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Disease and Nonbattle Injuries Sustained by a U.S. Army Brigade Combat Team During Operation Iraqi Freedom

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ABSTRACT Background: A longitudinal cohort analysis of disease nonbattle injuries (DNBI) sustained by a large combat-deployed maneuver unit has not been performed. Methods: A descriptive analysis was undertaken to evaluate for DNBI casualty care statistics incurred by a U.S. Army Brigade Combat Team (BCT) during a counterinsurgency campaign of Operation Iraqi Freedom. Results: Of the 4,122 soldiers deployed, there were 1,324 DNBI with 5 (0.38%) deaths, 208 (15.7%) medical evacuations (MEDEVAC), and 1,111 (83.9%) returned to duty. The DNBI casualty rate for the BCT was 257.0/1,000 soldier combat-years. Females, compared with males, had a significantly increased incidence rate ratio for becoming a DNBI casualty 1.67 (95% CI 1.37, 2.04). Of 47 female soldiers receiving MEDEVAC 35 (74%) were for pregnancy-related issues. Musculoskeletal injuries (50.4%) and psychiatric disorders (23.3%) were the most common body systems involved with DNBI casualties. Among the BCT cohort the psychiatric DNBI casualty rate and suicide rate were 59.8 and 0.58 per 1,000 soldier combat-years. The BCT cohort incidence rates for common musculoskeletal injuries per 1,000 combat–years were as follows: ankle sprain 15.3, anterior cruciate ligament rupture 3.3 and shoulder dislocation 1.2. Conclusions: Musculoskeletal injuries and psychiatric disorders accounted for 74% of the total DNBI casualties, and 43% of the DNBI casualties requiring subsequent MEDEVAC. The BCT cohort had a suicide rate nearly four times greater than previously reported, and selected musculoskeletal injury incidence rates were fivefold greater than the general population.

INTRODUCTION

There are five important sources of personnel attrition in the combat zone: (1) enemy action, which by definition includes not only battle injuries but also being captured; (2) disease; (3) nonbattle injury; (4) desertion; and (5) administrative action that results in the soldier being transferred.[1] Historically, disease and nonbattle injury (DNBI) has resulted in significantly more hospitalizations and time lost than battle injuries as a result of the hostile combat environment.[2–7] DNBI has accounted for 75% of all hospitalizations during the initial phases of Operation Iraqi Freedom (OIF).[8] Over the past 6 years during OIF, U.S. military servicemembers have sustained over 893 DNBI deaths, and over 37,732 DNBI casualties have been medically evacuated.[9] It is crucial to examine the current epidemiology of DNBI casualties and their treatment because rigorous scientific investigation of the mortality and health effects of war has been underreported.[10]

DNBI casualty care statistics are dependent on many intrinsic and extrinsic factors for example, the intensity of combat,[8,11–14] type of unit,[12–14] branch of military service, presence of endemic diseases, climate and environment and duration of deployment. Higher DNBI casualty rates have been reported during increased combat intensity[8,11–14] but there have been mixed results when comparing combat versus combat support or combat service support units.[11,12,14] The U.S. Army has reconfigured its structure and the Brigade Combat Team (BCT) is now the basic deployable unit of maneuver. The BCT

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14. ABSTRACT

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cohort in this study is therefore ideal for analysis because it is not only the principal combat unit for the Army but it also participated in a classic counterinsurgency operation "The Surge," making it particularly relevant to the U.S. Army's current military operations.

DNBI epidemiology on a unit level has yet to be defined, and the few existing reports that have been published on DNBI from OIF and from Operation Enduring Freedom (OEF) in Afghanistan have been either from hospitals and surgical treatment facilities.[15–17] The DNBI casualty statistics calculated from such facilities consistently underestimate the magnitude and nature of the problem because the denominator consists only of those reaching such sites. Other reports from Department of Defense administrative health databases are limited in that they only report hospital admission rates for DNBI casualties and fail to account for those soldiers treated in an ambulatory setting and returned to duty.[8,14] Studies of DNBI casualty statistics from World War I through OEF/OIF reflect primarily hospital admissions.[6] Data on ambulatory DNBI casualties must be included with hospitalization and mortality data if an adequate DNBI casualty analysis is to be performed.[18] Thus, the purpose of this research is to conduct a longitudinal cohort study of a large combat unit in which the number of soldiers is known and comprehensive DNBI casualty care incidence rates can be calculated.

METHODS

With approval of our institutional review board, a longitudinal cohort study of a U.S. Army BCT that was deployed to Iraq for 15 months (1.25 years) was performed. Unit rosters were obtained and a comprehensive database was created by querying each soldier's electronic medical record and the unit's casualty rosters. There are multiple levels of care from which information is obtained, starting at the point-of-entry, progressing through all ascending echelons of care, and terminating at a military treatment facility in the U.S. Each soldier's electronic medical record was queried for all medical visits occurring during deployment in OIF. Care was taken to eliminate the multiple counting of DNBI at different levels of care for the same medical problems, as well as to eliminate counting of follow-up visits for the same medical problem to ensure that each medical problem was accounted for only once. It is important to note that a soldier can be counted as a DNBI casualty more than once.

A "casualty" in customary military usage means an active duty servicemember lost to the theater of operations for medical reasons.[1] The term therefore includes illness and noncombat injuries as well as combat injuries. The definition of a battle (combat) injury is as follows[19]

Any casualty incurred as the direct result of hostile action sustained in combat or sustained going to or from a combat mission. Included are persons killed or wounded accidentally by friendly fire directed at a hostile force or what was thought to be a hostile force. However, the following injuries are not battle casualties: (1) self-inflicted wounds (except in unusual cases); and (2) wounds or death inflicted by a friendly force

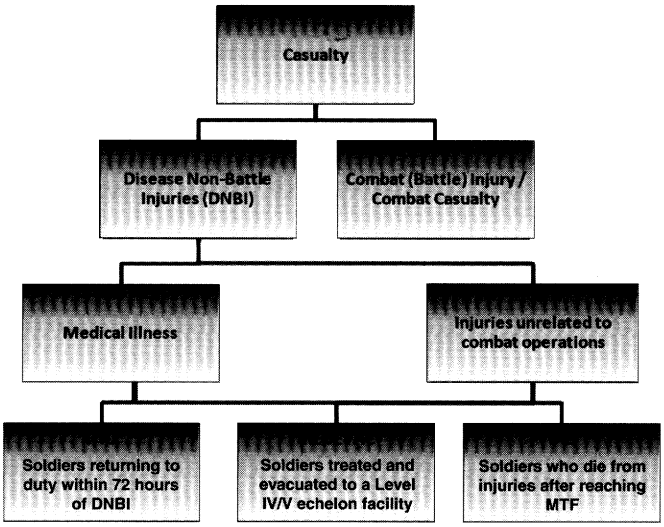

FIGURE 1. Definitions and classification scheme of military casualties.

while the soldier is absent without leave, dropped from the rolls, or is a voluntary absentee from his or her place of duty.

The DNBI casualty classification is subdivided into soldiers who died from DNBI (died), those treated and medically evacuated (MEDEVAC) and those treated and returned to duty within 72 hours (RTD) (Fig. 1).[20] The DNBI were further analyzed and categorized by body system to include head/eyes/ears/nose/throat (HEENT), pulmonary, cardiovascular, gastrointestinal, genitourinary, female reproductive, musculoskeletal, psychiatric, neurologic, dermatologic, hematologic/infectious disease and endocrine. DNBI musculoskeletal injuries were classified into the following major categories: upper extremity, lower extremity and axial spine. Psychiatric categories were comprised of homicidal/suicidal ideation, depression/mood, bipolar, post-traumatic stress, acute stress reaction, anxiety, adjustment, sleep disturbance, occupational, personality, psychotic, substance abuse and attention-deficit hyperactivity disorders.

Analysis of the BCT's DNBI epidemiology during the combat deployment included the overall DNBI casualty rate and selected musculoskeletal incidence rates to include ankle sprain, plantar fasciitis, anterior cruciate ligament (ACL) ruptures and first-time shoulder dislocation (per 1,000 at-risk combat-years). All ACL ruptures were confirmed by magnetic resonance imaging and only first-time shoulder dislocations were included in the analysis of reported shoulder instability. Additional factors analyzed included age, sex and rank. The rank groups used were junior enlisted (E1–E4), senior enlisted (E5–E9), warrant officers (WO1–WO5) through junior officers (O1–O3), and senior officers (O4–O6).

Statistical analysis was performed using SAS (Cary, NC). Significance was set at $p < 0.05$. The χ^2 test statistic and Poisson regression was used to evaluate whether there was an association between the nominally scaled values of rank group and DNBI casualty care statistics, gender and DNBI casualty care statistics, and body region injured and DNBI

TABLE I. Disease Nonbattle Injury (DNBI) Casualty Care Statistics (Rates per 1,000 Combat-Years [*N*]) by Rank Group

Rank Group	*N*	Died	MEDEVAC	RTD	DNBI Casualty
E1–E4	2079	1.2 (3)	41.9 (109)	228.6* (594)	271.7* (706)
E5–E9	1665	0.5 (1)	40.4 (84)	215.7* (449)	256.6*(534)
O1–O3/WO1–WO5	323	2.5 (1)	27.2 (11)	136.2 (55)	165.9 (67)
O4–O6	55	0.0 (0)	58.2 (4)	189.1 (13)	247.3 (17)
Total	4122	1.0 (5)	40.4 (208)	215.6 (1111)	257.0 (1324)

*Within the same column represents significant difference ($p < 0.05$) of the DNBI Casualty Care Statistics with the O1–O3 group as the referent group. DNBI, disease nonbattle injury; died, died of DNBI; MEDEVAC, medical evacuation; RTD, returned to duty. DNBI casualty rates per 1,000 combat years = (DNBI casualty × 1,000))/($N \times 1.25$).

casualty classification and to estimate the rate of DNBI for each group. The χ^2 statistic was used to assess whether there was any difference between the study groups in the proportions of the risk factor of interest. Fisher's exact test was used when there was not a sufficient sample size for the χ^2 statistic. Poisson regression was use to calculate unadjusted incidence rate ratios (IRR) as well as confidence intervals (CIs) for the demographic categories, using the demographic subset with the lowest incident rate, warrant officers (WO1–WO5) through junior officers (O1–O3).

RESULTS

A total of 4,122 (3,797 male, 325 female) BCT soldiers deployed in support of OIF during the specified time period. The average age was 27.0 years (range, 18 to 52). The median military rank was enlisted grade E4 (SPC). In 4,122 deployed soldiers (5,152 soldier combat-years at risk), there were 390 combat casualties and 1,324 DNBI casualties. Therefore, the majority of casualties sustained by the BCT were a result of DNBI (77.2%). The combat casualty cohort was excluded from the remainder of this analysis. Of the 1,324 DNBI casualties, 5 died of their DNBI, 208 were MEDEVAC, and 1,111 (83.9%) were RTD.

DNBI Casualty Care Statistics

Table I categorizes the DNBI casualty care statistics and incidence rates per 1,000 combat-years by rank group. There were a total of 1,324 DNBI casualties within the BCT for a DNBI casualty incidence rate of 257.0/1,000 soldier combat-years. Enlisted and non-commissioned officers accounted for 93.7% of the DNBI casualties while commissioned officers accounted for 6.3%. The various DNBI casualty care statistical rates per 1,000 combat-years were as follows: died of DNBI = 1.0, MEDEVAC = 40.4 and RTD = 215.6. Both the E1 – E4 (271.7 per 1,000 combat-years; $p < 0.0001$) and the E5 – E9 (256.6 per 1,000 combat-years, $p < 0.001$) rank category were at a significantly increased risk for being a DNBI casualty when compared to the O1–O3/WO1–WO5 category (165.9 per 1,000 combat-years). Both the E1–E4 ($p < 0.0002$) and the E5–E9 ($p < 0.001$) category had significantly higher rates for being a DNBI casualty RTD, 228.6 per 1,000 combat-years and 215.7 per 1,000 combat-years, respectively, when compared to the O1–O3/WO1–WO5 category, which had a DNBI casualty RTD rate of 136.2 per 1,000 combat-years. There was not a significant difference between the rank categories for the died and MEDEVAC DNBI rates.

TABLE II. Disease Nonbattle Injury Casualty Care Statistics (Rates per 1,000 Combat-Years [*N*]) by Sex

Sex	*N*	Died	MEDEVAC	RTD	DNBI Casualty
Female	325	0.0 (0)	115.7* (47)	292.9* (119)	408.6* (166)
Male	3797	1.1 (5)	33.9 (161)	209.0 (992)	244.0 (1158)
Total	4122	1.0 (5)	40.4 (208)	215.6 (1111)	257.0 (1324)

*Within the same column represents significant difference ($p < 0.05$) of the casualty care statistics with males as the referent group.

Table II categorizes the DNBI casualty care statistics and incidence rates per 1,000 combat-years by sex. Females comprised 7.9% of the total population at risk and accounted for 12.5% of the total DNBI. The incidence rate of DNBI casualties was 408.6 per 1,000 combat-years among females and 244.0 per 1,000 combat years among males. Females, compared with males, had a significantly increased incidence rate ratio (IRR) for becoming a DNBI casualty, 1.67 (95% CI 1.37, 2.04). Females had significantly higher rates for being a DNBI casualty MEDEVAC ($p < 0.0001$) and RTD ($p < 0.0020$), 115.7 and 292.9 per 1,000 combat-years respectively, when compared to males, 33.9 and 209.0 per 1,000 combat-years. Additionally female, when compared with male, DNBI casualties were at significantly increased risk for being MEDEVAC, 28.3% compared to 13.9% ($p < 0.0001$).

Table III categorizes the DNBI casualty classification for all soldiers by the body region injured. Of note in the died DNBI casualty classification, the three soldiers with psychiatric disorders died because of self-inflicted gunshot wounds, the cardiovascular death was secondary to a gunshot wound to the chest and the HEENT death was a result of head trauma from a helicopter crash. Musculoskeletal injuries (50.4%) and psychiatric disorders (23.3%) were the most common body systems involved with DNBI casualties, and comprised 43.3% of all DNBI casualties MEDEVAC. When comparing the DNBI casualty classification by body system there was a significant difference among the percentage of DNBI casualties that were MEDEVAC with the following body system being involved when compared to the musculoskeletal system

TABLE III. Disease Nonbattle Injury Casualty Classification by Body System Percentage (*N*)

DNBI Casualty Body System Injured	Died		MEDEVAC		RTD		Total
	%	*N*	%	*N*	%	*N*	*N*
Female Reproductive	0.0	—	*100.0	(35)	0.0	—	35
Endocrine	0.0	—	100.0	(3)	0.0	—	3
Pulmonary	0.0	—	*66.7	(2)	33.3	(1)	3
Cardiovascular	7.1	(1)	35.7	(5)	57.1	(8)	14
Dermatologic	0.0	—	36.8	(7)	63.2	(12)	19
Genitourinary	0.0	—	*36.1	(13)	63.9	(23)	36
Gastrointestinal	0.0	—	*27.0	(17)	73.0	(46)	63
Neurologic	0.0	—	*24.0	(18)	76.0	(57)	75
HEENT	1.7	(1)	*19.0	(11)	79.3	(46)	58
Hematologic/ Infectious Disease	0.0	—	16.3	(7)	83.7	(36)	43
Psychiatric	1.0	(3)	10.7	(33)	88.3	(272)	308
Musculoskeletal	0.0	—	8.5	(57)	91.5	(610)	667
TOTAL	0.4	(5)	15.7	(208)	83.9	(1,111)	1,324

*Within the same column represents significant difference ($p < 0.05$) of the DNBI casualty care statistics with musculoskeletal as the referent group.

8.5%: female reproductive 100% ($p < 0.0001$), genitourinary 36.1% ($p < 0.0001$), gastrointestinal 27.0% ($p < 0.0001$), neurologic 18.0% ($p < 0.0003$) and HEENT 19.0% ($p < 0.022$). There was not a significant difference among the percentage of DNBI casualties that were MEDEVAC when comparing the other body systems involved to the musculoskeletal body system. Of the 325 female soldiers, 35 (10.8%) were MEDEVAC because of female reproductive issues to include 26 pregnancies, 8 miscarriages, and 1 ectopic pregnancy. Seventy-four percent of the 47 females that were MEDEVAC had pregnancy-related issues.

Musculoskeletal Injuries by DNBI Casualty Classification

Table IV categorizes the musculoskeletal DNBI by rank group and casualty classification. The anatomic location of the 667 musculoskeletal DNBI injuries was 270 (40.5%) in the upper extremity, 284 (42.6%) in the lower extremity and 113 (16.9%)

TABLE IV. DNBI Musculoskeletal Injuries by DNBI Casualty Classification and Rank Group

		E1–E4		E5–E9		O1–O3/WO1–WO5		O4–O6		Total	
		RTD	Medevac	RTD	Medevac	RTD	Medevac	RTD	Medevac	RTD	Medevac
Upper Extremity	Fracture	25	5	17	1	2	1	0	0	44	7
	Tendon	3	0	4	0	1	0	1	0	9	0
	Sprain	16	0	18	0	1	0	0	0	35	0
	Strain	2	0	1	0	1	0	0	0	4	0
	Ligament	1	0	2	1	1	0	0	0	4	1
	Rupture	0	1	2	1	0	0	0	1	2	3
	Laceration	23	1	10	0	1	0	0	0	34	1
	Instability	12	3	8	2	2	0	0	0	22	5
	Neurovascular	4	1	3	1	0	0	0	0	7	2
	Pain	22	1	25	2	3	0	0	0	50	3
	Soft Tissue	16	4	15	0	1	0	1	0	33	4
	Total	124	16	105	8	13	1	2	1	244	26
Lower Extremity	Fracture	7	5	2	1	0	0	0	0	9	6
	Tendon	4	0	9	0	1	0	0	0	14	0
	Sprain	10	0	13	0	1	0	1	0	25	0
	Ankle Sprain	35	0	33	1	9	0	1	0	78	1
	Strain	5	0	3	0	1	0	0	0	9	0
	Ligament	3	3	3	4	0	0	0	0	6	7
	Rupture	0	1	0	1	0	0	0	0	0	2
	Laceration	1	0	2	0	0	0	0	0	3	0
	Instability	1	1	1	0	0	0	1	0	3	1
	Neurovascular	0	0	3	0	0	0	0	0	3	0
	Pain	35	0	32	4	5	0	0	0	72	4
	Soft Tissue	15	1	7	0	1	0	0	0	23	1
	Plantar Fasciitis	4	0	8	0	2	0	0	0	14	0
	Meniscus	2	0	0	1	0	0	0	0	2	1
	Total	122	11	116	12	20	0	3	0	261	23
Axial Spine	Cervicalgia	6	0	5	1	1	0	0	0	12	1
	Thoracic Pain	4	0	3	0	0	0	0	0	7	0
	Lumbago	45	0	32	1	2	0	1	0	80	1
	Degenerative Disk Disease	0	0	2	2	0	1	0	0	2	3
	Herniated Nucleus Pulposus	0	0	2	3	0	0	0	0	2	3
	Coccidynia	0	0	2	0	0	0	0	0	2	0
	Total	55	0	46	7	3	1	1	0	105	8
Musculoskeletal	Total	301	27	267	27	36	2	6	1	610	57

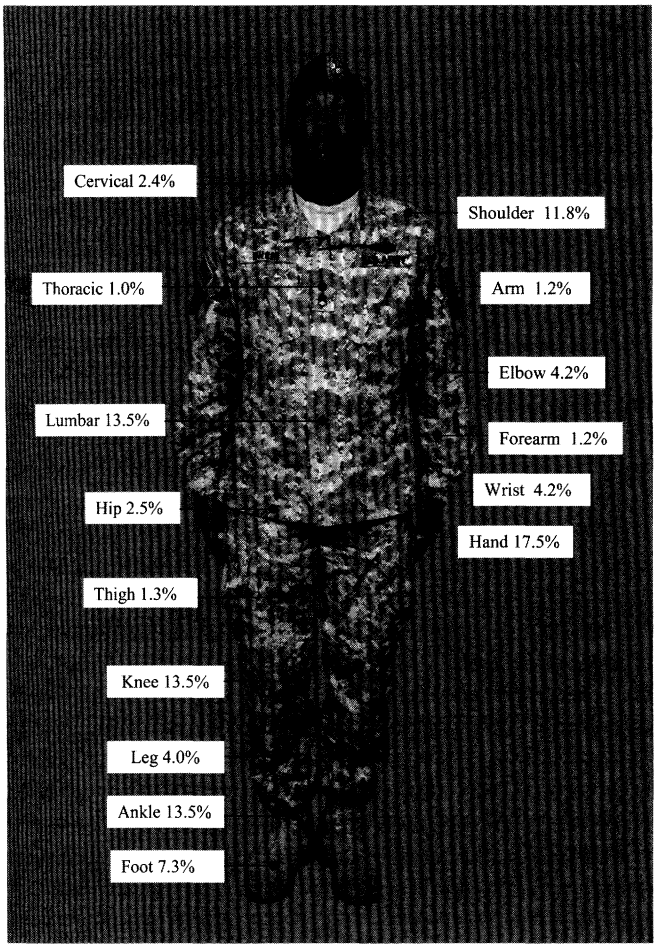

FIGURE 2. Nonbattle injury by body location.

in the axial spine. When comparing the DNBI casualty classification by musculoskeletal location there was not a significant difference among the groups that were MEDEVAC for upper extremity 9.6% ($p < 0.46$), and lower extremity 8.1% ($p < 0.75$) when compared to the axial spine 7.1%. Figure 2 provides a more detailed depiction of the anatomic location of all musculoskeletal DNBI. When comparing the DNBI casualty classification by rank group, there was not a significant difference among the percentage of DNBI casualties that were MEDEVAC: E1–E4 8.2% (27/328), E5–E9 9.2% (27/294), O1–O3/WO1–WO5 5.3% (2/38) and O4–O6 14.2% (1/7). Males 16.3%, compared with females 15.1%, were not at a significantly increased risk for becoming a musculoskeletal DNBI casualty ($p<0.63$). When analyzing the musculoskeletal DNBI casualty classification by sex, there was not a significant difference among the percentage of DNBI casualties that were MEDEVAC when comparing males 9.1% to females 2.0% ($p < 0.11$).

Table V categorizes the type of musculoskeletal DNBI by casualty classification and rank group. When comparing the DNBI casualty classification by the type of musculoskeletal DNBI, there was a significant difference among the percentage of DNBI casualties that were MEDEVAC with

TABLE V. Type of Musculoskeletal Injury by DNBI Casualty Classification

	MEDEVAC		RTD		
Musculoskeletal Injury	%	*N*	%	*N*	Total
Rupture	71.4	(5)	28.6	(2)	7
Degenerative Disk Disease	60.0	(3)	40.0	(2)	5
Herniated Nucleus Pulposus	60.0	(3)	40.0	(2)	5
Ligament	44.4	(8)	55.6	(10)	18
Meniscus Tear	33.3	(1)	66.7	(2)	3
Fracture	*19.7	(13)	80.3	(53)	66
Instability	*19.4	(6)	80.6	(25)	31
Neurovascular	16.7	(2)	83.3	(10)	12
Soft Tissue	*8.2	(5)	91.8	(56)	61
Cervical Spine Pain	7.7	(1)	92.3	(12)	13
Pain	*5.4	(7)	94.6	(122)	129
Laceration	2.6	(1)	97.4	(37)	38
Low Back Pain	1.2	(1)	98.8	(80)	81
Sprain	0.7	(1)	99.3	(138)	139
Tendon	0.0	-	100.0	(23)	23
Strain	0.0	-	100.0	(13)	13
Plantar Fasciitis	0.0	-	100.0	(14)	14
Thoracic Spine Pain	0.0	-	100.0	(7)	7
Coccidynia	0.0	-	100.0	(2)	2
Total	8.5	(57)	91.5	(610)	667

*Within the same column represents significant difference ($p < 0.05$) of the DNBI casualty care statistics with sprain as the referent group.

TABLE VI. Incidence of Common Musculoskeletal Disease Nonbattle Injuries Compared With Previous Military and General Population Incidence Studies (Rates per 1,000 Person-Years [*N*])

Musculoskeletal Injury	Army BCT	Military	General Population
Ankle Sprain	15.3 (79)	27.3[33]	5.3–7[21,23]
Plantar Fasciitis	2.7 (14)	10.5[32]	None Available
Anterior Cruciate Ligament Rupture	3.3 (17)	2.6–3.7[28,31]	0.3–0.6[22,25,27]
Shoulder Dislocation	1.2 (6)	1.69[29]	0.11–0.24[24,26,28]

the following types of musculoskeletal DNBI: fracture 19.7% ($p < 0.0001$), instability 19.4% ($p < 0.0001$), soft tissue 8.2% ($p < 0.02$), and pain 5.4% ($p < 0.04$) when compared to sprains 0.7%.

Common Musculoskeletal Injury Incidence Rates

A comparison of common musculoskeletal injury incidence rates with reports from previous general population[21–28] and military studies[29–33] is contained in Table VI. The BCT incidence rates for common musculoskeletal injuries per 1,000 combat-years were as follows: ankle sprain 15.3, plantar fasciitis 2.7, anterior cruciate ligament rupture 3.3, and first-time shoulder dislocation 1.2.

DISCUSSION

This study is the first known description and analysis of U.S. Army DNBI casualties during OIF from a unit perspective. During the counterinsurgency operation "The Surge", the

BCT lost 213 soldiers (41.3/1,000 soldier combat-years) to the theatre of operations who either died or were MEDEVAC due to DNBI. In a previous report,[34] the same BCT during this deployment lost 122 soldiers (23.7/1,000 soldier combat-years) to the theatre of operations who were either KIA/DOW or MEDEVAC due to battle injuries. Accordingly, this BCT lost to the theatre of operations 75% more soldiers as a result of DNBI compared to battle injuries incurred during their combat deployment. Additionally, the BCT cohort DNBI Died rate was 1.0/1,000 soldier combat-years which is substantial decrease from the 5% mortality rate reported in the DNBI casualty population during the Korean and Vietnam Wars.[6,35]

The DNBI casualty rate, which includes RTD, MEDEVAC and Died, for the BCT was 257.0/1,000 soldier combat-years, or 0.70 per 1,000 strength per day. When analyzing the aforementioned studies, one must always be cognizant that previous studies on DNBI casualty rates only reliably reported average daily DNBI hospital admission rates, whereas the current study includes all soldiers RTD and those who died of DNBI. Average daily DNBI admission rates among the ground operations in Okinawa, Korea, Vietnam, and Falklands were reported to range from 0.99 to 4.03 per 1,000 strength per day for combat troops and were found to have steadily decreased over the time period studied.[13] Further reductions in average daily DNBI hospital admission rates among all military servicemembers have been reported in studies examining data from the beginning of OEF and OIF through December 2004, with the average daily DNBI hospital admission rate ranging from 0.138 to 0.144 per 1,000 strength per day. This represents a 45% reduction compared to the average daily DNBI hospital admission rate observed in Operation Desert Shield/Desert Storm.[14,36]

This study found differences in the DNBI casualty care statistical rates between rank groups that were not previously reported. The significant difference was that each of the junior and senior enlisted rank groups were over 50% more likely to be a DNBI casualty or RTD compared to the warrant/junior officer rank group.

When analyzing the DNBI casualty classification by sex, females were at a significant risk of becoming a DNBI casualty and subsequently being MEDEVAC or RTD compared to males. Females were over threefold more likely to become a DNBI casualty MEDEVAC compared to males (115.7/1,000 combat-years versus 33.9/1,000 combat-years, $p < 0.05$). Female average daily DNBI hospital admission rates during the initial stages OIF and OEF were reported to be 16% and 74%, respectively, greater than males.[14] Of note in this study is that all 35 females with reproductive issues to include pregnancy, miscarriage or ectopic pregnancy were MEDEVAC (Table III). Thus, alarmingly 10.8% of females were lost to the theatre of operations due to female reproductive DNBI and 74% of all female DNBI MEDEVAC were pregnancy related. This is an increase over a retrospective review of records from an evacuation hospital during Operation Desert Storm that reported that 56% of all female DNBI MEDEVAC were pregnancy related.[37] Additionally, Clark et al.[38] reported that 55% of female soldiers presenting for prenatal care at a stateside hospital reported that their pregnancies were unintended. The high rates of pregnancy-related DNBI and subsequent MEDEVAC seen in the current study are of particular concern to the military because of their impact on unit morale and readiness as well as cost. Therefore, to minimize the effect of unintended pregnancies during deployment, all soldiers should be educated about the use of birth control by both sexes and it should be made readily available at all stages of deployment.

The improved treatment and control of infectious disease from World War I to the present conflict[3,6,39] has resulted in increased relative percentages of musculoskeletal injuries (50.4%) and psychiatric disorders (23.4%), the most common body systems involved in DNBI casualties in the BCT cohort. In contrast, reports from Department of Defense administrative health databases studying the initial stages of OEF/OIF reported lower percentages of principal diagnoses for musculoskeletal/injury (28%–42%) and mental disorders (5.8%–8.8%) among all DNBI hospital admissions.[8,14] The higher percentage of musculoskeletal injuries and psychiatric disorders observed in the BCT cohort may be attributable to the fact that the aforementioned studies excluded soldiers RTD without hospital admission, and both of these diagnoses had the highest RTD rates, 8.5% and 10.7% respectively, within the BCT cohort. Also, the BCT soldiers comprised a combat unit at increased risk for becoming either musculoskeletal or psychiatric DNBI casualties secondary to the counterinsurgency combat environment and combat intensity. Combat stress is not a new phenomenon. The psychiatric DNBI casualty rate was 59.8/1,000 soldier combat-years in the BCT cohort; whereas, the mental health disorder rate in the first year after OIF deployment was reported to have been 84.1/1,000 soldier-years.[40] Three of the five BCT soldiers who died as a result of DNBI committed suicide and had been diagnosed with psychiatric disorders. The suicide rate within the BCT cohort was 0.58 per 1,000 combat-years, which is nearly four times greater than the military suicide rate of 0.125 per 1,000 person-years reported using data from 1980 to 1992.[41]

When examining musculoskeletal DNBI, this study found no difference in the likelihood of being MEDEVAC based upon anatomic location. Additionally, there was no difference among the rank groups with the likelihood of being MEDEVAC for musculoskeletal DNBI. Female service members have previously been reported to have higher DNBI hospital admission rates because of disease compared with males (83% higher in OEF and 61% higher in OIF) but significantly lower chances of non-battle injury hospitalizations (43% in both campaigns).[14] In contrast, the current study found that males (16.3%) compared with females (15.1%) were not at a significantly increased risk for becoming a musculoskeletal DNBI casualty. These findings may be explained by the fact that in the BCT cohort both sexes were exposed to same hostile combat environment, whereas when studying all soldiers a greater percentage of females are in combat support

units exposed to a less dangerous environment. Finally, DNBI musculoskeletal injury casualties with a diagnosis of fracture, instability, pain or soft tissue injuries were at an increased risk for being MEDEVAC when compared to those with a sprain.

The ACL rupture and first-time shoulder dislocation incidence rates in the BCT cohort were at least five-fold greater than previous general population studies[22,24–28] (Table VI). Additionally, the ACL rupture and first-time shoulder dislocation incidence rates in the BCT cohort were equivalent to previously reported military population incidence rates.[30,31] Despite the exclusion of combat injuries and limited athletic exposure, which has previously accounted for at least 48 to 65% of these injuries, deployed soldiers continue to be at a substantially increased risk for ACL rupture and first-time shoulder dislocation secondary to the physical rigors of the combat-deployed environment.

Previous general population incidence studies of ankle sprain have reported overall incidence rate in the general population between 5 and 7 per 1,000 person-years, with the highest incidence rate occurring in males between ages 20 and 30 and in females between ages 10 and 20.[21,23] The incidence rate of ankle sprains in the Army BCT cohort was 15.3 per 1,000 person-years which is a two- to threefold increase compared to previous general population incidence studies and is attributable to the youth and activity level of the BCT cohort.

DNBI casualty definitions significantly affect DNBI casualty analysis results. Defining the population studied is necessary to perform valid comparisons between wars and to reach meaningful conclusions. The inclusion of DNBI casualties that either died or RTD in any cohort analyzed will affect the DNBI casualty care statistics and the relative percentages of body systems injured. In the current study, all statistical analyses included DNBI casualties classified as either died, MEDEVAC, or RTD but excluded those soldiers with battle injuries. The reporting of DNBI from previous wars is potentially biased toward more severe DNBI with RTD soldiers being overlooked.

We acknowledge the limitations in the current study. First is its retrospective nature which includes all inherent limitations to such a study. Second, multiple healthcare providers evaluated and coded the patient encounters which may decrease the accuracy of any specific diagnosis. Third, we did not address the possibility of preexisting medical conditions which might place such soldiers at higher risks of being a DNBI casualty. Finally, the BCT was involved in the counterinsurgency "The Surge" operation in Iraq, which must be taken into consideration and such results are therefore, not necessarily generalizable to all deployed military units.

Although reports from previous armed conflicts have been published after the cessation of combat in the involved theater, this study offers a descriptive longitudinal cohort analysis of DNBI for a large combat-deployed unit during the ongoing Iraq War. This study analyzed the DNBI epidemiology of a BCT involved in an active counterinsurgency campaign. A thoughtful analysis of the data would support that appropriate research and resource allocations would be directed toward examining the prevention, treatment and subsequent outcomes of musculoskeletal injuries and psychiatric disorders which accounted for 74% of the total DNBI casualties, and 52% of the DNBI casualties that required subsequent MEDEVAC that were not due to pregnancy-related issues. Collection and careful examination of DNBI casualty care statistics for continued operations in Iraq and Afghanistan would allow the military medical system not only to more effectively treat deployed soldiers but also to conserve the fighting strength.

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