Traumatic Brain Injury in Iraq and Afghanistan Veterans: New Results From a National Random Sample Study

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This study randomly sampled post-9/11 military veterans and reports on causes, predictors, and frequency of traumatic brain injury (TBI) (N=1,388). A total of 17.3% met criteria for TBI during military service, with about one-half reporting multiple head injuries, which were related to higher rates of posttraumatic stress disorder, depression, back pain, and suicidal ideation. The most common mechanisms of TBI included blasts (33.1%), objects hitting head (31.7%), and fall (13.5%). TBI was associated with enlisted rank, male gender, high combat exposure, and sustaining TBI prior to military service. Clinical and research efforts in veterans should consider TBI mechanism, effects of cumulative TBI, and screening for premilitary TBI.

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Traumatic brain injury (TBI) has been called a "signature injury" of the Iraq and Afghanistan conflicts.[1] The Defense and Veterans Brain Injury Center (DVBIC) report nearly 350,000 incident diagnoses of TBI in the U.S. military since 2000.[2] Among those deployed, estimated rates of probable TBI range from 11%−23%.[3–7]

Numerous consequences of traumatic brain injury are reported in the literature. Among veterans with positive TBI screens in Veterans Affairs (VA) facilities, 80% indicate comorbid psychiatric diagnoses.[8] Up to half of all service members with combat-related mild TBI (mTBI) meet criteria for posttraumatic stress disorder (PTSD).[4,9,10] Over one-third with a history of mTBI have depression,[3] with increased risk of suicidal ideation,[11] suicide attempts,[12] and suicide completion. Adjusting for psychiatric comorbidities, veterans with a history of TBI are 1.55 times more likely to die from suicide than those without TBI.[13] Additional sequelae associated with mTBI in veterans include cognitive impairment,[14–16] alcohol misuse[17] and binge drinking,[18] pain disorders,[19,20] and unemployment.[9,21] This corresponds to civilian research where TBI has been linked to suicide,[12] lower quality of life,[12] and mood and anxiety disorders.[12,22,23]

Despite known sequelae associated with TBI in Iraq and Afghanistan veterans, relatively less attention has been devoted to characterizing TBI. A RAND report on Iraq and Afghanistan veterans[3] found male gender, enlisted status, and younger age were related to probable TBI, though only combat trauma exposure was a significant factor controlling for covariates. Hoge et al.[4] demonstrated similar findings in Army soldiers; 15% of soldiers had probable mTBI and these soldiers were younger, junior rank, and male compared with soldiers with other injuries. Those with mTBI reported higher combat intensity and blast mechanism of injury.

The Medical Surveillance Monthly Report (MSMR) published by the Armed Forces Health Surveillance Center (AFHSC) in 2013 provided epidemiological data about TBI in U.S. military members from 2000 to 2011.[24] During this period, over 175,000 active service members had at least one TBI diagnosis; however, over 2/3 of all records of case-defining TBI medical encounters did not include a cause-of-injury code. From 2008 to 2011, 24,115 service members had a TBI-case defining medical encounter with recorded cause-of-injury. Accidents accounted for 74% of TBI, with motor vehicle accidents and fall each representing 20%. Assaults unrelated to war (N=2,526) and battle injuries (N=2,711) each accounted for 11%. Combat theater diagnoses accounted for only 10% of case-defining encounters. TBIs in men were more likely to be intentionally inflicted (assault, battle injury). TBIs from motor vehicle accidents comprised a higher proportion of TBI events among women (33%) than men (21%). According to DVBIC, for all TBIs diagnosed in U.S. military personnel between 2000 and August 2014, most were classified as mild (82.4%) and occurred in active duty personnel (81.6%).[2]

Regasa et al.[25] showed a relationship between deployment and postdeployment TBI diagnosis. Prior to deployment, active duty personnel had a 4-week TBI diagnosis rate of 119.8 per 100,000 service members, which increased to 1,055.8 per 100,000 service members in the 4-week period following deployment. The authors postulate increased occurrence of TBI in the postdeployment period is related to delayed diagnosis of deployment-related injuries and riskier behaviors leading to increased risk of injury.

The extant literature raises many questions about TBI in Iraq and Afghanistan veterans. What are typical characteristics of TBI events occurring during military service? How were soldiers most often injured? What percentage had head injuries prior to military service and did this have an impact? Are veterans with repeated head injuries more likely to report current physical and mental health symptoms than those with a single head injury? The present article addresses these questions, analyzing data from a national survey enrolling a random sample of military veterans who served since 9/11.

METHODS

Participants

The National Post-Deployment Adjustment Survey (NPDAS) sample was drawn by the VA Environmental Epidemiological Service (EES) in May 2009 from a random selection of over one million U.S. military service members who served after September 11, 2001, and were either separated from active duty or in the Reserves/National Guard. The sample was stratified by gender, oversampling women veterans; specifically, N=1,000 women veterans were randomly selected from all women who served in the military since 9/11 and N=2000 male veterans were randomly selected from all men who served in the military since 9/11. Addresses at the start of the study were updated by credit report.[26] Of names randomly selected, 63 did not have complete addresses or were deceased. Of the remaining 2,937, N=1,388 completed the survey, yielding a 56% corrected-response rate (N=438 had incorrect addresses), which is among the highest achieved in recent national surveys.[27]

The final sample was representative of all states, Washington D.C., and 4 territories. States with large military populations showed similar patterns in all response groupings. Gender did not differ between responders and nonresponders (33% women in both). Age and geographic differences were of small magnitude (36.2 years for responders versus 34.8 years for total surveys sent out). Race/ethnicity mirrored military breakdown: 71% Caucasian and 29% African-American, Hispanic, or other ethnicity. Military branch data of survey responders, 52% Army, 18% Air Force, 16% Navy, 13% Marines, and 1% Coast Guard, approximated the armed forces (48% Army, 22% Air Force, 17% Navy, 11% Marines, and 2% Coast Guard).[28]

Procedures

Following institutional review board approval, the survey utilized the Dillman Method,[29] which involved up to five contacts to maximize response rate. Potential participants were sent an introductory letter about the survey. Four days later, a letter was sent to potential participants containing a personal password, instructions on completing a 35-minute confidential web-based survey, and $4.40 in commemorative postage stamps. Twelve days after this letter, postcards were sent thanking veterans for completing the survey or reminding them to do so. Two weeks later, nonresponders received a paper survey with postage-paid return envelope. Two months after, a final letter was sent encouraging participation and alerting recipients the survey would close the following week.

A pilot (500 mailings) was conducted to identify technical problems, respondents received a $40 remuneration (fifteen percent of respondents completed the survey during the pilot phase). Eighty-five percent of respondents completed the survey during the rest of the study period, receiving $50 remuneration. Other than reimbursement, procedures were identical.

To examine differences in characteristics by survey medium or reimbursement rate, groups were compared on demographics and diagnoses. Using Bonferroni adjustment for multiple comparisons, no significant differences according to survey medium (paper versus web-based) or reimbursement rate were detected. Analyses were conducted comparing responders of the first invitation (wave 1 survey) to those who completed the survey after receiving later mailings. No differences were detected between responders from wave 1 and later responders, suggesting the survey process did not affect who was included in the achieved sample.

Measures

Data gathered included age, gender, race/ethnicity, marital status, employment, education, military branch, number/length/dates of deployments, and military rank.

TBI before, during and after military service was assessed using DoD/VA criteria[30] and published measures.[16] Occurrence of head injury was assessed with “was your head ever hurt/injured in a way that caused you problems?” If positive, veterans were asked, “How many head injuries causing you problems did you have [before, during, or after] your military service?” with answer choices of 0, 1, 2, 3, 4, and 5 or more. Participants provided data on their “worst head injury” sustained during each time period, defined as “the one that caused you the most problems.” Participants were asked “How old were you at the time?” and “How were you injured?” Responses were blast or explosion (rocket-propelled grenade, landmine, improvised explosive device [IED], grenade), vehicular accident/crash (include aircraft), fragment or bullet wound above the shoulder, fall, object hitting head or head hitting object, and knocked out by another person.

Veterans were asked: “Did you lose consciousness or did you get knocked out?” and then were prompted to specify duration of unconsciousness. Memory impairment was assessed by “Immediately after the injury or upon regaining consciousness, were you able to recall the event?” “Are you still unable to recall the event?” and “How long after the injury was it before you started remembering new things again?” Skull fracture and need for surgery were also assessed. Symptoms occurring immediately after injury were

TABLE 1. Characteristics of Veteran Sample (N=1,102)[a]

Characteristic	Military Veterans (N=1,102) N (%)
Gender	
Male	930 (84.4)
Female	172 (15.6)
Race/ethnicity	
White	775 (70.5)
Nonwhite	324 (29.5)
Education (years), more than high school	893 (81.1)
Branch of service[b]	
Army	584 (52.9)
Air Force	210 (19.1)
Navy	171 (15.6)
Marine Corps	122 (11.1)
Coast Guard	3 (0.3)
Reserve or National Guard	525 (47.7)
Officer rank	184 (16.7)
Deployments to Iraq and/or Afghanistan[c]	
0	185 (17.2)
1	606 (56.4)
≥2	284 (26.4)
Deployment >1 year	292 (26.5)
Type of service	
Direct combat	370 (33.7)
Combat or service support	731 (66.3)
Reported head injury during military service	223 (20.3)
Met criteria for probable TBI during military service	191 (17.3)
Number of head injuries during military service	
1	112 (50.2)
2	56 (25.0)
3	29 (13.2)
4	11(4.9)
≥5	15 (6.6)
Met criteria for probable TBI before military service	85 (7.8)
Number of head injuries before military service	
1	54 (64.1)
2	16 (19.5)
3	9 (10.5)
4	2 (2.4)
≥5	3 (3.8)
Of veterans with probable TBI during military service, sustained probable TBI before military service	22 (11.6)

[a] Women constituted 33% of the sample, whereas their proportion in the active military at the time of data collection was 15.6%; data were weighted to reflect the latter proportion, which involved adjusting the sample of N=1,388 to a weight-adjusted N=1,102.
[b] Missing branch of service data for 12 veterans.
[c] Missing deployment data for 27 veterans.

assessed: "Did you have any of the following symptoms immediately afterward or after you regained consciousness (if you got "knocked out")?" available responses were being dazed, confused or "seeing stars"; dizziness; blurred vision; loss of coordination; ruptured ear drums. Respondents were asked "Did any of the following problems begin or get worse afterward? (Please select all that apply)" Response choices were memory problems/lapses, balance problems or dizziness, headaches, sensitivity to bright light, irritability, and sleep problems.

Using expert consensus guidelines,[31] probable mild TBI (mTBI) was scored positive if reported loss of consciousness was less than 30 minutes, reported posttraumatic amnesia (PTA) was less than 24 hours, or the individual reported being dazed or "seeing stars" immediately after injury or upon regaining consciousness. Probable moderate-to-severe TBI was scored positive if the veteran reported a skull fracture, brain surgery, loss of consciousness greater than 30 minutes, or PTA greater than 24 hours. If either score met the cutoff, TBI was coded as positive, meaning criteria for TBI was met.

Combat exposure was measured with the Combat Experiences Scale from the Deployment Risk and Resilience Inventory.[32] PTSD was measured with the Davidson Trauma Scale, a cutoff score of 48 on this measure has shown diagnostic efficiency for probable PTSD.[33] MDD was assessed with the Patient Health Questionnaire using cutoff above 10.[34] Violence in the past year was measured with the Conflict Tactics Scale[35] and MacArthur Community Violence Interview.[36] Pain was measured on the Quality of Life Index.[37] Suicidal ideation was measured using the PHQ-9 item "Thoughts that you would be better off dead, or of hurting yourself in some way."[38]

Analysis

Data were weighted by gender to adjust for oversampling. Women constituted 33% of the NPDAS sample in contrast to 15.6% of the military based on September 2009 Defense Manpower Data Center figures.[28] Data were weighted to reflect the latter proportion, adjusting the sampled N=1,388 to a weight-adjusted N=1,102. Descriptive analyses provided frequencies of sample characteristics. Chi-square analyses compared veterans who did and did not meet criteria for a TBI during military service and between veterans who reported single versus multiple head injuries during military service. Multiple logistical regression was conducted on participants with nonmissing data to determine factors (rank, combat exposure, deployment, head injury before service) associated with having experienced a TBI during military service, controlling for covariates (age, gender, education).

RESULTS

Descriptive data on TBI of veterans sampled is presented in Table 1, which shows in this national sample, 223 (20.3%) reported a head injury during military service, of which 191 (17.3%) met criteria for TBI (see Table 1).

Table 2 indicates that among veterans with probable TBI during military service, mean age at time of injury was 26.1 years old (SD=7.1). Most common mechanism of injury was blast or explosion (N=63, 33.1%) by rocket-propelled grenade, landmine, IED, or grenade, followed by object hitting head or head hitting object (N=61, 31.7%), fall (N=26, 13.5%), vehicular accident or crash (N=17, 8.7%), knocked out by another person (N=12, 6.2%) and other (N=11, 5.6%). One TBI reported (0.5%) resulted from fragment or bullet wound above the shoulder.

Loss of consciousness occurred in 87 (45.6%) veterans. Immediate symptoms following injury included feeling dazed, confused, or "seeing stars" (N=172, 90%), dizziness (N=125, 65.5%), blurred vision (N=104, 54.5%), loss of coordination (N=96, 50.5%) and ruptured eardrums (N=25, 13.0%). PTA was experienced by 37 (19.2%) veterans. Seven (3.8%) veterans experienced skull fracture and one (0.5%) veteran required brain surgery. Probable mild TBI accounted for 87.3% of injuries, probable moderate-to-severe TBI represented 12.7% of injuries.

Chi-square analysis revealed male gender (19% v. 11%), multiple deployments (26% v. 14%) length of deployment longer than 12 months (27% v. 14%), enlisted rank (19% v. 11%), high combat exposure (26% v. 9%), and active duty service (22% v. 12%) were associated with probable TBI during military service. Service in the Marine Corps resulted in higher rates of probable TBI (23%), compared with service in the Army (19%), Navy (15%), and Air Force (11%). Veterans with probable TBI prior to military service had higher rates of probable TBI during military service (31% v. 16%). All comparisons are significant at the $p<0.05$ level. There was no difference in risk associated with race-ethnicity or level of education.

Multivariate logistic regression analysis (Table 3) demonstrates that sustaining probable TBI during military service is associated significantly with enlisted rank, high combat exposure, and sustaining probable TBI prior to military service. Nonsignificant factors were gender, race, post-high school education, multiple deployments, and deployments greater than 1 year.

Compared with veterans with a single probable TBI during military service, veterans who sustained multiple head injuries (see Table 4) during military service experienced significantly higher rates of PTSD (62% v. 28%), depression (62% v. 45%), suicidal ideation (31% v. 17%), back pain (75% v. 54%) and any pain (75% v. 57%). There was no statistically significant difference in violence and headache.

TABLE 2. Characteristics of Traumatic Brain Injury (TBI) During Military Service

Characteristic	Item
	Mean (SD)
Average age (years) at time of injury	26.1 (7.1)
TBI during service (N=191)	N (%)
Mechanism of injury	
Blast or explosion (rocket-propelled grenade, landmine, improvised explosive device, grenade)	63 (33.1)
Object hitting head or head hitting object	61 (31.7)
Fall	26 (13.5)
Vehicular accident/crash (including aircraft)	17 (8.7)
Knocked out by another person	12 (6.2)
Fragment or bullet wound above the shoulder	1 (0.5)
Other	11 (5.6)
Lost consciousness	87 (45.6)
Skull fracture	7 (3.8)
Required brain surgery	1 (0.5)
Immediate symptoms following TBI	
Dazed, confused, or "seeing stars"	172 (90.0)
Dizziness	125 (65.5)
Blurred vision	104 (54.5)
Loss of coordination	96 (50.5)
Ruptured eardrums	25 (13.0)
Severity of TBI	
Mild	167 (87.3)
Moderate/severe	24 (12.7)
Posttraumatic amnesia	37 (19.2)
Problems beginning or getting worse after TBI	
Headaches	111 (57.9)
Memory problems/lapses	92 (48.0)
Sleep problems	83 (43.5)
Irritability	76 (39.7)
Balance problems or dizziness	56 (29.4)
Sensitivity to bright light	55 (29.1)

DISCUSSION

The NPDAS provides a random sample of Iraq and Afghanistan war era military veterans and found 17.3% met criteria for TBI during military service and sustaining TBI during service was associated with enlisted rank, male gender, high combat exposure, and sustaining TBI prior to military service, consistent with past research.[3–7] To our knowledge, this study is the first to document how premilitary TBI relates to TBI experienced during military service. Research in civilians shows that history of TBI does potentially confer additional variance to predicting future TBI.[39] Correspondingly, current findings showed that veterans had double the odds of getting a TBI in the military, controlling for covariates, if they met criteria for TBI before service. The data suggest the utility of screening for premilitary TBI to ascertain deployment and placement in a combat zone. This study supports the current military Standards of Medical Fitness that includes comprehensive screening for premilitary TBI.

The study found the most common mechanisms of injury were blast (33.1%), object hitting head (31.7%), and fall

TABLE 3. Multivariate Analysis: Individuals Who Sustained Traumatic Brain Injury (TBI) During Military Service (N=1,102)[a]

	Sustained TBI During Military Service	
Covariate	Odds Ratio (95% CI)	p
Male gender	1.254 (0.731–2.149)	0.4111
Race	1.148 (0.794–1.658)	0.4632
Post-high school education	0.921 (0.615–1.379)	0.6893
Multiple deployments	1.464 (0.953–2.2480	0.816
Deployed >1 year	1.312 (0.846–2.036)	0.2250
Officer rank	0.502 (0.296–0.852)	0.0107
High combat exposure	2.877 (1.971–4.200)	<0.0001
TBI before military service	2.257 (1.288–3.956)	0.0045

[a] Multivariate analysis results are as follows: χ^2=83.32, df=8, $p<0.0001$; r-square=0.11.

TABLE 4. Outcomes of Single Compared With Multiple Head Injuries During Military Service

	Single Head Injury	Multiple Head Injuries	Analysis	
Outcome	N (%)	N (%)	χ^2	p
Posttraumatic stress disorder	26 (28.0)	62 (62.3)	22.5661	<0.0001
Depression	41 (44.8)	61 (61.7)	5.4111	0.0200
Suicidal ideation	16 (17.3)	31 (31.4)	5.1371	0.0234
Violence	16 (16.9)	20 (19.8)	0.2674	0.6051
Back pain	50 (54.0)	74 (74.8)	9.0900	0.0026
Headache	55 (59.8)	63 (63.8)	0.3254	0.5884
Any pain	52 (56.5)	74 (75.4)	7.5518	0.0060

(13.5%). This is generally consistent with the AFHSC 2013 report,[24] which found motor vehicle accidents, fall, and strikes by or against objects were most frequent causes of the first TBIs requiring medical care of military service members. The data attest to the need to pay attention to blasts with first responders as well as underscore the need to also allocate resources to preventing other TBIs. The current findings imply it would be useful for future research to explore potential differences and commonalities between blast and nonblast injuries.

The findings revealed the importance of how veterans are asked about TBIs; specifically, we found a difference between meeting criteria for TBI and asking veterans whether they experienced a head injury. Indeed, 14.3% of veterans who said they had head injury did not meet criteria for TBI when applied. A comprehensive TBI examination is common at the VA, but because many veterans do not go to the VA for their care, clinicians working with veterans may have "false positives" if they only ask about "head injuries," which can lead to potentially unnecessary treatment and inappropriate diagnosis. Alternatively, clinicians who take the extra time to utilize the VA and DOD criteria on TBI will have a clearer picture about severity (mild, moderate, severe) and a more accurate picture of occurrence of, and sequelae following, TBI.

Lastly, the national survey showed that many veterans reported multiple head injuries, associated with higher rates of PTSD, depression, suicidal ideation, back pain, and any pain. That half of veterans with TBI report multiple head injuries has implications for policy and practice. Bryan and Clemans[40] demonstrated lifetime suicidal ideation in 6.9% of veterans with single TBI, 21.7% of veterans with multiple TBI; similarly, rates of PTSD increased from 27.5% in single TBI to 35.3% in multiple. As such, current findings imply future research on TBI in veterans and military populations should inquire about number of TBIs and examine to what extent these lead to worse outcomes that need to be addressed in rehabilitation and recovery.

Several limitations should be noted. Self-reported data on TBI could have been affected by inaccurate or incomplete recall, a problem endemic in most empirical research as well as clinical work in TBI. Also, we only collected data on whether the veterans' worst head injury met criteria for TBI, not whether other head injuries met criteria; thus, we were limited to measuring repeated head injuries not repeated TBI. Given findings showing self-reported "head injuries" were not equivalent to meeting criteria for TBI, future research should continue to ensure variables are measured using DOD and VA criteria.

Additionally, given that 10% of the variance in meeting criteria for TBI during military service was accounted for by officer rank, combat exposure, and head injury before military service, there are likely other variables that need to be examined to obtain a more complete picture about what predicts TBI during military service. Despite this, statistically significant findings from multivariate models still warrant consideration when understanding predictors of TBI during military service.

Finally, although it is difficult to ensure perfect sample representativeness, a number of steps were taken to increase generalizability and external validity including random sampling of all U.S. veterans who served post 9/11, designing to achieve relatively high response rates, assessing for similarity between survey sample and actual military on demographics. To our knowledge, the current survey enrolled one of the most representative samples of post 9/11 military veterans to date.

In summary, current findings add knowledge to understanding TBI in post 9/11 military veterans. Of the 17.3% who met criteria for TBI during military service, about half reported multiple head injuries, comprising 7% of all veterans in the national sample. Multiple head injuries were related to higher rates of PTSD, depression, back pain, and suicidal ideation. Most common mechanisms of TBI included blast (33.1%), object hitting head (31.7%), and fall (13.5%). Veterans who sustained probable TBI prior to military service had double the risk of sustaining TBI when compared with other veterans. Taken together, the findings indicate clinical and research efforts in veterans should consider TBI mechanisms, cumulative TBI, and screening for premilitary TBI. Ultimately, better characterization effects of TBI in Iraq and Afghanistan veterans will ensure more accurate operationalization across different research studies and more informed clinical efforts to assess and treat medical and psychiatric conditions associated with TBI.

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