8]

For Vietnam, the final compilations appear relatively complete and have been reviewed and revised officially[10] and data sets of well-defined samples have been compiled and analyzed.[11,12] The Wound Data and Munitions Effectiveness Team (WDMET) database from the Vietnam War is arguably the most detailed source of information to date on weapons and wounding on a sample of approximately 4% of the total Vietnam casualties between 1965 and 1969. This initiative provides a model for field data retrieval; five field teams recorded the most complete, largest and detailed sample of modern combat injuries. However, early reporting on the medical consequences of both Vietnam and the current conflict have relied on reporting of data from individual medical units, with little or no outcome data available from the follow on levels of care and are necessarily skewed. In some of these essentially anecdotal data sets, the surgeons involved clearly identify this problem in the course of their reports,[13–19] but in others, there is little recognition of its existence.

Time- and unit-specific sampling of casualty and outcome data, however, planned and identified as such, is strongly encouraged. At its best, this work provides details, institutional memory, a scholarly foundation for combat casualty care, and generates hypotheses that can be tested on appropriate data sets. Furthermore, clinical outcomes can be reasonably expected to improve over the course of a conflict as surgeons and clinical teams trained in noncombat situations gain experience. This is documented by the steady decrease in Vietnam DOW rates from 6.1 to 2.4% between 1965 and 1971.[10,20,21] The time course, cause and dynamics of such improvements are less apt to be identified in end-of-conflict summary statistics.

Afghanistan/Iraq

The raw battle casualty data from the current United States military engagement in Afghanistan and Iraq available on the DIOR Website as of November 30, 2004, yielded a case fatality rate of 10%, and the conclusion published in the *New England Journal of Medicine* was that mortality had improved significantly over time.[3] What is not obvious, however, is that this analysis used data from Vietnam that excluded the RTD from the denominator, and data for Afghanistan and Iraq that did not. The Defense Link Website, which provides military casualty data for the current conflict, does distinguish between the RTD and those more seriously wounded.[1] By combining data from both websites, it is possible to adjust the Afghanistan/Iraq data to more accurately equate with the denominator provided by the DIOR site for Vietnam.[1,2] Table 2 displays the summary data available

Table 2 U.S. Military Combat Casualties, Afghanistan and Iraq, October 2001–October 2005, Data from the Department of Defense[1,2]

	WIA	RTD	Evacuated	DOW	KIA
Iraq	15,575	8,061	7,159	355	1,170
Afghanistan	660	243	389	28	96
Total	16,235	8,304	7,548	383	1,266

KIA, Killed in Action; DOW, Died of Wounds; RTD, Returned to Duty in 72 hours; WIA, Wounded in Action (WIA = RTD + Evacuated + DOW); Evacuated, Not RTD in 72 hours.

Table 3 Comparison of Proportional Statistics for Battle Casualties, U.S. Military Ground Troops, World War II, Vietnam, Afghanistan/Iraq

	WW II[8,9]	Vietnam[4]	Total Iraq/ Afghanistan[1,2]	Afghanistan[1,2]	Iraq[1,2]
% KIA	20.2[a]	20.0[b]	13.8[c]	18.7	13.5*
% DOW	3.5[a]	3.2[b]	4.8[c]	6.7	4.7*
CFR	19.1[a]	15.8[b]	9.4[c]	16.4	9.1*

Comparisons between WWII, Vietnam, and Total Iraq/Afghanistan, a,b,c, < 0.05.
Comparison between Iraq and Afghanistan * $p < 0.05$.
% KIA = 100 × KIA/(WIA − RTD) + KIA; % DOW = 100 × DOW/(WIA − RTD); CFR = 100 × (KIA + DOW)/(WIA + KIA).

from the two Websites for the major categories of interest for Iraq and Afghanistan.

Table 3 shows KIA, DOW, and CFR rates for three conflicts using the most comparable numerator and denominator figures for each (i.e. ground troops only and the ability to distinguish RTD) and using the definitions referred to above.

The case fatality rate (CFR) progressively decreased over the conflicts WWII > Vietnam > Iraq and Afghanistan; $p < 0.0001$ between conflicts). A similar pattern was noted in %KIA (WWII > Vietnam > Iraq and Afghanistan; $p < 0.0001$ between conflicts). Understandably a different pattern is seen for %DOW. There was an increase in %DOW during the most recent conflict (Iraq and Afghanistan > WWII > Vietnam; $p < 0.004$ between conflicts). Interestingly, both DOW and KIA are higher in Afghanistan than Iraq ($p < 0.05$).

Data were analyzed using SAS version 8.1 (SAS Institute Inc., Cary, NC). To compare among and between conflicts for the categorical variable Live/Die Chi-square tests were used. A Bonferroni adjustment was used for multiple comparisons and significance level is set at 0.05.

DISCUSSION

In the present conflict, now entering its fourth year, case fatality rates (Table 3) for combat injury among United States military personnel in Afghanistan and Iraq is indeed roughly half that of Vietnam and one-third that of World War II, ($p < 0.01$). It is not unreasonable to judge that some of this reduction may be a result of widespread use of improved body armor, because chest wounds are relatively decreased in preliminary data when compared with previous conflicts.[20] Particularly for the reduction in %KIA, ($p < 0.001$), additional contributing factors may include the successful transition of products from the 10 year DoD research program on improved hemorrhage control and increased focus on prehospital Tactical Combat Casualty Care training,[22] coupled with rapid evacuation. Some degree of reciprocity between KIA and DOW rates is expected[6,21] as many of the more severly injured casualties who in the past would have died before reaching MTF care (KIA), now die after rapid evacuation to MTFs, changing their classification to DOW. The observed increase ($p < 0.01$) in DOW rates would likely be higher if not for the improvements in surgical management utilizing damage control techniques, improved ICU care, earlier recognition of abdominal compartment syndrome, liberal use of fresh whole blood and recombinant factor VIIa (rFVIIa), among other new techniques, and institution of a theater-wide trauma systems approach. Interestingly, the calculation of DOW for Afghanistan reveals a rate of 6.7% while in Iraq it is 4.7 %, ($p < 0.05$), while the KIA rate is 18.7 in Afghanistan and in Iraq it is 13.5% ($p < 0.05$). Only by using common definitions and consistent equations can these comparative rates be determined. The cause of the differences between theaters is unclear. Smaller numbers overall, different application of DOW, KIA and dead on arrival definitions, wounding at altitude, much longer evacuation distances, different applications of body armor and different injury mechanisms are all probably important variables. However, these and other hypotheses cannot be tested until wound severity data are compiled in a fashion that permits appropriate case-control comparisons. Taken together, these and other changes in practice implemented on the current battlefield have resulted in a statistically and clinically significant decrease in the theater wide, four year CFR compared to previous conflicts, ($p < 0.001$).

In both WWII and Vietnam, of those Soldiers who died, 88% were KIA and 12% DOW.[4,23] Because of the significant decrease in the KIA rate in the current war, a greater percentage of patients are dying after reaching a MTF. In Iraq and Afghanistan of those who die, 23% are DOW and 77% KIA. Though the CFR rate has decreased, the near doubling of those patients now dying at the MTF's emphasizes the need to focus resources and research to aid these casualties.

Thoughtful review of KIA, DOW, and CFR rates for combat trauma are important for optimal medical planning, training, research, and resource allocation. The need to bring combat casualty epidemiology to a civilian standard requires utilization of both technology and organization that are routinely utilized in the United States civilian trauma community.[24,26] Thanks to efforts by the Deputy Assistant Secretary of Defense for Health Affairs and the Surgeons General of each of the armed services, raw data appropriate for this effort are now being collected in three separate databases developed by the United States Army Center for AMEDD Strategic Studies in conjunction with the United States Army Institute of Surgical Research, the Armed Forces Institute of Pathology, and the Navy/Marine Corps Naval Health Research Center. Standard operational definitions are in use for the cataloging and analysis of this complex information. Injury severity data are recorded, scored, and analyzed by methods that both meet trauma-community standards and are appropriate to meet the unique aspects of battle injuries. If these efforts are successful, the current war will be the first in history from which detailed concurrent analyses of the epidemiology, nature, and severity of injuries, care provided, and patient outcomes can be used to guide research, training, and resource allocation for improved combat casualty care.

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