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# Combat-related gunshot wounds in the United States military: 2000–2009 (cohort study)

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ABSTRACT

*Introduction:* The armed forces of the United States are engaged in the longest conflict in their history. No prior works have described the incidence or epidemiology of gunshot wounds in the U.S. military.
*Methods:* All combat-related gunshot wounds sustained by uniformed servicemembers in the years 2000–2009 were identified using the Defense Medical Epidemiology Database. Demographic information for all individuals identified as having sustained gunshot injuries was obtained and like data was captured for the entire military population serving in the same time-period. Raw unadjusted incidence rates were calculated for gunshot wounds within the entire demographic, as well as for the subcategories of sex, military rank, branch of service, and age. Adjusted incidence rate ratios were also calculated via multivariate Poisson regression analysis, using subcategories with the lowest unadjusted incidence rates as referents.
*Results:* We identified 4693 gunshot wounds within a population of 13,813,333 person-years for an overall incidence of 0.34 per 1000 person-years. Marine Corps service demonstrated the highest unadjusted incidence rate at 0.68 per 1000 person-years. Male sex, Junior Enlisted rank, Army and Marine Corps service, and ages 20-29 demonstrated significant adjusted incidence rate ratios and maintained unadjusted incidence rates above the population mean.
*Conclusions:* Male sex, Junior Enlisted rank, Army and Marine Corps service, and ages 20–29 were identified as significant independent risk factors for war-related gunshot injuries. This investigation is the first to report on the incidence and epidemiology of gunshot wounds and includes the largest cohort of individuals to sustain such injuries in the literature.

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## 1. Introduction

Throughout its military history, the Armed Forces of the United States have engaged in 11 major conflicts, the overwhelming majority of which were conducted along the lines of conventional Western warfare. The Global War on Terror, comprised of two battlefronts; Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF), has largely consisted of unconventional warfare where enemy combatants engage a superior force using the asymmetric tactics of ambush, terrorism, and improvised fragmentary blast attacks.[1–3] Since the start of OEF in 2001, the combined fronts of the Global War on Terror have resulted in close to 50,000 casualties and more than 4600 combat-related fatalities.[4]

Although there have been an unprecedented number of works documenting various military-medical experiences in OIF and OEF over the last decade,[1–3,5–11] few have been comprehensive in their analysis and none have completely described the incidence, or epidemiology, of specific battlefield injuries. Investigations regarding the causation and risk factors for combat wounds are not only a historical necessity, but also have immediate implications for the staffing of medical facilities in theater, the targeting of populations with elevated risk-profiles, and the development of more advanced personnel protective measures.

The present study sought to describe the incidence of combat-related gunshot wounds, as well as risk factors for this injury, within the United States military from 2000 to 2009 using the Defense Medical Epidemiology Database (DMED). To the best of our knowledge, this study is unique in that it specifically examines the incidence and epidemiology of gunshot wounds. This work also encompasses the single largest body of individuals sustaining injuries from gunshot to be reported in the literature.

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## 2. Materials and methods

The methodology of the DMED has been extensively described in previous publications.[12,13] Briefly, the system contains demographic information regarding servicemembers in the military and also catalogues medical diagnoses for individuals by International Classification of Diseases Code, Ninth Revision (ICD-9). The DMED has previously been used as a means to characterize the incidence and epidemiology of medical conditions ranging from sports related injuries[12] to orthopaedic trauma.[13]

Authorized access to the DMED website and approval from our institution's Investigational Review Board, were obtained prior to commencing this investigation. Inclusion criteria for this study consisted of all individuals in the four branches of the military (Army, Navy, Air Force, Marine Corps) who sustained combat-related gunshot wounds from 2000 to 2009. This period encompasses the majority of OIF (March 2003–September 2010), OEF (October 2001-present) and Operation Joint Guardian in Kosovo (March 1999-present). The DMED would capture information on all servicemembers who were wounded in action and survived to receive treatment at an American facility in Germany or the United States. Thus, individuals killed in action, or those who died of their wounds in theater, are not included in this dataset.

ICD-9 codes for combat-related gunshot wounds (E991.0, E991.1, E991.2, E991.3, E991.9) were used to query the DMED and demographic information for all those identified as sustaining gunshot injuries were obtained. Demographic data is limited to that contained within the DMED, but includes sex, military rank, branch of service, and age. Sex is reported as male or female and branch consists of Army, Navy, Air Force, or Marine Corps. The DMED automatically bins age and rank into predetermined categories. Age is categorized as <20 years, 20–24, 25–29, 30–34, 35–39 and >/= 40. Military rank is classified as Junior Enlisted (private/seaman/airman to specialist/corporal/senior airman/petty officer 3rd class), Senior Enlisted (all non-commissioned officer ranks), Junior Officers (2nd lieutenant/ensign to captain/lieutenant and junior warrant officers) and Senior Officers (major/lieutenant commander to lieutenant general/vice admiral and senior warrant officers). Like demographic data was obtained for all individuals serving in the military over the same time-period using the population feature of the DMED website. This was determined to be the population at risk for this investigation.

## 3. Statistical analysis

All statistical calculations were conducted using SAS version 9.2 (SAS, Cary, NC). The raw incidence of gunshot wounds was initially calculated for the entire population by dividing the number of incident gunshot injuries identified through the DMED for 2000–2009 by the entire military population for this time-period. Due to the methodology of the DMED, the population at risk is expressed in person-years, where a single person-year indicates one calendar year of service in the military for one individual. Unadjusted incidence rates (IR) were obtained for the subgroups present in the model, including sex, military rank, branch of service and age. All incidence rates were expressed as the rate per 1000 person-years.

Once unadjusted IRs were determined, the category within each subgroup that maintained the lowest IR was identified as a referent. Referents were then used in a multivariate Poisson regression analysis, controlling for other factors in the model, to identify adjusted incidence rate ratios (IRR) and 95% confidence intervals (CI), along with $p$-values, for the other categories in the subgroup. All demographic factors in the model were controlled in the regression analysis as was the racial classification of servicemembers. Potentially important risk factors for gunshot wound were identified in multivariate analysis, but the factors most indicative of increased risk were maintained to be those that demonstrated a statistically significant IRR and an unadjusted IR higher than the average for the entire cohort. Statistical significance was determined apriori to be present for $p$-values <0.05.

## 4. Results

From January 1, 2000 to December 31, 2009, 4693 servicemembers were identified as having sustained a combat-related gunshot wound in a population at risk of 13,813,333 person-years. The raw incidence of gunshot injuries was 0.34 per 1000 person-years. Male sex, Junior Enlisted ranks, service in the Army or Marine Corps, and ages 20–29 demonstrated IRs higher than the population average (Tables 1 and 2). Marine Corps service demonstrated the highest unadjusted IR at 0.68 per 1000 person-years.

Due to their IRs being the lowest within the subgroups of interest, the categories of female sex, senior officers, Air Force service, and age >/ = 40 were used as referents for the multivariate Poisson regression analysis. Following regression analysis, male sex, Junior Enlisted and Senior Enlisted ranks, Army and Marine Corps service, and all ages less than 40 were found to be at significantly increased risk of gunshot injuries when compared to their respective referents (Tables 1 and 2). However, only male sex, Junior Enlisted ranks, Army and Marine service, and ages 20–29 demonstrated statistically significant IRRs as well as unadjusted IRs greater than the population mean. Army service was found to have the highest adjusted IRR at 21.92 (95% CI 17.37, 27.65).

## 5. Discussion

Ballistic missiles have been recognized as a substantial cause of combat-related morbidity and mortality since their widespread introduction in the Age of Gunpowder. Indeed, even as their incidence has diminished over the course of the last century and a half,[1] the lethality of war-related gunshot wounds has increased.[5,6,8,14,15] However, it should be noted that since the Vietnam conflict, war-related penetrating head injuries have been more likely to result from gunshots than munitions fragments.[15] In OIF and OEF, gunshot wounds have been reported to account for 19–24% of all combat injuries.[1–3,7,8]

Presently, war injuries from gunshot are divided into low velocity (pistol, Fig. 1) and high velocity (automatic rifle, Fig. 2) wounds. Particularly when high velocity gunshots involve the face or head, these injuries are widely recognized as carrying a poor prognosis and high prevalence of mortality.[5,6,15] While several reports have incidentally documented gunshot wounds within the scope of analyses involving OIF[2,3,5–9] and OEF,[3,5,10,11] none have described the incidence of such injuries, or postulated risk factors for their occurrence. The main obstacle in this respect rests in the fact that most prior studies have focused on the individual experiences of military units,[2,5,9] medical units,[10,11] or theater

**Table 1**
Unadjusted Incidence Rates (IR) and Adjusted Incidence Rate Ratios (IRR) of gunshot wounds among US military servicemembers, 2000–2009.

| Category | Number of cases | Person-years | Unadjusted IR[a] | Adjusted IRR (95% CI) | $p$-value |
|---|---|---|---|---|---|
| Male | 4627 | 11,795,305 | 0.39 | 6.02 (4.71, 7.68)[b] | <0.001 |
| Female | 66 | 2,018,028 | 0.03 | N/A | N/A |
| Junior Enlisted | 2896 | 6,077,634 | 0.48 | 2.00 (1.50, 2.66)[c] | <0.001 |
| Junior Officers | 265 | 1,354,332 | 0.20 | 1.27 (0.94, 1.72)[c] | 0.12 |
| Senior Enlisted | 1472 | 5,506,970 | 0.27 | 1.96 (1.49, 2.60)[c] | <0.001 |
| Senior Officers | 60 | 874,397 | 0.07 | N/A | N/A |
| Army | 3274 | 4,976,608 | 0.66 | 21.92 (17.37, 27.65)[d] | <0.001 |
| Navy | 122 | 3,549,191 | 0.03 | 1.30 (0.97, 1.74)[d] | 0.08 |
| Air Force | 73 | 3,484,086 | 0.02 | N/A | N/A |
| Marines | 1224 | 1,803,448 | 0.68 | 17.78 (14.03, 22.53)[d] | <0.001 |

N/A = not applicable because this category was used as the referent category for calculations.
[a] Incidence rate is per 1000 person-years.
[b] Adjusted for age, race, rank group, and service. Female was the referent category.
[c] Adjusted for age, sex, race, and service. Senior Officers was the referent category.
[d] Adjusted for age, sex, race, and rank group. Air Force was the referent category.

**Table 2**
Incidence rate ratios (IRR) of Gunshot Wounds among servicemembers in the U.S. military, 2000–2009, by age group.

| Age group | No. of cases | Person-years | Incidence rate[a] | Adjusted IRR (95% CI)[b] | *p*-value |
|---|---|---|---|---|---|
| <20 | 324 | 1,084,882 | 0.30 | 2.18 (1.70, 2.79) | <0.001 |
| 20–24 | 2482 | 4,613,200 | 0.54 | 4.16 (3.32, 5.20) | <0.001 |
| 25–29 | 1043 | 2,919,000 | 0.36 | 3.21 (2.58, 4.01) | <0.001 |
| 30–34 | 491 | 1,996,712 | 0.25 | 2.48 (1.98, 3.12) | <0.001 |
| 35–39 | 252 | 1,773,252 | 0.14 | 1.63 (1.29, 2.07) | <0.001 |
| 40+ | 101 | 1,426,287 | 0.07 | N/A | N/A |

N/A = not applicable because this category was used as the referent.
[a] Incidence rate is per 1000 person-years.
[b] Adjusted for sex, service, rank group and race. The 40+ year-old group was used as the referent category.

hospitals[6,8,10] with relatively small samples and no means to define a population cachement. As a result, the ability to quantify a true incidence of war-related gunshot wounds is obviated in these prior works.

The present study engaged the DMED as a means to define a known population at risk, and capture a substantial number of American military personnel who sustained gunshot wounds as a result of combat. This report represents the first time that an incidence of gunshot wounding has been calculated for a time-period encompassing the Global War on Terror.

We report an overall incidence of gunshot wounds of 0.34 per 1000 person-years. Furthermore, this study identified male sex, Junior Enlisted rank, Army and Marine Corps service, and ages 20–29 as significant independent risk factors for gunshot injuries. While Senior Enlisted rank and ages <20, 30–34, and 35–39 also demonstrated significant adjusted IRRs relative to their referents, we employ caution in interpreting such findings as none of these categories exhibited unadjusted IRs greater than the population average.

Many of the risk factors identified in this analysis are substantiated by the results of prior studies. For example, Owens et al.,[3] Ramasamy et al.,[7] and Lakstein and Blumenfeld[14] identified combat injuries and/or gunshot wounds as predominantly occurring in males. Similarly, Owens et al.,[3] and Belmont et al.[2] both documented an increased incidence of combat wounds among enlisted personnel. Zouris and co-workers found that Marines were at greater risk of war injury relative to Naval personnel[9] and several

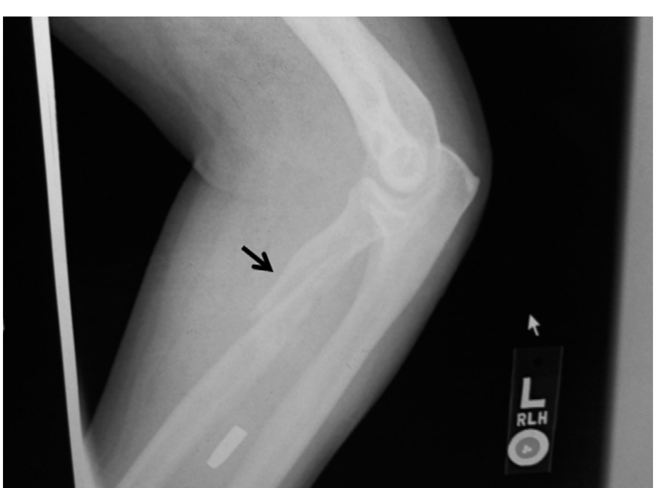


**Fig. 1.** Radiograph of a low velocity gunshot wound to the left forearm. The bullet is visible in between the radius and ulna. The gunshot wound caused a minimally displaced proximal radius fracture (arrow).

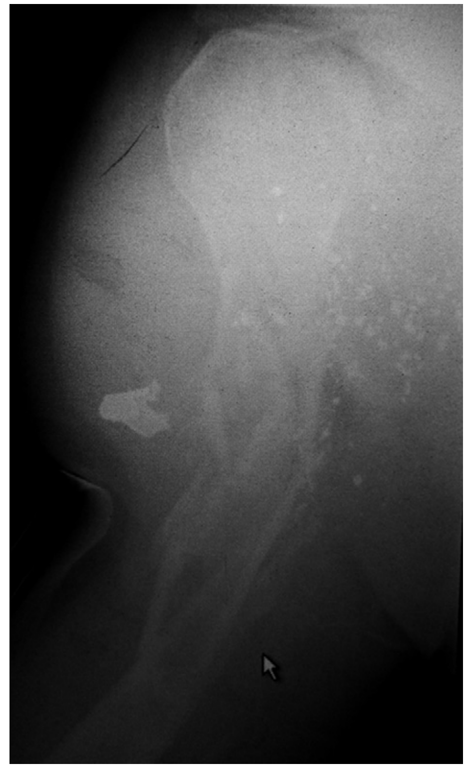

**Fig. 2.** Radiograph of a high velocity gunshot wound to the right proximal humerus. The gunshot caused massive soft-tissue devitalization, along with a comminuted proximal humeral shaft fracture with substantial bone loss, and radial and axillary nerve palsies.

authors have reported servicemembers in the third decade of life to be at increased risk of battle wounding[3,6] or combat-related gunshot injury.[7] Most of these factors can be explained by the direct exposure of individuals of male sex, enlisted rank, and younger age (often because of position in the rank structure) to the combat environment. While Naval and Air Force personnel also participate in combat, the asymmetric structure of the current conflicts limits their exposure to situations where gunshot injuries might occur.[1]

Although the DMED does not contain detailed information regarding zones of injury with respect to gunshots, data contained within the Joint Theater Trauma Registry (JTTR) highlights the magnitude of these wounds. In their review of the JTTR from 2001 to 2005, Owens et al. documented that gunshot wounds were responsible for 8% of all combat-related head and neck injuries, 19% of thoracic wounds, 17% of abdominal wounds, and 17% of extremity injuries.[3] A more recent survey of the JTTR conducted by the present authors revealed 2392 musculoskeletal wounds precipitated by gunshot (Table 3).

**Table 3**
Musculoskeletal injuries due to gunshot wounds as reported in the Joint theater trauma registry (2005–2009).

| Injury Description | Number (percent of total) |
|---|---|
| Musculoskeletal injuries | 2392 (100%) |
| Soft-tissue injuries | 1042 (44%) |
| Open fractures | 813 (34%) |
| Closed fractures | 178 (7%) |
| Amputation | 42 (2%) |
| Neurological injuries | 297 (12%) |
| Joint dislocations | 20 (1%) |

Of these, 34% entailed open fractures, while 12% resulted in neurological injuries. Two-percent of gunshot wounds precipitated an amputation.

It should be appreciated that limitations are present in this analysis. One must recognize that this was a database study and our findings are limited by the information contained within the DMED. The most ready example of this is that, as the DMED does not contain information on soldiers killed in action, our findings are solely informed by the cases of servicemembers who survived their wounding long enough to reach a medical facility in Germany or the United States. Another example is that the study would have been enhanced by knowledge of the specific military specialty of the injured servicemembers (i.e. infantryman, combat engineer, truck driver, etc.) as well as the theater in which the gunshot wound occurred. However, such data are not captured by the DMED system.

Furthermore, as reporting within the DMED is entirely dependent on the accuracy of coding in the military's electronic medical records systems, there is the possibility that coding error skewed our results. Finally, as the population cachement for the DMED includes the entire military population, and not solely those individuals deployed to a combat zone, the overall IR reported here is likely an underestimation of the incidence of gunshot wounds among personnel actually present in a theater of hostilities.

In spite of these limitations, it should be appreciated that this analysis is the first such work to report an incidence of combat-related gunshot wounds for American military personnel in the Global War on Terror and one of the few to propose risk factors for the development of war injuries. The findings of this report could have a direct impact on targeting at risk populations within the armed forces with enhanced personnel protective equipment, as well as education that could potentially mitigate the risk of such battlefield injuries. Undoubtedly, as more investigations continue to document the nature of combat wounds in the Global War on Terror, a more enhanced appreciation for the true scope of injuries and precipitating mechanisms for their occurrence may be had.

## Disclaimer

Some authors are employees of the U.S. Federal Government and the United States Army. 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 William Beaumont Army Medical Center, Winn Army Community Hospital, the Department of Defense, or United States government.

*Conflict of interest statement*

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## Author contribution

Walker – study design, data collection, data analysis, writing.
Kelly – study design, data analysis, writing.
McCriskin – data collection, data analysis.
Bader – data analysis, writing.
Schoenfeld – study design, data collection, data analysis, writing.

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