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Trends in the Epidemiology of Disability Related to Traumatic Brain Injury in the US Army and Marine Corps: 2005 to 2010

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Background: Traumatic brain injury (TBI) has been recognized as a major public health issue for several decades. Despite technological advancements in protective equipment and medical care available during recent military conflicts, TBI is the most common neurological condition among Soldiers and Marines evaluated for discharge from service. This study describes the demographic, service-related, and disability characteristics of Soldiers and Marines referred for combat-related TBI disability evaluation. **Methods:** Cross-sectional analysis of Soldiers and Marines evaluated for combat-related disability between October 1, 2004 and September 30, 2010 was performed. Traumatic brain injury cases were identified using the Veterans Affairs Schedule for Rating Disabilities code for TBI and compared with other combat-related disabilities. **Results:** Combat-related TBI disability rates have significantly increased in both the Army and the Marine Corps since 2005. Significantly more unfitting conditions are present on average in combat-related TBI cases than in other combat-related disability cases. Combat-related TBI disability cases are more likely to be medically retired than other types of combat-related disability. **Conclusions:** Because veterans with combat-related TBI disabilities are likely to require chronic care for TBI-associated medical conditions, disability evaluation policy and programs must ensure that combat-related TBI disabilities are accurately identified and compensated, and the potential long-term care needs are addressed. **Key words:** *disability evaluation*, *military personnel*, *traumatic brain injury*

TRAUMATIC BRAIN INJURY (TBI) is generally regarded as one of the most important injuries associated with Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF).[1] These combat operations have resulted in the deployment of more than 2 million US service members in the past decade.[2] An estimated 25% to 30% of wounded warriors present with injuries to the head, face, or neck,[1,3,4] and explosive mechanisms are responsible for more than 75% of combat injuries.[4] The impact of combat-related TBI is compounded by its prevalence in the US civilian population where it affects approximately 1.7 million Americans every year.[5–7] More than 40% of Americans with TBI experience continued disability within a year of injury.[8] With an estimated 1.1% of the US civilian population living with TBI-related disability following a TBI-related hospitalization,[9] TBI has been recognized as major public health issue for several decades.[10] Considerable variability in general trends and reporting procedures for TBI exists across the United States leading to recommendations for improved surveillance, prevention, and intervention programs.[11]

Throughout the recent military conflicts, improvements in body armor, equipment, and medical care have likely led to an increased number of personnel surviving previously fatal injuries, particularly blast injuries, and subsequently developing TBI.[1,3,12–14] Retrospective studies of a cohort of Soldiers injured in

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OIF/OEF showed high prevalence of head trauma compared to earlier wars,[14] a large proportion of explosive blast injuries,[14] and meaningful survival improvement due to rapid neurosurgical intervention.[13] Reports of the ongoing conflict in Afghanistan emphasized the impact of emergent and aggressive neurosurgical procedures on survival.[15,16] With these advancements, more than 69 000 veterans began receiving Veterans Affairs (VA) disability compensation for neurological conditions in fiscal year (FY) 2011, reflecting a general increase over the past 5 years.[17] In the Department of Defense (DoD) Disability Evaluation System (DES), neurological conditions are among the top 3 most prevalent conditions evaluated for disability, with TBI the most common neurological condition among Soldiers and Marines.[18] Despite extensive research on TBI prevention, comorbidity, and management, little is known about the epidemiology of combat-related TBI disability and discharge within the military population.

In the civilian population, risk factors for TBI include male sex, low socioeconomic status, and extremes of age.[5,7] In particular, young adults aged 15 to 19 years, the age group from which the military recruits, are among the most likely to incur TBI[7] when TBI-related emergency department visits, hospitalizations, and deaths are combined.[6] Although the risk of TBI is increased in younger age groups and males, rates of TBI disability increase with age and female sex, with falls and firearm-related TBI representing the mechanisms of injury most associated with long-term disability.[8] In addition to long-term disability, both military and civilian TBI populations show increased rates of psychiatric comorbidity.[19–23]

Research on disability within the DoD has focused on general descriptions of the population with disabilities[24–28] and musculoskeletal disability in particular.[28–32] Studies of pre-enlistment characteristics and disability evaluation among Soldiers and Marines have identified female sex, older age, and elevated body mass index as risk factors for disability.[33,34] These studies also showed a healthy warrior effect in which service members who deployed were less likely to become disabled.[33,34] Several studies of a small cohort of wounded Soldiers medically evacuated from OIF/OEF in 2001 to 2005 examined orthopedic and other combat injuries, long-term disability, and the economic burden of combat disabilities.[4,35–37] Analyses of this cohort found that compared with earlier wars, a greater proportion of wounds from OIF/OEF were due to head and neck injuries,[4] combat-related extremity injuries have the greatest projected disability costs,[35] and orthopedic injuries were the most common type of disability.[36] A descriptive study of psychiatric disability in Army personnel found that mental health disability discharges were more likely in Soldiers deployed to combat zones.[38] Analysis of posttraumatic stress disorder (PTSD)-related disability evaluation in the Army and Marine Corps showed that almost all cases were deployed and were considered combat related, with rates and severity of PTSD-related disability increasing noticeably in recent years.[39]

The purpose of this study is to describe the demographic, service-related, and disability characteristics of Soldiers and Marines evaluated for combat-related TBI disability from 2005 to 2010. This study also compares the odds of medical retirement in service members evaluated for combat-related TBI with those evaluated for other types of combat-related disability, controlling for demographic-, service-, and deployment-related characteristics. This epidemiologic analysis aims to identify significant trends in combat-related TBI disability that distinguish it from other combat-related disability in the context of the recent conflicts in Iraq and Afghanistan. The findings from this study may indicate areas of needed future research and inform policy and programs supporting the identification, compensation, and future healthcare needs of veterans with combat-related TBI disability.

METHOD

Study Design

This cross-sectional analysis of service members evaluated for a disability by the US DoD DES compares those evaluated with a combat-related TBI disability with all other combat-related disabilities in the Army and Marine Corps. This study was performed under a minimal risk human use protocol reviewed and approved by the Walter Reed Army Institute of Research Institutional Review Board.

Each military service is responsible for maintaining a fit and vital force and for providing equitable compensation to those who become unfit for military service due to an injury or illness incurred in the line of duty.[40] Upon illness or injury, a service member is referred into a service-specific disability evaluation system by a physician. Disability evaluation includes a medical evaluation board and a physical evaluation board. The medical board comprises at least 2 physicians, including one who is board certified/eligible in a specialty pertinent to the condition under evaluation, and determines whether the service member meets the medical retention standards for his or her office, grade, rank, and military occupation. If medical retention standards are not met, the findings of the medical board are sent to the physical evaluation board.

The physical examination board determines the service member's fitness to continue military service as well as eligibility for disability compensation. For each condition evaluated, the physical evaluation board

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determines whether the disability condition is unfitting, precluding the fulfillment of the service members military duties required by his or her occupational specialty. If deemed unfit by the physical examination board, each unfitting condition is assigned a Veterans Affairs Schedule for Rating Disabilities (VASRD) code and rating.[40] Determinations regarding whether a disability was combat related are also made by the physical examination board. Combat-related disability is defined by the DoD as "injuries or diseases attributable to the special dangers associated with armed conflict or the preparation or training for armed conflict."[40]

Study Population

All Army and Marine Corps personnel who underwent an initial disability evaluation for a combat-related disability at the US Army Physical Disability Agency or Secretary of the Navy Council of Review Boards between October 1, 2004 and September 30, 2010 were eligible for inclusion in this study. Evaluation records for TBI cases and the comparison group were restricted to FYs 2005 to 2010. Individuals were excluded from the study population if the first disability evaluation record during the study period indicated a disposition of "Retained on the Temporary Disability Retirement List" which by definition is not an initial disposition.

Combat-related TBI cases were identified from the study population when the VASRD code 8045 (residuals of TBI) was present and the physical evaluation board determined that the service member's disability was combat related. TBI cases were classified as a case only if the first disability evaluations as well as all subsequent disability evaluations that occurred during the study period included a VASRD code indicating TBI. Because unfitting conditions may change at periodic reevaluation, if a VASRD code for TBI was not present at all disability evaluations, the service member was excluded from the study population (<1% of study population). Service members who were evaluated for combat-related disabilities other than TBI were selected as the comparison group.

Measures

Data pertaining to disability evaluations are collected and maintained separately by each service's disability agency and include demographic characteristics, medical review date, disposition and date of disposition, disability ratings, and VASRD codes. The US Army Physical Disability Agency and the US Navy Council of Review Boards provided physical evaluation board data on Army and Marine Corps personnel, respectively. The Defense Manpower Data Center, Seaside, California, provided accession dates and total service member population counts by FY.

All demographic variables were derived from the record with the earliest disposition date in the service-specific disability databases. Final disposition, percent rating, and combat-related determinations were collected from the most recent disability record. Length of service was calculated for all study participants with an accession record and represented the length of time, in years, from accession to the beginning of the first disability evaluation.

Disability medical codes are defined by the Veterans Affairs Schedule for Rating Disabilities and assigned to service members with disability by the physical examination board. Each VASRD code indicates a potentially unfitting condition and is associated with a percent rating, reflecting the amount of compensation to which an individual is entitled.[41] When a service member has more than one condition that receives a disability rating, the total rating is determined from the combined percent ratings for each assigned VASRD code and ranges from 0% to 100% compensation. For this analysis, similar VASRD codes were consolidated into one VASRD condition category. For example, all VASRD codes associated with paralysis or limitations of motion were consolidated regardless of anatomical location. All arthritis and dorsopathies were consolidated as well due to nonspecific VASRD coding associated with these types of musculoskeletal conditions described by Bell et al.[25] All unique VASRD condition categories comorbid with TBI were included in the comorbidity analysis. Veterans Affairs Schedule for Rating Disabilities codes used in conjunction with another VASRD code to define one condition (ie, analogous codes) were not included in the analysis of comorbid disability.

Disability dispositions assigned by the physical evaluation board include placement on the permanent disability retired list, placement on temporary disability retired list, separated with severance pay, or separated without benefits. Evaluations resulting in total percent ratings of 30% or greater are eligible for disability retirement; therefore, percent ratings were categorized into 30% or more and less than 30%. Time to final disposition was calculated utilizing the time, in months, elapsed between a service member's first medical evaluation board and the date of the most recent physical evaluation board determination.

Statistical Analysis

Service-specific incidence rates of combat-related TBI disability and all other combat-related disabilities were calculated per 100 000 service members per year on the basis of total Army and Marine Corps population counts. The Cochran-Armitage test for trend was utilized to determine whether there was a linear trend in the relationship between incident combat-related

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disability evaluation, categorized as TBI-related or other disability, and FY.

Frequency distributions were generated to describe the demographic, service, and disability characteristics of the study population. Descriptive statistics were stratified by service and combat-related disability condition type, defined as TBI disability or all other disabilities. For categorical variables, including demographic, service, and disability variables, odds ratios (ORs) and 95% confidence intervals (95% CIs) were calculated to compare demographic and disability characteristics between those evaluated for a combat-related TBI disability and those evaluated for other combat-related conditions. Means and standard deviations were calculated to assess average length of service, average length from medical board date to final determination date, and average number of condition codes. These continuous variables were stratified by service and compared by TBI status and using Welch's analysis of variance.

The most common comorbid disabilities in combat-related TBI and other combat-related disability conditions were identified by determining the frequency distribution for comorbid disabilities. Frequencies were calculated excluding multiple VASRD codes used together to indicate the same condition. Chi-square tests were conducted to compare the distribution of comorbid disabilities in the Army with the distribution in the Marine Corps combat-related disability cases and were stratified by disability condition type.

Bivariate and multivariate logistic regression models were generated to compute unadjusted and adjusted ORs and to assess associations between disability retirement (ie, placement on permanent disability retired list or temporary disability retired list) and demographic and service characteristics. The primary exposure of interest was combat-related disability type (TBI or other disability). Adjusted logistic regression models were constructed for both the Army and the Marine Corps, controlling for gender, age, race, rank (categorized as enlisted or officer), and component (categorized as active or reserve). All statistical analyses were performed using SAS version 9.2 (SAS Institute, Cary, North Carolina).

RESULTS

Between FY 2005 and FY 2010, 2268 Soldiers and 599 Marines were evaluated for combat-related TBI disability and 11 969 Soldiers and 2574 Marines were evaluated for combat-related disability for other conditions. Rates of combat-related TBI disability have increased since 2005 in both the Army and the Marine Corps (see Figure 1). Cochran-Armitage tests for trend showed that

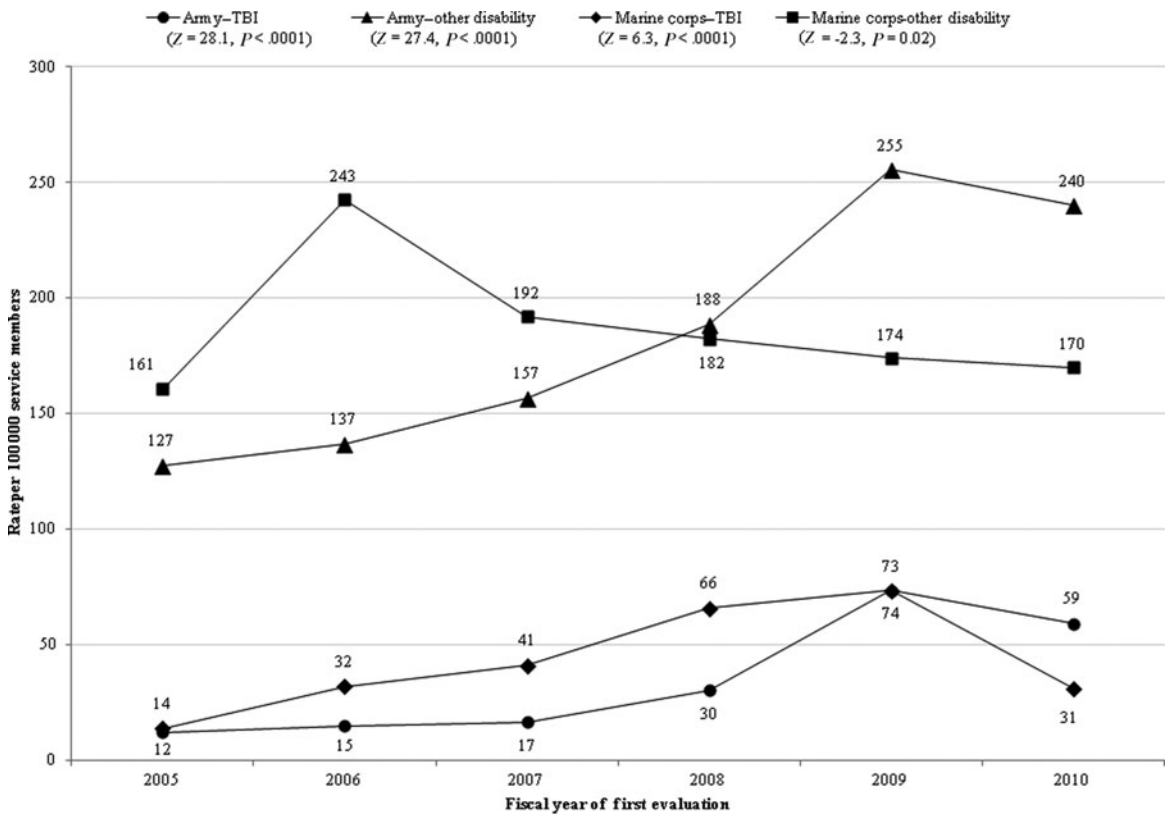

Figure 1. Rate of combat-related disability evaluation in the Army and the Marine Corps, FY 2005 to FY 2010. TBI indicates traumatic brain injury.

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the rate of combat-related TBI disability evaluation increased significantly over the study period for both the Army ($Z = 28.1$, $P < .0001$) and the Marine Corp ($Z = 6.3$, $P < .0001$) personnel. Other combat-related disabilities increased significantly in the Army in the same time period ($Z = 27.4$, $P < .0001$) while in the Marine Corps other combat-related disability rates decreased ($Z = -2.3$, $P = .02$). Substantial decreases in the rate of TBI disability evaluation were noted in both services beginning in 2009. In the Army, this decrease was also observed among other combat-related disabilities. Among Marines, other combat-related disabilities exhibited decreasing incidence in the period from 2006 to 2010.

In total, 14 248 Soldiers and 3178 Marines were evaluated for disability between FY 2005 and FY 2010. The majority of the participants were white, enlisted, active duty males who had deployed and were younger than 30 years at the time of disability evaluation (see Table 1). Males were significantly more likely to be evaluated for combat-related TBI than females in both Soldiers (OR: 1.78, 95% CI: 1.38-2.30) and Marines (OR: 3.56, 95% CI: 1.65-7.70). Odds of combat-related TBI disability were also significantly higher in the Soldiers older than 30 years (30-39 years–OR: 1.19, 95% CI: 1.08-1.32; ≥40 years–OR: 1.18, 95% CI: 1.03-1.34) than those younger than 30 years. Black Soldiers were significantly less likely than white Soldiers to have combat-related TBI disability (OR: 0.75, 95% CI: 0.64-0.87). Active Duty Soldiers were significantly less likely than Reserve Component to have combat-related TBI (OR: 0.80, 95% CI: 0.72-0.90). No significant differences in the likelihood of combat-related TBI were observed in the Marines by age, race, or component. No significant differences in rank were found in Soldiers or Marines evaluated for combat-related TBI as compared with other combat-related disabilities. Deployment frequency had no significant effect on the odds of combat-related TBI disability in Soldiers. In Marines, 2 deployments were significantly associated increased odds of combat-related TBI (OR: 1.44, 95% CI: 1.18-1.75) relative to a single deployment, but 3 or more deployments were not significantly associated with combat-related TBI disability.

When comparing the dispositions among combat-related TBI disability cases with other types of disability, TBI cases were significantly less likely to receive a disposition of separated with severance pay (Army–OR: 0.22, 95% CI: 0.19-0.26; Marine Corps–OR: 0.17, 95% CI: 0.13-0.23), fit (Army–OR: 0.08, 95% CI: 0.02-0.33), or other types of dispositions (Army–OR: 0.57, 95% CI: 0.42-0.78; Marine Corps–OR: 0.19, 95% CI:

TABLE 1 *Demographic and service characteristics of the study population by service and disability condition*

	Army				Marine Corps			
	TBI ($n = 2268$) %	All other ($n = 11\,969$) %	OR	95% CI	TBI ($n = 599$) %	All other ($n = 2574$) %	OR	95% CI
Sex								
Male	97.0	94.8	1.78	1.38-2.30	98.8	96.0	3.56	1.65-7.70
Female	3.0	5.2	1.00	. . .	1.2	4.0	1.00	. . .
Age at first evaluation, y								
<30	55.1	59.3	1.00	. . .	83.8	87.4	1.00	. . .
30-39	30.2	27.3	1.19	1.08-1.32	13.7	11.2	1.27	0.98-1.66
≥40	14.7	13.5	1.18	1.03-1.34	2.5	1.6	1.68	0.92-3.07
Race								
White	81.6	78.3	1.00	. . .	77.5	73.8	1.00	. . .
Black	9.3	12.0	0.75	0.64-0.87	4.0	5.4	0.70	0.45-1.10
Other	9.1	9.8	0.90	0.77-1.05	18.4	20.7	0.85	0.67-1.06
Rank								
Enlisted	95.7	96.1	0.93	0.74-1.16	97.5	98.3	0.77	0.43-1.38
Officer	4.3	4.0	1.00	. . .	2.5	1.9	1.00	. . .
Component								
Active	79.3	82.7	0.80	0.72-0.90	89.3	88.3	1.12	0.84-1.49
Reserve	20.8	17.7	1.00	. . .	10.7	11.8	1.00	. . .
Deployment frequency								
1	58.4	58.2	1.00	. . .	50.6	44.9	1.00	. . .
2	28.7	26.3	1.09	0.98-1.20	37.7	23.3	1.44	1.18-1.75
3+	10.2	9.7	1.05	0.90-1.22	7.5	5.9	1.13	0.79-1.61

Abbreviations: CI, confidence interval; OR, odds ratio; TBI, traumatic brain injury.

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0.06-0.62) regardless of service (see Table 2). Regardless of service, nearly 90% of combat-related TBI disability cases were medically retired, whereas 68% of Soldiers and 58% of Marines with other types of combat-related disability were retired. Medical retirement was significantly more common in combat-related TBI disability than in other combat-related disability in both the Army (OR: 4.63, 95% CI: 3.98-5.38) and the Marine Corps (OR: 5.80, 95% CI: 4.43-7.61). The mean number of unfitting conditions in combat-related TBI disability cases was significantly higher than the mean number of unfitting conditions present in service members evaluated for other combat-related disabilities in both the Army ($F_{2863.5,1}$ $P < .001$) and the Marine Corps ($F_{639.0,1}$ $P < .0001$). Soldiers evaluated for combat-related TBI had an average of 3.1 unfitting conditions while those evaluated for other combat-related disabilities had an average of 1.9 unfitting conditions. In the Marine Corps, combat-related TBI disability cases had 3.2 unfitting conditions on average as compared with 1.5 unfitting conditions on average in other combat-related disability cases.

Multivariate logistic regression analysis of risk of disability retirement showed that combat-related TBI cases were significantly more likely to be medically retired than other combat-related disability cases, after adjustment for other significant covariates (Army–OR: 3.94, 95% CI: 3.40-4.56; Marine Corps–OR: 3.99, 95% CI: 3.00-5.32) (see Table 3). Those aged 30 years or older at first disability evaluation, relative to those younger than 30 years, were significantly associated with disability retirement in adjusted analysis in the Army (30-39 years–OR: 1.31, 95% CI: 1.19-1.44; ≥40 years–OR: 1.95, 95% CI: 1.68-2.25). The association between age and disability retirement in adjusted models for Marines showed no significant association between age in the 30 to 39 years age group (OR: 1.22, 95% CI: 0.91-1.64) and marginally significant association between age and medical retirement in those aged 40 years or older at the time of first disability (OR: 2.96, 95% CI: 1.01-8.71). Increased deployment frequencies were also associated with increased odds of medical retirement. Soldiers and Marines with 3 or more deployments had highest odds of medical retirement in adjusted models (Army–OR: 1.64, 95% CI: 1.42-1.89; Marine Corps–OR: 1.77, 95% CI: 1.22-2.59), relative to those who deployed only once. No significant differences in odds of medical retirement were observed in adjusted models by rank or component in either service.

The distribution of the most common comorbid disability conditions in both services differed between combat-related TBI disability cases and those evaluated for other combat-related disabilities (see Table 4). No significant difference in the prevalence of PTSD was

TABLE 2 *Characteristics of disability evaluation in the study population by service and TBI status*

	Army				Marine Corps			
	TBI $n = 2268$ %	All other $n = 11\,969$ %	OR	95% CI	TBI $n = 599$ %	All other $n = 2574$ %	OR	95% CI
Disposition								
Retired	89.5	68.0	1.00	. . .	89.1	57.8	1.00	. . .
SWSP	8.3	28.4	0.22	0.19-0.26	10.4	38.9	0.17	0.13-0.23
Fit	0.1	0.8	0.08	0.02-0.33	0.0	1.6	. . .	. . .
Other	2.1	2.8	0.57	0.42-0.78	0.5	1.7	0.19	0.06-0.62
Percent rating								
<30	8.9	30.7	1.00	. . .	10.7	40.9	1.00	. . .
≥30	89.6	67.0	4.63	3.98-5.38	89.3	59.0	5.80	4.43-7.61
Years of service			*F* (*df*)[a]				*F* (*df*)[a]	
N	1498	7750			548	2345		
Mean (SD)	5.1 (2.1)	4.7 (2.1)	38.9 (1)[b]		4.3 (3.5)	3.5 (2.1)	25.7 (1)[b]	
Months to final disposition								
N	2189	11 693			518	2430		
Mean (SD)	6.8 (11.1)	6.4 (10.4)	2.8 (1)		12.0 (15.1)	11.8 (16.2)	0.02 (1)	
Unfitting conditions								
N	2269	11 979			599	2579		
Mean (SD)	3.1 (1.0)	1.9 (1.0)	2863.5 (1)[b]		3.2 (1.5)	1.5 (1.0)	639.0 (1)[b]	

Abbreviations: CI, confidence interval; OR, odds ratio; SWSP, separated with severance pay; TBI, traumatic brain injury.
[a]Welch's analysis of variance comparing TBI disability to all other disabilities.
[b]$P < .0001$.

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TABLE 3 *Unadjusted and adjusted[a] odds ratios for disability retirement in TBI cases by service*

	Army				Marine Corps			
	OR	95% CI	OR[a]	95% CI	OR	95% CI	OR[a]	95% CI
Disability type								
TBI	4.01	3.49-4.61	3.94	3.40-4.56	6.00	4.58-7.85	3.99	3.00-5.32
All other	1.00	. . .	1.00	. . .	1.00	. . .	1.00	. . .
Gender								
Male	0.98	0.83-1.16	0.83	0.69-1.01	3.26	2.20-4.84	0.93	0.44-1.98
Female	1.00	. . .	1.00	. . .	1.00	. . .	1.00	. . .
Age at first evaluation, y								
<30	1.00	. . .	1.00	. . .	1.00	. . .	1.00	. . .
30-39	1.42	1.31-1.55	1.31	1.19-1.44	1.77	1.38-2.25	1.22	0.91-1.64
≥40	2.13	1.88-2.41	1.95	1.68-2.25	3.62	1.70-7.69	2.96	1.01-8.71
Race								
White	1.00	. . .	1.00	. . .	1.00	. . .	1.00	. . .
Black	1.05	0.93-1.18	0.97	0.85-1.10	0.78	0.57-1.08	0.89	0.58-1.36
Other	1.12	0.98-1.27	1.02	0.89-1.17	1.20	1.00-1.45	1.41	1.11-1.79
Rank								
Enlisted	0.69	0.56-0.84	0.87	0.70-1.08	0.24	0.11-0.51	0.48	0.19-1.17
Officer	1.00	. . .	1.00	. . .	1.00	. . .	1.00	. . .
Component								
Active	0.69	0.63-0.77	0.95	0.84-1.06	0.78	0.62-0.99	0.96	0.71-1.29
Reserve	1.00	. . .	1.00	. . .	1.00	. . .	1.00	. . .
Deployment frequency								
1	1.00	. . .	1.00	. . .	1.00	. . .	1.00	. . .
2	1.40	1.28-1.53	1.42	1.30-1.56	1.52	1.25-1.85	1.44	1.17-1.77
3+	1.65	1.44-1.90	1.64	1.42-1.89	1.79	1.24-2.58	1.77	1.22-2.59

Abbreviations: CI, confidence interval; OR, odds ratio; TBI, traumatic brain injury.
[a]Adjusted for all variables listed.

TABLE 4 *Most common comorbid disabilities in combat-related TBI disability cases and other combat-related disability cases compared by service[a]*

	Army		Marine Corps	
	Count	%	Count	%
TBI				
Posttraumatic stress disorder	1343	59.2	327	54.6
Dementia[b]	553	24.4	286	47.7
Dorsopathies[b]	724	31.9	66	11.0
Arthritis[b]	369	16.3	57	9.5
Paralysis[b]	174	7.7	80	13.4
Total individuals		2268		599
All other				
Posttraumatic stress disorder[b]	6727	56.2	904	35.1
Dorsopathies[b]	3901	32.6	297	11.5
Arthritis	2498	20.9	451	17.5
Limitation of motion[b]	1356	11.3	544	21.1
Paralysis[b]	900	7.5	316	12.3
Total individuals		11 969		2574

Abbreviation: TBI, traumatic brain injury.
[a]Chi-square test comparing comorbid disability in the Army to the Marine Corps for TBI and for all other disability cases.
[b]$P < .0001$.

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observed when comparing combat-related TBI disability cases in the Army with Marine Corps cases. In both the Army and the Marine Corps, PTSD was present in the majority of combat-related TBI disability cases (59% of Soldiers, 55% of Marines). Dementia was significantly more common among combat-related TBI cases ($\chi^2_{95.1,1}$ $P < .0001$) in the Marine Corps than in the Army. Musculoskeletal comorbid disabilities, arthritis, and dorsopathies were more common among combat-related TBI cases (arthritis: $\chi^2_{15.8,1}$ $P < .0001$; dorsopathies $\chi^2_{84.1,1}$ $P < .0001$) in the Army than in the Marine Corps. Posttraumatic stress disorder was more common among other combat-related disability cases in the Army than in the Marine Corps ($\chi^2_{86.8,1}$ $P < .0001$) though PTSD was most common condition among other combat-related disabilities in both the Army (56%) and the Marine Corps (35%).

DISCUSSION

Rates of combat-related TBI disability have been increasing in both the Army and the Marine Corps from 2005 through 2009. Veterans with combat-related TBI are commonly male, white, and enlisted, with substantially more comorbid disabilities and longer time to final disposition determination compared with those with other combat-related disabilities. Combat-related TBI disability is also associated with significantly more comorbidity than other types of combat-related disability in this study. On average, Soldiers and Marines with combat-related TBI were evaluated for more unfitting conditions than service members evaluated for other types of combat-related disability. Because of the high comorbidity observed in TBI cases relative to other combat disabilities, veterans with combat-related TBI disability were significantly more likely to receive higher disability ratings and, therefore, were also significantly more likely to receive medical retirement than those with non-TBI combat disabilities.

Posttraumatic stress disorder was the most common combat-related disability in this study population. Not only was PTSD present in more than 50% of combat-related TBI disability cases but also was the leading comorbidity in non-TBI combat disabilities. Musculoskeletal conditions such as dorsopathies, arthritis, and limitation of motion were more common among those with non-TBI combat disabilities than among those with TBI. Substantial decreases in the rate of TBI disability evaluation were noted in both services beginning in 2009, concurrent with a decrease in other combat-related disability in the Army and a decreasing trend in the Marine Corps since 2006. These decreases in combat-related disability including TBI may reflect the recent drawback of troop presence in support of OIF/OEF. Overall, this study describes an enlarging population of predominantly young, male, combat veterans with severe disability in whom other chronic neuropsychiatric comorbid disabilities are common.

The primary strength of this study is the comprehensive data capture allowing for a large study population of both TBI and non-TBI disability cases, with information on demographic characteristics, deployment characteristics, and disability evaluations. Although this study was retrospective and largely descriptive, the robust data set allowed for a variety of statistical comparisons between TBI cases and those with other disabilities. Although this study's large sample size of Marines and Soldiers allows for assessment of a wide variety of risk factors associated with combat-related TBI in the Army and the Marine Corps, these findings may have limited applicability to the Navy and Air Force, which may have different demographic factors, deployment characteristics, and occupational exposures.

The most important limitation of this study centers on the difficulty in determining a service member's exact medical diagnosis at disability evaluation. Disability evaluation records include only VASRD codes rather than clinical diagnoses. Veterans Affairs Schedule for Rating Disabilities codes are used to ascertain the level of disability for compensation purposes and often cannot be translated into *International Classification of Diseases, Ninth Revision (ICD-9)* codes.[25] Disability condition groups were used in this analysis because previous studies of service members with disability hospitalized prior to discharge showed that the most common diagnoses present in hospitalization records were consistent with the condition group of the disability condition.[25,42] A study of a small sample of combat-wounded Soldiers who were subsequently evaluated for disability reviewed clinical encounter narratives to determine more precise medical diagnoses,[36] but the large sample size of the current study precludes the use of that methodology. In 2008, the VASRD system was updated on the basis of a FY 2009 National Defense Authorization Act to more accurately rate individuals with TBI, changing the definition of TBI disability from "traumatic brain injury" to "residuals of traumatic brain injury" and increasing the mandated percent rating/compensation. Changes in the VASRD coding system, inconsistent use of the lower-rated TBI disability codes prior to 2008, and the limitations inherent in disability codes that only roughly reflect diagnoses create significant challenges in the investigation of risk factors for combat-related TBI disability.

This is the first study to explore demographic and service-related factors associated with combat-related TBI severe enough to warrant referral into the DoD DES. Findings from this study, specifically that combat-related TBI disability cases are commonly young adult enlisted service males, are consistent with trends

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established in the civilian literature.[5,6] In particular, the age group from which the military recruits, young adults 15 to 19 years of age, is more likely to sustain a TBI than other age groups.[6] Dementia was also found to be a common comorbid disability in both the Army and the Marine Corps. Because the VASRD metric for evaluating TBI disability is complex and involves assessment of a variety of neurobehavioral facets which are then translated into a compensation rating on the basis of level of impairment,[41] the high prevalence of dementia in combat-related TBI cases may be due to similarities in the cognitive impairment resulting from dementia and TBI.

This study also substantiates military medical literature identifying TBI among the most important medical challenges of the current conflicts.[1,3,12,14–16] The prevalence of psychiatric comorbidity in this study population is consistent with the higher rates of psychiatric comorbidity reported in both military and civilian TBI populations.[19–23] In this study population, PTSD was the most frequent comorbid psychiatric condition in combat-related TBI cases and was more common in combat-related TBI than in other combat-related disabilities. However, no significant associations between deployment frequency and combat-related TBI were found in this study. Future research is necessary to determine whether other exposures related to deployment, such as country/conflict deployed to, period of rest between deployments, and occupation category while deployed can more clearly define risk factors for TBI with and without PTSD comorbidity.

Studies of TBI-related long-term disability in the civilian population have reported mixed findings in terms of comorbid conditions, residual symptoms, and trends in post-TBI outcomes. A post-TBI quality-of-life survey indicated that participants endorsed problems with memory, thinking and physical/emotional health, which increased with severity of injury, but high level of life satisfaction overall.[43] The majority of respondents to a telephone survey of long-term TBI survivors reported ongoing musculoskeletal conditions, particularly bodily pain, especially in those with elevated body mass index.[44] A review of psychiatric conditions following TBI found that TBI survivors had higher rates of psychiatric symptoms, but the onset of symptoms postinjury was variable and premorbid psychiatric symptoms were common.[19] Significant changes in socioeconomic factors during the first year postinjury, including marital status, employment, personal income, and insurance status, were described in a prospective cohort study of individuals discharged with TBI from acute care hospitals.[45] This study showed that the Army and Marine Corps combat-related TBI disability population comprises severely injured, young adult combat veterans with associated psychiatric comorbidity. Together, these studies suggest continued need for long-term but individualized physical and mental healthcare and socioeconomic support for veterans transitioning into civilian life.

Further research is needed to establish the long-term effects of the increased rates of combat-related TBI on both the DoD and VA disability systems. The VA has recorded a gradual increase in neurologic disabilities and substantial increases in mental health–related disabilities over the past 5 years, ranking the fourth and fifth most common disabilities among veterans of the recent conflicts, but TBI is not among the most prevalent neurologic disabilities.[17] In the DoD DES, TBI is the most common neurologic disability[18] and is predominantly combat related. It is possible that veterans with TBI disability are fully compensated and cared for through the current DoD disability process and may have little need for further VA evaluation. However, the findings from this descriptive study, specifically that combat-related TBI disabilities have been increasing since 2005 and are associated with greater severity and disability compensation (ie, medical retirement), taken in the context of the large body of civilian medical literature indicating that long-term disability and comorbid symptoms are associated with severe TBI, suggest that veterans with combat-related TBI disability may be entering into civilian lives and careers with a substantial need for long-term disability and comorbidity care. Combat-related TBI may represent a significant burden on the VA disability system that will continue to increase in years to come.

Although TBI is common in the military in war and peacetime, frequently due to motor vehicle accidents and athletic injuries,[46,47] this study shows that combat TBI disability during the most recent conflicts in Iraq and Afghanistan is severe, relatively common, and often accompanied by other neuropsychiatric disabilities. In contrast to several previous studies of a cohort of combat-wounded Soldiers evaluated for disability following a medical evacuation for definitive care,[35–37] this study of all Soldiers and Marines evaluated for a disability deemed combat-related by the physical examination board found that PTSD was by far the most common combat disability, exceeding both orthopedic and TBI disabilities. In addition, this study shows that in veterans with combat disability , PTSD is a much more prevalent comorbid disability than orthopedic disabilities. These differences in findings may be due to study design and methodology; this study offers a much larger study sample derived from the entire disability system rather than restricting the study to only medically evacuated participants, and the study period is more recent, representing the matured effects of OIF/OEF.

Because veterans with TBI disability are likely to require chronic care for TBI-associated medical conditions, especially behavioral health,[20] disability evaluation policy and programs must ensure that

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TBI-related disabilities are accurately identified and compensated, and the potential long-term care needs are addressed. Comparisons of those sustaining TBIs pre- and postdeployment as well as studies of service members incurring multiple mild TBIs are areas of needed research to identify potential differences in the characteristics, including disability characteristics, of deployment-related versus non–deployment-related TBI. A study is currently underway investigating the impact of pre-enlistment medical factors, such as comorbid psychiatric disorders, as risk factors for TBI-related disability.

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