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Odds of Hospitalization Among Marine Corps Personnel by Military Occupational Specialty and Causative Agents During OEF and OIF

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ABSTRACT Objective: This study investigated the risk of hospitalization among Marines deployed during Operations Enduring and Iraqi Freedom by military occupational specialty (MOS). Methods: Trends in risk of hospitalization as a function of injury cause (explosive munitions and small arms [EM/SA]), anatomical location, and injury type were analyzed to identify which MOSs were more likely to have open wound injuries or trauma to the extremities. The study population consisted of 163,939 Marines deployed at any time during the study period (September 11, 2001–January 31, 2007). Hospitalized Marines (n = 2,718) were matched to nonhospitalized Marines on rank, time deployed, and number of deployments. Results: Noninfantry MOSs had lower risk of hospitalization compared with infantry, regardless of injury cause or location. Trends differed for EM/SA versus other injury causative agents, but did not differ by anatomical location among EM/SA. Conclusion: This information allows for quantitative assessment of risk by MOS in combat situations.

INTRODUCTION

The objective of the present study was to characterize the effect of military occupational specialty (MOS) on wounding patterns and subsequent hospitalizations among Marines deployed in Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF). Previous research has shown that rates of wounded in action (WIA) and disease and nonbattle injury (DNBI) hospitalizations during OEF, OIF, and other combat operations differed by combat phase and branch of service.[1–4] Before OEF and OIF, DNBI rates were shown to differ by MOS.[5] Therefore, we hypothesized that risk of hospitalization would differ by MOS during OEF and OIF, with infantry personnel having the highest risk of hospitalization.

In previous and current conflicts, including OEF and OIF, explosive munitions and small arms (EM/SA) caused more than 50% of injuries.[6–8] Upper and lower extremity (UE/LE) injuries make up more than 60% of injuries sustained during OEF and OIF[6,8–10] and are among the most common EM/SA injury locations.[6] Open wounds represent more than 40% of injuries sustained during OEF and OIF and are the most common EM/SA injury types.[6] Consequently, investigating EM/SA wounding metrics and their relationship to extremity injuries and open wounds is essential for future medical planning.

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METHODS

Deployment data were obtained from the Defense Manpower Data Center. Demographic and hospitalization data were obtained from the Career History Archival Medical and Personnel System.[11] Hospitalization data included *International Classification of Diseases*, Ninth Revision (ICD-9) diagnoses for hospitalizations because of DNBI and WIA. The cause of injury leading to hospitalization was also included.

A total of 170,704 U.S. Marine Corps personnel were deployed in support of OEF and OIF at any time during the period of September 11, 2001–January 31, 2007. Of the 170,704 deployed Marines, 2,835 were hospitalized at least once during their deployment for DNBI or WIA. Hospitalization was defined as an admission to a treatment facility requiring a 24-hour stay. Only the first instance of hospitalization was used in the analysis.

Previous research indicates that military rank is a risk factor for injury and/or hospitalization[6] and is positively correlated with age.[12,13] Time at risk (i.e., number of deployments) and temporal risk (i.e., deployment during periods of intense fighting) were also considered potential risk factors for hospitalization and were controlled along with military rank. This was accomplished using individual category matching. Every deployed Marine was placed into a category on the basis of number of deployments, time injured (for hospitalized cases) or deployed (for controls or nonhospitalized), and rank. Rank was divided into five groups: (1) E1–E4, (2) E5–E9, (3) O1–O4, (4) O5–O9, and (5) warrant officer. Deployment time was broken down into four quarters: January–March, April–June, July–September, and October–December. A nonhospitalized Marine was placed into a deployment quarter if he or she was in theater at any point during the quarter. Marines may have been in more than one deployment quarter (e.g., deployed for more than 3 months). Permutations of number of deployments, rank, and deployment time resulted in 420 categories. Marines were matched on the following criteria: cases and controls had the same number of deployments, cases and controls were of the same rank category, and controls who were deployed during the same quarter cases were injured.

The individual category matching process yielded 2,718 cases (hospitalized) and 161,221 controls (not hospitalized). Controls with no matching cases (n = 6,648) were excluded from analysis. A small percentage of cases without matching controls were also excluded (n = 117). This population of 163,939 Marines was used to address whether the risk of hospitalization differed by MOS and to compare trends in risk of EM/SA and other injury hospitalizations by MOS.

To examine the effect of MOS on the odds of anatomical injury location-specific and injury type-specific hospitalizations (among EM/SA only), data were rematched so that a nonhospitalized Marine (control) was matched to an EM/SA-hospitalized Marine. The matching criteria (deployment period, number of deployments, and rank) were applied and resulted in a second study population of 145,725 Marines (1,230 cases [hospitalized] and 144,495 controls [not hospitalized]).

MOS was the exposure of interest (or independent variable) for all analyses. The Marines break their enlisted and officer jobs down into MOSs and group them with similar functions together into groups called "Occupational Fields." The occupational fields that were considered in the first study population that includes EM/SA and other injury causative agents were (1) Infantry; (2) Motor Transport; (3) Communications; (4) Aircraft Maintenance; (5) Engineer, Construction Facilities and Equipment; (6) Supply Administration and Operations; (7) Field Artillery; (8) Logistics; and (9) Other. The Other category included all other occupational groups that comprised less than 3% of the data set. For the second study population (or the EM/SA only data set), the Logistics MOS was included in the Other category because of sparse data.

Four separate analyses of the effect of MOS on the hospitalization outcome were performed: (1) odds of hospitalization because of any cause (hospitalized versus nonhospitalized), (2) odds of hospitalization because of EM/SA causes contrasted with odds of hospitalization because of other causes, (3) odds of hospitalization from EM/SA-induced extremity injuries contrasted with odds of hospitalization from EM/SA injuries located elsewhere, and (4) odds of hospitalization from EM/SA-induced open wounds contrasted with odds of hospitalizations from other EM/SA injuries. All statistical analyses were performed using SAS statistical software, version 9.1 (SAS Institute, Inc., Cary, NC).

A detailed description of the statistical methods has been divided by two types: models investigating dichotomous outcomes and models investigating multiple outcomes.

Dichotomous Outcomes

Because the study design included matching, conditional logistic regression was used to determine the odds ratios (ORs) and 95% confidence intervals (CIs) for the dichotomous outcome model. MOS was the exposure of interest and hospitalization status was the outcome of interest. Observations with missing values for exposure or outcome were not included in the analysis.

Multiple Outcomes

Polychotomous logistic regression (PLR) was used to determine the OR and 95% CI for the multiple outcomes. PLR is an extension of logistic regression where multiple outcomes can be considered. PLR is similar to dividing the population into smaller subsets and considering each outcome individually and generally yields similar results. Using PLR adheres to the study design by considering several possible outcomes.

For example, consider the three outcomes of EM/SA hospitalization, other hospitalization, and a reference outcome of no hospitalization. Also consider MOS as the exposure of interest. PLR results in a set of ORs relating exposures to each outcome: the effect MOS has on the odds of EM/SA hospitalization versus no hospitalization and the effect MOS has on the odds of other hospitalization versus no hospitalization.

RESULTS

Hospitalized versus Nonhospitalized

Table I shows the distribution and OR of hospitalization status by MOS. Compared with Infantry, all of the other MOS groups have lower odds of hospitalization ($p < 0.001$). Supply Administration and Operations had the lowest odds of hospitalization in comparison with Infantry. Those in Supply Administration and Operations had 0.29 the odds (or 71% fewer odds) of hospitalization when compared with Infantry (95% CI, 0.21–0.38). Inverting the OR allows us to consider Infantry's risk of hospitalization. Thus, Infantry had 3.48 the odds of hospitalization (95% CI, 2.63–4.61) when compared with Supply Administration and Operations. Field Artillery had the highest odds of hospitalization when compared with Infantry. Those in Field Artillery had 0.48 the odds (or 52% fewer odds) of hospitalization compared with Infantry (95% CI, 0.37–0.60).

EM/SA Hospitalization, Other Hospitalization, and Nonhospitalization

This analysis investigated the odds of any hospitalization for specific MOS groups with polychotomous hospitalization subtypes: hospitalization as a result of an EM/SA cause and those as a result of a non-EM/SA cause. Table II shows the breakdown of EM/SA versus non-EM/SA cause by MOS.

When considering hospitalizations caused by EM/SA injury and those that were not, Infantry still has the highest odds of hospitalization. However, the OR profile between the two logit models is significantly different ($p < 0.0001$). This indicates that the OR trends by MOS are significantly different for hospitalizations because of EM/SA and hospitaliza-

TABLE I. Odds Ratios for Hospitalization by Military Occupational Specialty

Military Occupational Specialty	Total (*n* = 163,939)		Not Hospitalized (*n* = 161,221)		Hospitalized (*n* = 2,718)			
	No.	(%)	No.	(%)	No.	(%)	OR (95% CI)	*p* value
Infantry	40,760	(24.9)	39,417	(24.4)	1,343	(49.4)	Ref	<0.001
Motor Transport	14,842	(9.1)	14,620	(9.1)	222	(8.2)	0.48 (0.41, 0.55)	
Communications	13,465	(8.2)	13,323	(8.3)	142	(5.2)	0.37 (0.31, 0.44)	
Aircraft Maintenance	11,162	(6.8)	11,081	(6.9)	81	(3.0)	0.29 (0.23, 0.37)	
Engineer, Construction, Facilities, and Equipment	10,148	(6.2)	9,996	(6.2)	152	(5.6)	0.48 (0.40, 0.56)	
Supply Administration and Operations	6,012	(3.7)	5,960	(3.7)	52	(1.9)	0.29 (0.21, 0.38)	
Field Artillery	5,478	(3.3)	5,401	(3.4)	77	(2.8)	0.48 (0.37, 0.60)	
Logistics	4,969	(3.0)	4,928	(3.1)	41	(1.5)	0.30 (0.21, 0.40)	
Other	57,103	(34.8)	56,495	(35.0)	608	(22.4)	0.39 (0.35, 0.43)	

OR, odds ratio; CI, confidence interval.

TABLE II. Odds Ratios for EM/SA and Other Hospitalization by Military Occupational Specialty

Military Occupational Specialty	Not Hospitalized (*n* = 161,221)		Hospitalized, EM/SA (*n* = 1,230)			Hospitalized, Other (*n* = 1,488)		
	No.	(%)	No.	(%)	OR (95% CI)[a]	No.	(%)	OR (95% CI)[a]
Infantry	39,417	(24.4)	843	(68.5)	Ref	500	(33.6)	Ref
Motor Transport	14,620	(9.1)	57	(4.6)	0.18 (0.14, 0.24)	165	(11.1)	0.89 (0.75, 1.06)
Communications	13,323	(8.3)	41	(3.3)	0.14 (0.11, 0.20)	101	(6.8)	0.60 (0.48, 0.74)
Aircraft Maintenance	11,081	(6.9)	11	(0.9)	0.05 (0.03, 0.08)	70	(4.7)	0.50 (0.39, 0.64)
Engineer, Construction, Facilities, and Equipment	9,996	(6.2)	54	(4.4)	0.25 (0.19, 0.33)	98	(6.6)	0.77 (0.62, 0.96)
Supply Administration and Operations	5,960	(3.7)	8	(0.7)	0.06 (0.03, 0.17)	44	(3.0)	0.58 (0.43, 0.79)
Field Artillery	5,401	(3.4)	32	(2.6)	0.28 (0.19, 0.40)	45	(3.0)	0.66 (0.48, 0.89)
Logistics	4,928	(3.1)	4	(0.3)	0.04 (0.01, 0.10)	37	(2.5)	0.59 (0.42, 0.83)
Other	56,495	(35.0)	180	(14.6)	0.15 (0.13, 0.18)	428	(28.8)	0.60 (0.53, 0.68)

Note: Trends in logit model odds ratios for EM/SA versus other hospitalizations were statistically different ($p < 0.001$). EM/SA, explosive munitions and small arms; OR, odds ratio; CI, confidence interval.
[a]Logit model odds ratios.

tions because of other causes. Table II shows the OR profiles for EM/SA cause and non-EM/SA cause by MOS.

Because of the significant difference in OR profiles, it makes sense to consider a subset of data that consider cases hospitalized because of EM/SA and associated controls, as we do in the next section.

EM/SA Hospitalizations: Upper Extremity, Lower Extremity, and Other Injuries

Anatomical location of injury for this analysis was derived from the Barell Matrix,[14] which uses primary diagnoses and ICD-9 codes. Table III shows the breakdown of injury location by MOS and OR by MOS stratified by anatomical injury location.

When considering hospitalizations with an EM/SA cause, Infantry still has high odds of hospitalization compared with other MOS groups. Additionally, the OR profile is not different based on anatomical location of injury (LE vs. UE, $p = 0.5108$; other vs. UE, $p = 0.5620$; other vs. LE, $p = 0.1884$). Thus, we would not expect to see significantly different trends in the OR by MOS when stratified by anatomical injury location.

Given that the cause of injury was EM/SA, the odds ratios for Infantry being hospitalized because of an UE injury had a high of 0.33 (95% CI, 0.18–0.63), with Field Artillery having 0.33 times the odds (or 67% fewer odds) of hospitalization because of an UE injury compared with Infantry. The lowest odds ratio was 0.05 (95% CI, 0.016–0.16) with those in Aircraft Maintenance having 0.05 times the odds (or 95% fewer odds) of hospitalization because of an UE injury compared with Infantry.

Given that the cause of injury was EM/SA, the odds ratios for Infantry personnel being hospitalized because of a LE injury had a low of 0.05 (95% CI, 0.016–0.158) with those in Aircraft Maintenance having 0.05 times the odds (or 95% fewer odds) of hospitalization caused by a LE injury versus Infantry. The highest odds ratio was 0.28 (95% CI, 0.187–0.428),

TABLE III. EM/SA Hospitalization Odds Ratios for Upper Extremity, Lower Extremity, and Other Injuries by Military Occupational Specialty

Military Occupational Specialty	Not Hospitalized (n = 144,495)		Hospitalized, EM/SA Injuries: Upper Extremity (n = 324)			Lower Extremity (n = 454)			Other (n = 452)		
	No.	(%)	No.	(%)	OR[a]	No.	(%)	OR[a]	No.	(%)	OR[a]
Infantry	36,100	(25.0)	223	(68.8)	Ref	325	(71.6)	Ref	295	(65.3)	Ref
Motor Transport	13,929	(9.6)	12	(3.7)	0.14	18	(4.0)	0.14	27	(6.0)	0.24
Communications	11,944	(8.3)	6	(1.9)	0.08	17	(3.7)	0.16	18	(4.0)	0.18
Aircraft Maintenance	9,628	(6.7)	3	(0.9)	0.05	4	(0.9)	0.05	4	(0.9)	0.05
Engineer, Construction, Facilities, and Equipment	9,437	(6.5)	15	(4.6)	0.26	24	(5.3)	0.28	15	(3.3)	0.20
Supply Administration and Operations	5,540	(3.8)	2	(0.6)	0.06	3	(0.7)	0.06	3	(0.7)	0.07
Field Artillery	4,853	(3.4)	10	(3.1)	0.33	9	(2.0)	0.21	13	(2.9)	0.33
Other[b]	53,064	(36.7)	53	(16.4)	0.16	54	(11.9)	0.11	77	(17.0)	0.18

Note: Trends in logit model odds ratios were not statistically different for upper versus lower extremity injuries ($p = 0.51$), upper extremity versus other injuries ($p = 0.56$), and lower extremity versus other injuries ($p = 0.19$). EM/SA, explosive munitions and small arms; OR, odds ratio.
[a]All logit model odds ratios were significant at the $p < 0.05$ level. [b]Includes Logistics specialty.

TABLE IV. EM/SA Hospitalization Odds Ratios for Open Wounds and Other Injuries by Military Occupational Specialty

Military Occupational Specialty	Not Hospitalized (n = 144,495)		Hospitalized, EM/SA Injuries: Open Wounds (n = 388)			Other Injury (n = 842)		
	No.	(%)	No.	(%)	OR[a]	No.	(%)	OR[a]
Infantry	36,100	(25%)	275	(71%)	Ref	568	(67%)	Ref
Motor Transport	13,929	(10%)	13	(3%)	0.12	44	(5%)	0.2
Communications	11,944	(8%)	11	(3%)	0.12	30	(4%)	0.16
Aircraft Maintenance	9,628	(7%)	4	(1%)	0.06	7	(1%)	0.05
Engineer, Construction, Facilities, and Equipment	9,437	(7%)	19	(5%)	0.26	35	(4%)	0.24
Supply Administration and Operations	5,540	(4%)	2	(1%)	0.05	6	(1%)	0.07
Field Artillery	4,853	(3%)	7	(2%)	0.19	25	(3%)	0.33
Other[b]	53,064	(37%)	57	(15%)	0.14	127	(15%)	0.15

Note: Trends in logit model odds ratios for open wound versus other injury type were not significantly different ($p = 0.68$). EM/SA, explosive munitions and small arms; OR, odds ratio.
[a]All logit model odds ratios were significant at the $p < 0.05$ level. [b]Includes Logistics specialty.

with those in Engineering and Construction having 0.28 times the odds (or 72% fewer odds) of hospitalization because of a LE injury versus Infantry.

Given that the cause of injury was EM/SA, the odds ratios for Infantry being hospitalized because of an Other injury had a high of 0.33 (95% CI, 0.188–0.572), with those in Field Artillery having 0.33 times the odds (or 67% fewer odds) of hospitalization because of an Other injury compared with Infantry. The lowest odds ratio was 0.05 (95% CI, 0.019–0.136), with those in Aircraft Maintenance having 0.05 times the odds (or 95% fewer odds) of hospitalization because of an Other injury versus Infantry. Differences between the logit models were not significantly different (UE vs. LE injuries [$p = 0.51$], UE vs. other injuries [$p = 0.56$], and LE vs. other injuries [$p = 0.19$]).

EM/SA Hospitalizations: Open Wounds and Other Injuries

Table IV shows the breakdown of injury type by MOS and odds ratios by MOS stratified by injury type.

When considering hospitalizations with an EM/SA cause, Infantry still had high odds of hospitalization compared with other MOS groups. The OR profile was not significantly different based on injury type ($p = 0.68$). Thus, we would not expect to see different trends in the OR by MOS when stratified by injury type.

Given that the hospitalization was caused by an EM/SA, the odds ratios for Infantry being hospitalized because of an open wound had a high of 0.26 (95% CI, 0.166–0.421), with those in Engineer, Construction, Facilities, and Equipment having 0.26 times the odds (or 74% fewer odds) of hospitalization because of an open wound than Infantry. The odds ratios had a low of 0.05 (95% CI: 0.012–0.191), with those in Supply Administration and Operations having 0.05 times the odds (or 95% fewer odds) of hospitalization because of an open wound compared with Infantry.

Odds ratios for Infantry being hospitalized because of another injury type had a high of 0.33 (95% CI, 0.219–0.489), with Field Artillery having 0.33 times the odds (or 67% fewer odds) of hospitalization because of an Other injury type versus Infantry. The odds ratios had a low of 0.05 (95% CI, 0.022–0.097), with those in Aircraft Maintenance having 0.05 times the odds (or 95% fewer odds) of hospitalization because of an Other injury type versus Infantry.

DISCUSSION

This study found that Infantry had the highest risk of hospitalization regardless of the injury cause (EM/SA, other causes), injury type (open wounds, other injury types), or anatomical injury location (UE, LE, other injury location). This higher risk ranged from a low of 1.12 times higher odds of hospitalization because of a non-EM/SA injury cause when compared with Motor Transport, to a high of 20 times higher odds of hospitalization because of other injury type versus Aircraft Maintenance. This higher risk is likely the result of infantry experiencing higher levels of combat than other MOS groups. Future work will examine various occupation specialties within Infantry to provide further risk of hospitalization. For example, the risk of hospitalization among riflemen and machine gunners.

A previously unpublished finding is that MOS group risk trends differ between EM/SA and other hospitalization causes (J.M. Zouris, unpublished data). That is, risk patterns for different MOS groups differ when stratified by cause (EM/SA vs. other injury cause). This may be because of the inclusion of DNBI hospitalizations in the Other cause category. Rates of disease hospitalization do not significantly differ between MOS groups (data not shown). Thus, including disease data in the Other category may have diluted the association between MOS and WIA hospitalizations. Future research should investigate risk stratified by type of hospitalization (disease, NBI, and WIA).

Looking exclusively at injuries caused by explosives, there was no evidence to suggest that MOS group risk patterns changed on the basis of the anatomical location of injury (LE, UE, or other location) or the type of injury (open wounds, other injury type). One potential explanation for this finding is that once a Marine is in an EM/SA situation, the risk for all injury types and locations are equally likely (within a specific MOS). Other anatomical locations and injury types would need to be evaluated to validate this hypothesis.

Identifying risk of hospitalization among military personnel is important for combat effectiveness, manpower replacements, and implications for logistical planning and medical simulations. Combat effectiveness is a combination of operational and tactical effectiveness, which is the performance of military units in direct contact with the enemy. Identifying which MOS are at highest risk provide meaningful information on the tactical effectiveness that can be directly attributed to the actual performance of combatant forces (infantry, armor, artillery, warships, and combat aviation units) in engagements with the enemy.

Manpower replacements can be directly related to which units are being lost because of illness and injury. Manpower replacements are required for unit filler or casualty replacements. Early identification allows for the mobilization planning of these units. Normally reserve units are identified in commander-in-chief (CINC)-developed operation plans (OPLANs) and time-phased force and deployment data.

As reported in this study, infantry units were at highest risk followed by motor transport. Motor vehicle accidents were a major problem during OIF primarily because of the rough terrain, poor visibility, constant maneuvering of troops, and the fast moving convoys. Future planning should take into consideration MOS specialties that are at highest risk when developing time-phased force and deployment data and redeployment assignments.

Overall, this study reaffirmed that the Infantry Military Occupational Specialty group has the highest risk of hospitalization overall after matching with other MOS groups on the basis of rank, number of deployments, and deployment time. After matching, Infantry also had the highest risk of hospitalization when considering hospitalizations caused by EM/SA and hospitalizations as a result of other causes. Analyzing the odds ratios further, the study found that the injury types (open wounds vs. other types) and locations (UI, LE, and other locations) tested in the analysis did not have different odds ratio trends among the various MOS.

Identifying risk of hospitalization among military personnel is important for combat effectiveness, manpower replacements, and implications for logistical planning and medical simulations. Furthermore, as with any medical topic, surgeons must understand the pathophysiology of war wounds to best care for the patient.

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14. ABSTRACT (maximum 200 words)

This study investigated the risk of hospitalization among Marines deployed during Operations Enduring and Iraqi Freedom by Military Occupational Specialty (MOS). Trends in risk of hospitalization as a function of injury cause (explosive munitions and small arms [EM/SA]), anatomical location, and injury type were analyzed to identify which MOSs were more likely to have open wound injuries or trauma to the extremities. The study population consisted of 163,939 Marines deployed at any time during the study period (September 11, 2001–January 31, 2007).Hospitalized Marines (*n* = 2,718) were matched to nonhospitalized Marines on rank, time deployed, and number of deployments. Non-Infantry MOSs had lower risk of hospitalization compared with Infantry, regardless of injury cause or location. Trends differed for EM/SA versus other injury causative agents, but did not differ by anatomical location among EM/SA. This information allows for quantitative assessment of risk by MOS in combat situations.

14. SUBJECT TERMS
odds ratios, wounded-in-action, operation Iraqi Freedom, Marines, causative agents, explosive munitions, small arms

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UNCL	UNCL	UNCL	UNCL	6	Commanding Officer

18b. TELEPHONE NUMBER (INCLUDING AREA CODE)
COMM/DSN: (619) 553-8429