Combat wounds in Iraq and Afghanistan from 2005 to 2009

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Ernest E. Moore, MD, Editor, received research support from Haemonetics. David B. Hoyt, MD, Associate Editor/CME Editor, Ronald Maier, MD, Associate Editor, and Steven Shackford, MD, Associate Editor have nothing to disclose. Jennifer Crebs, Managing Editor, received consulting fees from Golden Helix, Expression Analysis, Illumina, and Lineagan. Jo Fields, Editorial Assistant, and Angela Sauaia, MD, Biostatistician, have nothing to disclose.

Author Disclosures:

All authors have nothing to disclose.

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Submitted: October 20, 2011; Revised: January 13, 2012; Accepted: January 9, 2012.

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All of the authors of this article are members of the US military and employees of the US government. The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or reflecting the views of the Department of Defense, the US government, or William Beaumont Army Medical Center. The JTTR is not responsible for the statistical analysis or conclusions drawn in this work.

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DOI: 10.1097/TA.0b013e318250bfb4

BACKGROUND: There have been no large cohort studies examining the wounding patterns and injury mechanisms in Iraq and Afghanistan from 2005 to 2009. This investigation sought to characterize the incidence and epidemiology of combat-related injuries for this period.

METHODS: Using the Joint Theater Trauma Registry, a detailed description of the combat casualty care statistics, distribution of wounds, and injury mechanisms sustained by all US service members for wounds (DRG International Classification of Diseases—9th Rev. codes 800–960) during the Iraq and Afghanistan Wars from 2005 to 2009 was performed.

RESULTS: Among the 1,992,232 military service members who were deployed, there were 29,624 distinct combat wounds in 7,877 combat casualties. The mean age of the combat casualty cohort was 26.0 years old. The combat casualties were predominantly male (98·8%), Army (77·5%), and junior enlisted (59·0%). The distribution of combat wounds was as follows: head/neck, 28·1%; thorax, 9·9%; abdomen, 10·1%; and extremities, 51·9%. Explosive injury mechanisms accounted for 74·4% of all combat casualties, which was significantly higher than those caused by gunshot wounds (19·9%) ($p < 0.0001$). From 2005 to 2007, explosive mechanisms of injury were significantly more common in Iraq than in Afghanistan ($p < 0.001$). The percentage of explosive mechanisms increased significantly in Afghanistan between the years 2007 (59·5%) and 2008 (73·6%) ($p < 0.0003$).

CONCLUSION: The wounding patterns observed in Iraq and Afghanistan from 2005 to 2009 differ from previous conflicts. Explosive mechanisms accounted for 74·4% of combat casualties, which is a higher percentage than in previous US conflicts. A progressive increase in the use of explosive mechanisms in Afghanistan, eventually equaling that in Iraq, was observed during the study period. (*J Trauma Acute Care Surg*. 2012;73: 3–12. Copyright © 2012 by Lippincott Williams & Wilkins)

LEVEL OF EVIDENCE: Epidemiological study, level II.

KEY WORDS: Military; combat; casualty; wound; epidemiology.

The importance of characterizing the incidence and character of war injuries, as well their precipitating mechanisms, has been recognized since the 19th century, when such an endeavor was conducted at the end of the American Civil War.[1] Since that time, catalogues of the types of combat wounds sustained by American military personnel in each major conflict have been published to varying degrees.[2–8] At the present time, the US Armed Forces are engaged in the most prolonged military conflict in this nation's history.[7–16] Moreover, the two fronts of the eponymous Global War on Terror, the Iraq and Afghanistan wars, have not only produced more combat-related casualties since the Vietnam era but also witnessed the wide-scale use of protective equipment for both military personnel and vehicles, as well as irregular enemy tactics, which have resulted in increased wound severity and concomitant disability.[7,8,11,16]

The study of combat-related wounds and their causes is important for reasons that are not merely historical because such factors have an important influence on the creation of more effective protective equipment, identification of specific at-risk populations within the armed forces, and the allocation of military medical resources and practitioners to the combat theater.[16] In addition, because the enemies in the Iraq and Afghanistan wars have relied extensively on irregular means of warfare, such as the use of improvised explosive devices (IEDs) and suicide/homicide bombers,[7,8,16] findings from the study of injured military personnel may also have implications for disaster preparedness and mass-casualty events that result from terrorism in the civilian sector.[17]

Although the Global War on Terror has been conducted for the better part of a decade, relatively few studies have sought to comprehensively characterize the nature of combat wounds in this conflict. What work has been done mostly focused on the experiences of specific hospitals in theater,[9–15] or casualties sustained by individual units[8] during isolated periods of deployment. Only the effort of Owens et al.[7] has previously sought to describe the nature of combat wounds in the Iraq and Afghanistan wars, and this effort was limited to the years 2001 to 2005 and included slightly more than 3,000 casualties. The present study sought to characterize the incidence and nature of combat wounds for the Iraq and Afghanistan wars from 2005 to 2009 as well as the influence of demographic factors, combat theater, combat year, and precipitating mechanism on the risk of injury. To the best of our knowledge, this work represents the most complete effort at describing the nature of war injuries in the Global War on Terror and the first to contrast injury patterns and causation between the two major fronts in the conflict.

MATERIALS AND METHODS

Institutional review board approval was obtained before the start of this investigation. Using the Joint Theater Trauma Registry (JTTR), a detailed query was performed of the combat casualty care statistics, distribution of wounds (DRG International Classification of Diseases—9th Rev. [ICD-9] codes 800–960), and mechanisms of injury incurred by all US service members in the Iraq and Afghanistan wars from 2005 to 2009. The JTTR is a prospective database of demographic, diagnostic medical treatment information on combat-wounded patients treated at US military medical facilities within the theater of operations. There are multiple levels of care from which information is obtained, starting at the point-of-injury in theater, progressing through all ascending echelons in the evacuation chain, and terminating at a military treatment facility in the United States. Individuals killed in action (KIA) and those sustaining nonbattle injuries were not included in the JTTR data set.

Care was taken to avoid duplicate counting of injuries within the same patient by performing counts of distinct patients within each ICD-9 code. For the purposes of this study, multiple similar ICD-9 codes were classified as a single distinct injury. For example, a blast injury to the lower leg would frequently include codes for fractured tibia/fibula, injury to the lower leg, saphenous vein injury, soft tissue injury to the leg, and peroneal nerve injury, and these were all classified as a single lower-extremity injury. Multiple abdominal, thoracic, or

facial wounds were also considered single injuries. Head injuries (e.g., skull fracture or head abrasion) were listed as a single distinct injury, whereas associated intracranial pathologic findings (e.g., subdural hematoma or concussion) was counted as a second wound entity. A burn injury was classified as a separate, distinct injury from a fracture or other wound in the same body region.

Wounds were analyzed and compiled by body region and type of injury. The particular body regions were separated according to the criteria described by Beebe and DeBakey,[18] corresponding with previous works using the JTTR.[7] The head and neck region included all wounds of the head, face, cervical spine, and neck superior to the clavicles. The thorax included all chest injuries and thoracic spine wounds. The abdomen included the lumbar spine, abdomen, pelvis, and external genitalia. The upper extremity included the clavicle and scapula. The lower extremity did not include the pelvis but started at the proximal femur.

Additional factors analyzed included the age of injured personnel as well as the personnel's sex, branch of service, rank, date of injury, deployment location (e.g., Iraq or Afghanistan), and mechanism of injury. The rank groups used were junior enlisted (enlisted personnel excluding noncommisioned officers), senior enlisted (all noncommisioned officers), warrant officers through junior officers (ensign/second lieutenant to lieutenant ([Navy]/captain), and senior officers (lieutenant commander/major to admirals/general officers). Deployed military service member data were obtained from the Defense Manpower Data Center. A member's deployment at any point during the calendar year was counted toward that year's total. For service members deployed in both Iraq and Afghanistan during a calendar year, the deployment location listed was deemed to be where the soldier spent more time. Crude estimates of the percentage of combat casualties to deployed service members were calculated using these data.

The raw data used to calculate combat casualty care statistics from the Iraq and Afghanistan wars from each war's beginning were obtained from the Directorate for Information Operations and Reports.[19] A *casualty* in military terms denotes individuals lost to the combat theater for any medical reason,[2] including illness and injuries not related to combat. *Combat injury* is defined as "any casualty [resulting from] hostile action sustained in combat or [en route] to or from a combat mission."[20] Individuals who die of wounds before receiving treatment at a military facility are deemed KIA. Soldiers who survive their injury until arrival at a military treatment facility are defined as wounded in action (WIA). The WIA group is further subdivided into soldiers who died of wounds (DOW) from combat injuries after reaching a military treatment facility, those treated and returned to duty within 72 hours (RTD) and those treated and medically evacuated.[21] Using the Directorate for Information Operations and Reports, service members WIA who required medical air transport were classified as patients who were treated and medically evacuated, and those who did not require medical air transport were classified as RTD.

The percent KIA is defined by the following equation: $\%KIA = KIA / [KIA + (WIA - RTD)] \times 100$.[22] The percent DOW is defined by the following equation: $\%DOW = DOW / (WIA - RTD) \times 100$.[22] The case fatality rate (CFR) is defined as the percentage of fatalities among all wounded and is defined by the following equation: $CFR = (KIA + DOW) / (KIA + WIA) \times 100$.[22] The incidence of regional injuries as defined by Beebe and DeBakey[18] and the incidence of service members WIA and DOW were also calculated and expressed as the incidence per 100,000 deployed personnel in theater per year.

Statistical analysis was performed using SAS statistical software (SAS Institute, Cary, NC). The χ^2 test statistic was used for categorical variables, and *t* tests were used for continuous variables. Fisher's exact test was used when there was not a sufficient sample size for performance of the χ^2 test. Significance was determined, a priori, at $p < 0.05$.

RESULTS

Combat Casualties by Branch of Service and Theater by Year

For the period under study, among the 1,992,232 military service members who were deployed, a total of 59,774 ICD-9 codes were reviewed and 29,624 distinct combat wounds were identified in 7,877 combat casualties classified as WIA-DOW (Table 1) and 272 service members who were classified as DOW. The distribution of combat wounds was as follows: head/neck, 28·1%; thorax, 9·9%; abdomen, 10·1%; and extremities, 51·9%. In addition, 1,064 (13·5%) of all combat casualties also sustained burn injuries. The incidence of injuries by body region was 83.7 for head and neck wounds, 29.5 for thoracic injuries, 30 for abdominal injuries, and 154.2 for extremity injuries per 100,000 deployed personnel in theater per year.

The percentage of combat casualties among those deployed to Iraq, Afghanistan, and overall was 0.39%, 0.43% and 0.40%, respectively. For each year studied and for each military operation, Army and Marine service members, when compared with Navy and Air Force, maintained higher percentages of combat casualties per deployed service member (Table 1). The Army (0.45%) and Marines (0.99%) also demonstrated the highest overall percentage of combat casualties per deployed service member in the Iraq and Afghanistan campaigns, respectively.

Combat Casualty Demographics by Theater and Year

The mean (SD) age of combat casualties was 26.0 (6.2) years. Most of the combat casualties (WIA-RTD) were male (98.5%), in the Army (78.1%), and from the junior-enlisted rank group (59.2%) (Table 2), and similar findings were found within those soldiers classified as DOW (Table 3). The mean age of the combat casualties was similar across all years studied and across both military operations except for Iraq in 2006 when it was significantly lower than the preceding (2005–2006, $p < 0.00001$) and following (2006–2007, $p = 0.038$) years. The distribution of combat casualties by sex was similar across all years studied and both military operations except for Iraq between years 2008 and 2009 ($p < 0.038$) when the percentage of female combat casualties increased from 0.8% to 2.8%.

The distribution of combat casualties by branch of service between the theaters of operation was significantly different

TABLE 1. Combat Casualties by Branch of Service and Theater by Year (WIA-DOW)

	2005		2006		2007		2008		2009		Total	
	Deployed	Casualties	Deployed	Casualties	Deployed	Casualties	Deployed	Casualties	Deployed	Casualties	Deployed	Casualties
Iraq												
Army	185,716	1,289 (0.69%)	222,042	1,200 (0.54%)	209,353	1,600 (0.76%)	234,172	593 (0.25%)	231,305	225 (0.1%)	1,082,588	4,907 (0.45%)
Navy	9,254	38 (0.41%)	12,062	49 (0.41%)	14,519	25 (0.17%)	17,533	8 (0.05%)	15,308	4 (0.03%)	68,676	124 (0.18%)
Air Force	26,892	15 (0.06%)	29,953	11 (0.04%)	37,652	27 (0.07%)	38,775	12 (0.03%)	30,626	4 (0.01%)	163,898	69 (0.04%)
Marines	65,290	445 (0.68%)	67,970	420 (0.62%)	71,241	240 (0.34%)	66,728	51 (0.08%)	37,096	20 (0.05%)	308,325	1,176 (0.38%)
Theater total	287,152	1,787 (0.62%)	332,027	1,680 (0.51%)	332,765	1,892 (0.57%)	357,208	664 (0.19%)	314,335	253 (0.08%)	1,623,487	6,276 (0.39%)
Afghanistan												
Army	33,598	73 (0.22%)	37,332	138 (0.4%)	40,135	251 (0.63%)	52,286	279 (0.53%)	85,380	504 (0.59%)	248,731	1,245 (0.5%)
Navy	1,368	2 (0.15%)	2,241	1 (0.04%)	2,953	1 (0.03%)	5,765	11 (0.019%)	8,681	21 (0.24%)	21,008	36 (0.17%)
Air Force	6,253	3 (0.05%)	9,946	4 (0.04%)	13,709	6 (0.04%)	16,661	5 (0.03%)	23,547	16 (0.07%)	70,116	34 (0.05%)
Marines	3,222	14 (0.43%)	2,350	7 (0.3%)	1,381	11 (0.8%)	6,300	61 (0.97%)	15,637	193 (1.2%)	28,890	286 (0.99%)
Theater total	44,441	92 (0.21%)	51,869	150 (0.29%)	58,178	269 (0.46%)	81,012	356 (0.44%)	133,245	734 (0.55%)	368,745	1,601 (0.43%)
Total	331,593	1,879 (0.57%)	383,896	1,830 (0.48%)	390,943	2,161 (0.55%)	438,220	1,020 (0.23%)	447,580	987 (0.22%)	1,992,232	7,877 (0.40%)

Data provided are derived from the number of deployed military service members according to the Defense Manpower Data Center Statistics for 2005 to 2009. The number of combat casualties is documented as the raw number with percentage of the deployed service members supplied in parentheses (percentage of deployed).

across all years studied with a greater percentage of Army service members sustaining combat injuries in Afghanistan compared with Iraq from 2005 to 2007 and Marine service members sustaining the greatest number of injuries within the same theater during 2008 to 2009 (see Table, Supplemental Digital Content 1, http://links.lww.com/TA/A98). The distribution of combat casualties by branch of service across all years, by theater of operation, demonstrated statistically significant increases in the percentage of Army combat casualties in Iraq from 71.4% to 89.3% from 2006 to 2008 as well as a significant increase in the percentage of Marine combat casualties in Afghanistan from 4.1% to 26.3% from 2007 to 2009 (Tables 2 and Table, Supplemental Digital Content 1, http://links.lww.com/TA/A98). When examining the distribution of combat casualties by rank group for each theater of operation, significant differences were noted in the enlisted rank group in Iraq with a decrease from 61.5% to 56.8% from 2007 to 2008 ($p < 0.0001$) and in Afghanistan with an increase from 52.5% to 58% from 2008 to 2009 ($p = 0.0251$) (Tables 2 and Table, Supplemental Digital Content 1, http://links.lww.com/TA/A98).

Mechanism of Injury by Theater and Year

IED, mortar, and rocket-propelled grenade data were grouped into the explosion category for comparison to previous conflicts. Explosive mechanisms of injury accounted for 74.4% of all combat casualties, which was significantly greater than those caused by gunshot wounds (19.9%, $p < 0.0001$) (Table 4). Gunshot wounds accounted for 30.2% of all service members classified as DOW (Table 5).

With respect to both explosive and gunshot mechanisms of injury, significant changes were recorded between years 2005 and 2007, between theaters, and between successive years in either one of the theaters apart from 2006 to 2007 (Table 4). Explosive mechanisms were significantly more common in Iraq than in Afghanistan from 2005 to 2007 ($p < 0.001$), whereas during the same period, gunshot wounds were significantly more common in Afghanistan than in Iraq ($p < 0.05$) (see Table, Supplemental Digital Content 2, http://links.lww.com/TA/A99). There was a significant decrease in the percentage of explosive mechanisms of injury from 79.5% to 74.6% ($p = 0.0007$) with a concomitant increase in the percentage of gunshot wounds from 15.6% to 21.8% ($p < 0.0001$) between the years 2005 and 2006 in Iraq (Table 4 and Supplemental Digital Content 2, http://links.lww.com/TA/A99). In the Afghanistan theater, a significant increase in the percentage of explosive mechanisms of injury occurred between the years 2007 (59·5%) and 2008 (73·6%) ($p < 0.0003$, Table 4 and Supplemental Digital Content 2, http://links.lww.com/TA/A99).

DISCUSSION

This study is the first known description and analysis of all US military combat casualties from the wars in Iraq and Afghanistan, as contained in the JTTR (2005–2009). To better analyze the incidence and epidemiology of US military combat-related injuries, it is important to understand the US military operational themes in both wars during the study timeframe. During the 5-year study period, the US military was

TABLE 2. Casualty Demographics by Theater and Year (WIA-DOW)

	2005		2006		2007		2008		2009		Total		
	Iraq	Afghanistan	Iraq	Afghanistan	Iraq	Afghanistan	Iraq	Afghanistan	Iraq	Afghanistan	Iraq	Afghanistan	Total
Age, mean, y	26.2	26	25.1	27.1	25.5	25.6	25.9	26.2	26.6	26.1	25.9	26.2	26.0
Sex													
Male	1,755 (98.2%)	90 (97.8%)	1,657 (98.6%)	148 (98.6%)	1,858 (98.2%)	264 (98.1%)	659 (99.2%)	354 (99.4%)	246 (97.2%)	726 (98.9%)	6,175 (98.4%)	1,582 (98.8%)	7,757 (98%)
Female	32 (1.8%)	2 (2.2%)	22 (1.3%)	2 (1.3%)	34 (1.8%)	5 (1.9%)	5 (0.8%)	2 (0.6%)	7 (2.8%)	8 (1.1%)	100 (1.6%)	19 (1.2%)	119 (1.5%)
Unknown	0	0	1 (0.1%)	0	0	0	0	0	0	0	1 (0.01%)	0	1 (0.01%)
Total	1,787	92	1,680	150	1,892	269	664	356	253	734	6,276	1,601	7,877
Branch of service													
Army	1,289 (72.1%)	73 (79.3%)	1,200 (71.4%)	138 (92%)	1,600 (84.6%)	251 (93.3%)	593 (89.3%)	279 (78.4%)	225 (88.9%)	504 (68.7%)	4,907 (78.2%)	1,245 (77.8%)	6,152 (78.1%)
Navy	38 (2.1%)	2 (2.2%)	49 (2.9%)	1 (0.7%)	25 (1.3%)	1 (0.4%)	8 (1.2%)	11 (3.1%)	4 (1.6%)	21 (2.9%)	124 (2%)	36 (2.3%)	160 (2.0%)
Air Force	15 (0.8%)	3 (3.3%)	11 (0.7%)	4 (2.7%)	27 (1.4%)	6 (2.2%)	12 (1.8%)	5 (1.4%)	4 (1.6%)	16 (2.2%)	69 (1.1%)	34 (2.1%)	103 (1.3%)
Marines	445 (24.9%)	14 (15.2%)	420 (25%)	7 (4.7%)	240 (12.7%)	11 (4.1%)	51 (7.7%)	61 (17.1%)	20 (7.9%)	193 (26.3%)	1,176 (18.7%)	286 (17.9%)	1,462 (18.6%)
Total	1,787	92	1,680	150	1,892	269	664	356	253	734	6,276	1,601	7,877
Rank													
Junior enlisted	1,058 (59.2%)	45 (48.9%)	1,029 (61.3%)	77 (51.3%)	1,163 (61.5%)	157 (58.4%)	377 (56.8%)	187 (52.5%)	148 (58.5%)	426 (58%)	3,775 (60.2%)	892 (55.7%)	4,667 (59.2%)
Senior enlisted	599 (33.5%)	40 (43.5%)	555 (33%)	60 (40%)	591 (31.2%)	91 (33.8%)	232 (34.9%)	124 (34.8%)	91 (36%)	258 (35.1%)	2,068 (33%)	573 (35.8%)	2,641 (33.5%)
Junior officers	102 (5.7%)	7 (7.6%)	80 (4.8%)	9 (6%)	118 (6.2%)	19 (7.1%)	38 (5.7%)	35 (9.8%)	11 (4.4%)	39 (5.3%)	349 (5.6%)	109 (6.8%)	458 (5.8%)
Senior officers	21 (1.2%)	0	14 (0.8%)	4 (2.7%)	20 (1.1%)	2 (0.7%)	14 (2.1%)	5 (1.4%)	3 (1.3%)	6 (0.8%)	72 (1.1%)	17 (1.1%)	89 (1.1%)
Unknown	7 (0.4%)	0	2 (0.1%)	0	0	0	3 (0.5%)	5 (1.4%)	0	5 (0.7%)	12 (0.2%)	10 (0.6%)	22 (0.3%)
Total	1,787	92	1,680	150	1,892	269	664	356	253	734	6,276	1,601	7,877

Junior enlisted, E1–E4; Senior enlisted, E5–E9; Junior officers, O1–O3 and all warrant officers; Senior officers, O4–O10. Data are provided as the raw number with the percent of total casualties denoted in parentheses, where applicable.

TABLE 3. DOW Demographics by Theater and Year

	2005		2006		2007		2008		2009		Total		
	Iraq	Afghanistan	Iraq	Afghanistan	Iraq	Afghanistan	Iraq	Afghanistan	Iraq	Afghanistan	Iraq	Afghanistan	Total
Age, mean	27.3	24	26.1	NA	25.6	36	25.6	32.5	25.3	25.32	26.1	27.3	26.1
Sex													
Male	50 (96.2%)	2 (100%)	42 (97.7%)	0	83 (96.5%)	1 (100%)	50 (98%)	8 (100%)	6 (85.7%)	21 (95.5%)	231 (96.7%)	32 (97%)	263 (96.7%)
Female	2 (3.9%)	0	1 (2.3%)	0	3 (3.5%)	0	1 (2%)	0	1 (14.3%)	1 (4.5%)	8 (3.4%)	1 (3%)	9 (3.3%)
Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	52	2	43	0	86	1	51	8	7	22	239	33	272
Branch of service													
Army	48 (92.3%)	2 (100%)	35 (81.4%)	0	79 (91.9%)	1 (100%)	46 (90.2%)	8 (100%)	7 (100%)	15 (68.2%)	215 (90%)	26 (78.8%)	241 (88.6%)
Navy	0	0	0	0	0	0	0	0	0	0	0	0	0
Air Force	0	0	0	0	2 (2.3%)	0	1 (2%)	0	0	0	3 (1.3%)	0	3 (1.1%)
Marines	4 (7.7%)	0	8 (18.6%)	0	5 (5.8%)	0	4 (7.8%)	0	0	7 (31.8%)	21 (8.8%)	7 (21.2%)	28 (10.3%)
Total	52	2	43	0	86	1	51	8	7	22	239	33	272
Rank													
Junior enlisted	24 (46.2%)	1 (50%)	26 (60.5%)	0	54 (62.8%)	0	29 (56.9%)	3 (37.5%)	4 (57.1%)	14 (63.6%)	137 (57.3%)	18 (54.5%)	155 (57%)
Senior enlisted	23 (44.2%)	0	12 (27.9%)	0	25 (29.1%)	1 (100%)	17 (33.3%)	2 (25%)	2 (28.6%)	6 (27.3%)	79 (33.1%)	9 (27.3%)	88 (32.4%)
Junior officers	5 (9.6%)	1 (50%)	5 (11.6%)	0	7 (8.1%)	0	3 (5.9%)	2 (25%)	1 (14.3%)	0	21 (8.8%)	3 (9.1%)	24 (8.8%)
Senior officers	0	0	0	0	0	0	2 (3.9%)	1 (12.5%)	0	0	2 (0.8%)	1 (3%)	3 (1.1%)
Unknown	0	0	0	0	0	0	0	0	0	2 (9.1%)	0	2 (6.1%)	2 (0.7%)
Total	52	2	43	0	86	1	51	8	7	22	239	33	272

Junior enlisted, E1–E4; Senior enlisted, E5–E9; Junior officers, O1–O3 and all warrant officers; Senior officers, O4–O10. Data are provided as the raw number with the percent of total DOW denoted in parentheses, where applicable.

TABLE 4. Mechanism of Injury by Theater and Year (WIA-DOW)

	2005		2006		2007		2008		2009		Total		
	Iraq	Afghanistan	Iraq	Afghanistan	Iraq	Afghanistan	Iraq	Afghanistan	Iraq	Afghanistan	Iraq	Afghanistan	Total
Explosion	1,421 (79.5%)	55 (59.8%)	1,254 (74.6%)	93 (62%)	1,389 (73.4%)	160 (59.5%)	474 (71.4%)	262 (73.6%)	193 (76.3%)	561 (76.4%)	4,731 (75.4%)	1,131 (70.6%)	5,862 (74.4%)
Gunshot wound	279 (15.6%)	25 (27.2%)	366 (21.8%)	49 (32.7%)	402 (21.3%)	72 (26.8%)	142 (21.4%)	72 (20.2%)	34 (13.4%)	123 (16.8%)	1,223 (19.5%)	341 (21.3%)	1,564 (19.9%)
Motor vehicle crash	45 (2.5%)	4 (4.4%)	31 (1.9%)	2 (1.3%)	38 (2%)	28 (10.4%)	14 (2.1%)	11 (3.1%)	18 (7.1%)	19 (2.6%)	146 (2.3%)	64 (4%)	210 (2.7%)
Other	42 (2.4%)	8 (8.7%)	29 (1.7%)	6 (4%)	63 (3.3%)	9 (3.4%)	34 (5.1%)	11 (3.1%)	8 (3.2%)	31 (4.2%)	176 (2.8%)	65 (4.1%)	241 (3.1%)
Total	1,787 (100%)	92 (100%)	1,680 (100%)	150 (100%)	1,892 (100%)	269 (100%)	664 (100%)	356 (100%)	253 (100%)	734 (100%)	6,276 (100%)	1,601 (100%)	7,877 (100%)

The raw number of casualties by mechanism is provided with the percentage of total injuries for the year provided in parentheses.

TABLE 5. DOW Mechanism of Injury by Theater and Year

	2005		2006		2007		2008		2009		Total		
	Iraq	Afghanistan	Iraq	Afghanistan	Iraq	Afghanistan	Iraq	Afghanistan	Iraq	Afghanistan	Iraq	Afghanistan	Total
Explosion	35 (67.3%)	1 (50%)	29 (67.4%)	0	53 (61.6%)	0	33 (64.7%)	4 (50%)	5 (71.4%)	16 (72.7%)	155 (64.9%)	21 (63.6%)	176 (64.7%)
Gunshot wound	14 (26.9%)	1 (50%)	12 (27.9%)	0	28 (32.6%)	0	16 (31.4%)	4 (50%)	2 (28.6%)	5 (22.7%)	72 (30.1%)	10 (30.3%)	82 (30.2%)
Motor vehicle crash	1 (1.9%)	0	0	0	1 (1.2%)	1 (100%)	0	0	0	0	4 (1.7%)	1 (3%)	5 (1.8%)
Other	2 (3.9%)	0	2 (4.7%)	0	4 (4.7%)	0	2 (3.9%)	0	0	1 (4.6%)	8 (3.4%)	1 (3%)	9 (3.3%)
Total	52	2	43	0	86	1	51	8	7	22	239	33	272

The raw number of DOW by mechanism is provided with the percentage of total injuries for the year provided in parentheses.

engaged in irregular wars in both Iraq and Afghanistan. In Iraq, a comprehensive counterinsurgency strategy, The Iraq War Troop Surge, was used with a large influx of US troops in 2007 to 2008.[23,24] A similar concept was only beginning to be applied on a large scale in Afghanistan during 2009.

By using Defense Manpower Data Center statistics, crude estimates of the percentage of combat casualties among deployed service members were calculated. The highest percentage of combat casualties to deployed service members occurred in Iraq in 2007 (0.57%) and in Afghanistan in 2009 (0.43%). These facts coincide with the deployment of the greatest numbers of military personnel to each theater. The aforementioned timeframe in Iraq coincided with the height of the US counterinsurgency campaign, whereas that in Afghanistan occurred during the apex of the Taliban resurgence before the United States began its comprehensive counterinsurgency campaign. The higher percentage of combat casualties among the Army and Marines, when compared with the Navy and Air Force, reflects the fact that Army and Marine service members, in general, were more extensively involved in combat operations. Similarly, that males and junior-enlisted personnel represented most of all combat casualties in this study reflects the heightened exposure of these groups to this specific combat environment.[8,17]

During the last century of American warfare, there has been a steady increase in the number of combat casualties resulting from explosive mechanisms of injury, including mortars, rocket-propelled grenades, landmines, and IEDs, when compared with gunshot wounds. Explosive mechanisms of injury accounted for 35% of all recorded combat casualties in World War I,[18] 65% in Vietnam,[5,25] and 74·4% of combat casualties in the present study. Previous reports detailing the Iraq and Afghanistan wars have consistently found that explosive injuries (77–81%) have outpaced gunshot wounds (19–23%) and are now responsible for the greatest proportion of US combat casualties. [7,8] Similarly, the distribution of combat wounds by body region has evolved from previous conflicts dating back to World War II.[3–5,7] The widespread use of advanced individual body armor, including protective vests and Kevlar helmets, by US military personnel provides initial protection for the head, thorax, and abdomen, not only reducing the overall percentage of thoracic injuries but also diminishing the impact of what might otherwise be life-threatening wounds. These measures likely also explain the relative increased incidence of extremity wounds, especially as compared with thoracic and abdominal injuries.

The overall crude combat casualty rate per deployed service member in this report was 0.40% and was 18-fold less than the 7.57% rate reported in a prospective, longitudinal analysis of 4,122 US Army brigade combat team soldiers deployed during The Iraq War Troop Surge.[8] The brigade combat casualty rate is substantially higher than the one documented here for several reasons, illustrating the limitations in the use of overall crude percentage of combat casualties per deployed service member. First, the aforementioned study was prospective, and all soldiers were followed for their entire deployment using the unit's combat casualty roster, the soldier's electronic medical record, and the JTTR, ensuring all combat wounds were recorded. Second, the length of time a soldier was deployed was known, in contrast to the Defense Manpower Data Center statistics used in the present work, which counted a service member's deployment at any point during the calendar year toward that year's total. Thus, it is likely that due to this methodology, combat casualty rates reported here are somewhat reduced relative to those experienced by service members assigned in combat roles. Lastly, the publication of Belmont et al.[8] followed an Army combat arms unit deployment during one of the highest periods of combat intensity, different from the present effort that includes all branches of service, various types of units (e.g., combat, medical, veterinary, and transportation), and variable conflict intensity. Nonetheless, similar deployed military service member data have recently been used by Cohen et al.[26] to identify clinical variables associated with return to duty in soldiers from the wars in Iraq and Afghanistan, and these can be used as a historical benchmark to compare with previous and future conflicts.

The distribution of combat casualties by branch of service across all years, by theater of operation, found statistically significant increases in the percentage of Army combat casualties in Iraq from 2006 to 2008 because the Army assumed an increased role in the counterinsurgency operation in Iraq, as well as a significant increase in the percentage of Marine combat casualties in Afghanistan from 2007 to 2009 while the Marines did the same in Afghanistan (see Table, Supplemental Digital Content 1, http://links.lww.com/TA/A98). When examining the distribution of combat casualties by rank group for each theater of operation, significant differences were noted in the enlisted rank group in Iraq with a decrease from 61.5% to 56.8% from 2007 to 2008 and in Afghanistan with an increase from 52.5% to 58% from 2008 to 2009 (see Table, Supplemental Digital Content 1, http://links.lww.com/TA/A98).

The increase in the percentage of combat casualties within the junior enlisted rank group coincided with the increased counterinsurgency operations and combat intensity in both Iraq and Afghanistan during these periods. Despite current US tactical doctrine which espouses proximate on-the-ground leadership from senior noncommissioned officers and commissioned officers, the junior-enlisted rank group, who are the service members principally involved in the direct combat tactical operations of a counterinsurgency campaign, were more likely to become a combat casualty during the conduct of these operations.

The JTTR database endeavors to collect the demographic and diagnostic medical treatment information on every American

TABLE 6. US Military Combat Casualty Care Statistics for the Iraq and Afghanistan Wars (as of November 22, 2011)

	Iraq	Afghanistan
WIA	32,224	14,733
RTD	23,179	10,213
Medically Evacuated	9,045	4,520
DOW	812	348
KIA	2,695	1,094
CFR	10.04%	9.11%
Percentage KIA	22.96%	19.49%
Percentage DOW	8.98%	7.70%

military casualty cared for in US military facilities. Based on the data provided, the information contained in this report represents approximately 42% of the estimated 19,329 combat casualties that were WIA during the study period.[19] Although this is not a complete casualty analysis, it is the most complete for evaluating demographic information, injury location, and mechanism of wounding. This study represents a 55% increase in the number of combat casualties analyzed, relative to the work of Owens et al.[7] and now constitutes the most comprehensive report to date.

The most complete documentation of combat casualty care statistics from the Iraq and Afghanistan wars (through November 22, 2011; Table 6) is located at the Directorate for Information Operations and Reports. Using these data for the periods 2005 to 2009, the incidence of WIA for deployed service members was 256 per 100,000 per year, and the incidence of KIA/DOW was 11.7 per 100,000 deployed personnel per year. It should be emphasized, however, that it is important to correctly and descriptively categorize combat casualties, as well as wounding patterns, to maintain consistency when comparing combat casualty statistics within and between wars.[22,27,28] Combat casualty care epidemiology reporting is valid only when a clearly defined population is studied and combat casualty classification is reliably performed. Calculating combat casualty care statistics using the Directorate for Information Operations and Reports is limited by the classification of service members and a priori categorization of individuals KIA/DOW in a single status.

A prospective, longitudinal analysis of 4,122 soldiers on a 1.25 year combat deployment during Operation Iraqi Freedom reported a %KIA of 22.1%, %DOW of 3.2%, and CFR of 7.7%.[8] That thoroughly detailed study reported that 73.8% of WIA casualties were classified as RTD.[8] In comparison, the information from the Directorate for Information Operations and Reports used in the current study shows that 70.9% of WIA casualties were classified as RTD, ostensibly substantiating its validity.

The present study is the first to analyze the distribution of combat wounds by examining each ICD-9 code for each combat casualty and classify multiple similar ICD-9 codes as a single distinct combat injury, thus avoiding redundancy and overestimation of the burden of combat injuries. Furthermore, not only the primary but also other additional distinct combat injuries were accounted for, potentiating an accurate data analysis. Clearly, identifying the casualty population at risk (denominator) is necessary to perform valid comparisons between wars and reach meaningful conclusions. It must be emphasized that the current study relied on crude yearly estimates of the combat casualty population at risk, obtained from the Defense Manpower Data Center statistics, as well as aggregate data regarding the category of KIA/DOW for the purposes of calculating incidence. The combat casualty cohort in the current study included all service members WIA, including those who were returned to duty. Combat casualties that are returned to duty and excluded from casualty statistical analysis will bias the reported results to more severe injuries. A substantial limitation of the current study is the absence of information detailing injury severity and its subsequent evaluation, the ideal of which is described in the work of Champion et al.[29] The authors contend that the present study's detailed data analysis allows for the most complete and thorough reporting of combat injuries to date.

In conclusion, the wounding patterns observed in Iraq and Afghanistan from 2005 to 2009 differ from previous conflicts. Explosive mechanisms accounted for 74·4% of all combat casualties, a higher percentage than in previous wars. A significant increase in the use of explosive mechanisms in Afghanistan, ultimately equaling that encountered in Iraq, was also observed during the period under study.

AUTHORSHIP

P.J.B., B.J.M., R.N.S., and A.J.S. designed this study. B.J.M., R.N.S., and A.J.S. participated in the data collection. P.J.B. and R.B. performed the statistical analyses. P.J.B., B.J.M., R.N.S., and A.J.S. drafted the article, which was critically revised by P.J.B., R.B., and A.J.S.

DISCLOSURE

The authors declare no conflicts of interest.

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