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Prevalence of Lifetime History of Traumatic Brain Injury among Older Male Veterans Compared with Civilians: A Nationally Representative Study

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Abstract

Traumatic brain injury (TBI) is common among older adults as well as among veterans in the United States and can increase risk for dementia. We compared prevalence of TBI in older male veterans and civilians using a nationally representative sample. We examined data from 599 male respondents to the 2014 wave of the Health and Retirement Study (HRS), a nationally representative survey of older adults, randomly selected to participate in a comprehensive TBI survey. Respondents self-reported no injury, non-TBI head/neck injury (NTI), or TBI. We used weighted analyses to examine prevalence of injury and relative risk of injury subtypes. Among male veterans, we found a national prevalence of more than 70% for lifetime history of any head/neck injury (TBI plus NTI), 14.3% for multiple NTI, and 36% for lifetime history of at least one TBI. In contrast, prevalence estimates for male civilians were 58% for lifetime history of head/neck injury, 4.8% for multiple NTI, and 45% for lifetime history of at least one TBI (all comparisons, $p < 0.001$). Male civilians have higher self-reported TBI prevalence, whereas male veterans have higher self-reported NTI and multiple-NTI prevalence. Further research on drivers of the unexpectedly higher prevalence of lifetime history of TBI in male civilians, as well as on mechanisms and sequelae of the highly prevalent non-TBI head/neck injuries among older male veterans, is warranted.

Keywords: nationally representative; traumatic brain injury; veterans

Introduction

Traumatic brain injury (TBI) is extremely common in the United States.[1] The Centers for Disease Control and Prevention estimate that TBI, defined as an injury to the head or neck causing loss of consciousness (LOC) and/or peri-traumatic amnesia or feeling dazed (PTA), causes 2.8 million emergency department visits, hospitalizations, or deaths each year.[2] However, this estimate does not include injuries that did not result in medical attention, those that were treated in outpatient clinics or federal facilities (such as military or Veterans Affairs [VA] medical centers), or those injuries to the head or neck that were asymptomatic and therefore did not meet criteria for a TBI.[3,4] Thus, to estimate the total lifetime burden of TBI in a population, self-report is usually necessary and considered standard.

Understanding the epidemiology of head/neck injury specifically among older adults is important because both TBI and repetitive asymptomatic head injuries are associated with heightened risk for several neurodegenerative diseases and other adverse health outcomes in aging.[5–11] It is often assumed that military veterans have a higher prevalence of lifetime history of head/neck injury, including TBI, compared with civilians due to exposure to blasts and other military-related head injuries, particularly in light of recent conflicts in which blast and resultant mild TBIs are signature injuries.[12] However, total lifetime prevalence of head/neck injury subtypes among older adult civilians compared with veterans in the United States is unknown as most prior studies have evaluated only one population or the other (thereby precluding direct comparison) or only focus on one specific injury subtype, such as mild TBI.[13] A more complete understanding of the epidemiology and sequelae of these injuries in the older adult veteran and civilian populations, however, has substantial implications for health-care planning and resource allocation in both civilian and VA health-care systems.

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This study aimed to describe and directly compare the prevalence of self-reported TBI and other head/neck injury subtypes in older male veterans versus civilians in the United States using a single nationally representative survey study that included both community-dwelling older veterans and civilians: the Health and Retirement Study (HRS).

Methods

Design and protocol approval

Data used for this study were de-identified, publicly available data from the HRS. All HRS respondents provided oral consent prior to data collection. This study was deemed exempt by the University of California, San Francisco Human Research Committee due to the use of publicly available de-identified data.

Data source and sampling

HRS is a longitudinal, nationally representative study of older adults (age 51 years and older) that has administered surveys every 2 years since study launch in 1992. HRS employs national area probability sampling of U.S. households with supplemental oversampling of black individuals, Hispanic individuals, and Florida state residents (see http://hrsonline.isr.umich.edu for further details). For the present study, we used data from male respondents to the TBI module survey, which was administered to a random subsample of the 2014 survey respondents ($n=1489$ of the 16,642 non-proxy respondents; overall $n=599$ men; see the study by Gardner and colleagues[14] for additional details). Female respondents were not included due to the very small number of female veterans in the sample ($n=7$). Of the 599 male respondents to the TBI module, 188 (32%) endorsed having served in the U.S. military during the 2014 HRS survey or in prior waves and were classified as veterans. Information about combat exposure status was not available.

Head/Neck injury exposure

Participants in the TBI module responded to questions from a modified version of the Ohio State University TBI Identification Method (OSU-TBI-ID[15]). This measure, which has demonstrated excellent reliability and predictive validity, is recommended by the National Institute of Neurological Disorders and Stroke (NINDS) for assessment of self-report of lifetime exposure to TBI in clinical research.

In the present study, ''No injury'' was defined as no head or neck injury of any kind. ''Head/neck injury'' was defined as any lifetime history of traumatic injury to the head or neck. ''TBI'' was defined as any injury to the head or neck resulting in loss of consciousness (LOC; i.e., ''Were you knocked out or did you lose consciousness?''), PTA (i.e., ''Were you dazed, or did you have a gap in your memory?'') or both. ''Non-TBI head/neck injury'' (NTI) was defined as any traumatic injury to the head or neck that did not result in symptoms of LOC or PTA. ''Multiple NTI'' was defined as having more than one NTI.

Demographics, medical comorbidities, and neurobehavioral conditions

We examined age, ethnicity, race, years of education, and self-report of medical comorbidities diagnosed by a physician. We also examined self-reported neurobehavioral symptoms including pain, sleep problems, depression, and subjective memory impairment using validated symptom scales and established cutoff scores, as described previously.[16] Missingness was under 1% for all variables.

Statistical analysis

All analyses were conducted using SPSS version 25 (IBM Corp., Armonk, NY).[17] Raking and weight trimming were used to adjust the sample to have the characteristics of all non-institutionalized men 51 and older in the United States as identified in the 2000 U.S. Census and 2004 Current Population Survey.[18] Baseline demographics, medical comorbidities, and neurobehavioral symptoms were compared across head/neck injury, veteran, and civilian groups using weighted chi square and *t* tests. We estimated weighted nationally representative prevalence of head/neck injury subtypes among veterans versus civilians. We used weighted chi square analyses to investigate relative risk of head injury severity and frequency among veterans versus civilians.

Results

Weighted nationally representative prevalence estimates of head/neck injury subtypes for male veterans versus civilians are shown in Table 1. Surprisingly, compared with civilians, veterans

Table 1. Weighted Head/Neck Injury Characteristics among Male Veterans Compared with Civilians

	Mean (SD) or %		
	Veterans (n=*188*)	*Civilians* (n=*411*)	P
Injury status			<0.001
No injury	28.9	41.6	
Head/neck injury	71.1	58.4	
TBI status: history	36.2	45.5	
of at least 1TBI	52.8	21.7	
Injury cause	47.5	49.6	
Blast	37.6	46.5	
Vehicle accident	75.3	74.7	<0.001
Sports/Playground			
Other			
Injury frequency			
No injury	28.9	41.6	<0.001
1 NTI, no TBI	20.6	8.1	
>1 NTI, no TBI	14.3	4.8	
1 TBI	19.9	23.1	
>1 TBI	16.3	22.4	
Treated in ED or required			<0.001
hospitalization	39.1	57.5	
Yes, for any head injury	13.7	22.6	
Yes, for NTI only	63.5	67.3	
Yes, for any TBI			
Injury severity			<0.001
No injury	28.9	41.6	
NTI only	34.9	12.8	
NTI and TBI (at least one of each)	15.3	14.1	
TBI without LOC	16.4	18.2	
TBI with LOC	19.8	27.4	
Time since injury			
Years since first head injury	47.37 (16.21)	41.68 (15.69)	<0.001
Years since last head injury	39.30 (19.17)	35.00 (17.78)	<0.001
Years since first NTI	47.79 (14.66)	40.80 (20.04)	<0.001
Years since last NTI	41.53 (18.34)	39.05 (19.88)	<0.001
Years since first TBI	46.96 (17.59)	41.93 (14.24)	<0.001
Years since last TBI	37.11 (19.72)	33.89 (16.98)	<0.001

Percentages are based on weighted data, but unweighted sample sizes are 411 civilians and 188 veterans.

ED, emergency department; LOC, loss of consciousness; NTI, non-TBI head/neck injury; SD, standard deviation; TBI, traumatic brain injury.

have significantly lower prevalence of TBI (36 vs. 45%, $p < 0.001$), including lower prevalence of both single and multiple TBI (see Table 1). Compared with civilians, veterans have significantly higher prevalence of head/neck injury (71 vs. 58%, $p < 0.001$), largely driven by their higher prevalence of single and multiple NTIs. Veterans have more than twice the prevalence of blast TBI compared with civilians ($p < 0.001$), but prevalence of other injury causes is similar.

Estimated nationally representative demographics and prevalence of medical and neurobehavioral conditions for older veterans and civilians by head injury status are shown in Table 2. Overall, veterans are older and more likely to be white. Both older veteran and civilian respondents have high prevalence of medical conditions, and those with TBI or NTI were more likely to have hypertension and arthritis compared with those without. Civilians are more likely to have depression across all head injury groups except the TBI group, in which veterans have almost a two-fold increased prevalence of depression (19.8 vs. 10.1%, $p < 0.001$). Veterans with multiple NTIs were also more likely to have neurobehavioral comorbidities, including pain and sleep problems.

Weighted risk ratios for head/neck injury subtypes among veterans versus civilians are shown in Table 3. When the reference category is no head/neck injury, veterans have significantly increased risk of head/neck injury frequency/severity, including 15% increased risk of TBI and nearly four times the risk of NTI, as compared with civilians. When risk of TBI was examined relative to ''no TBI'' (and thus the reference group included NTI), however, veterans appeared to have a significantly lower risk of TBI compared with civilians.

Discussion

In this nationally representative study of older U.S. men, we found a very high prevalence of lifetime history of TBI. Surprisingly, TBI prevalence was significantly higher among civilians compared with veterans, affecting nearly half of older male civilians. There are more than 93 million civilians age 50 and older in the United States, and about 47% are men.[19] Our results suggest that more than 19 million have a history of TBI; more than half may have a history of head/neck injury exposure (i.e., TBI or NTI). Concurrently, there are almost 15 million veterans age 50 or older in the United States, the vast majority of whom are male.[20] We found that 36% of older (51+) male veterans in the United States have a lifetime history of TBI, and almost three quarters report a lifetime history of head/neck injury. These figures suggest that there are almost 11 million older veterans aging with a history of head/neck injury exposure. However, only about 5 million within this group have a history of TBI. The remainder has experienced non-TBI head/neck injury (NTI). This estimate is nationally representative and may include veterans who do not access care from VA medical centers as well as those who do, an important strength of this study.

It is unclear why TBI is more prevalent among civilian men compared with male veterans in this sample, and this finding is unexpected. It is well documented that TBI occurs at higher rates in

Table 2. Characteristics of Weighted Nationally Representative Male Sample by Head/Neck Injury and Veteran Status

	Veterans				Civilians			
Values are mean (SD) or %	*No injury* (n=*62*)	*Single NTI* (n=*38*)	*Multiple NTI* (n=*19*)	*Any TBI* (n=*69*)	*No injury* (n=*187*)	*Single NTI* (n=*46*)	*Multiple NTI* (n=*22*)	*Any TBI* (n=*156*)
Demographics								
Age, years	72.00 (9.77)	70.09 (8.86)	67.89 (7.67)	67.96 (10.42)	63.29 (8.29)	65.07 (9.27)	2.83 (5.01)	62.37 (6.50)
Hispanic	5.6	3.9	0.4	1.1	16.6	11.1	3.4	6.7
White	93.3	86.4	97.6	84.9	75.4	83.5	88.8	84.1
Black	3.4	13.6	2.4	8.1	9.4	9.2	8.2	12.3
Other/Unknown	3.2	0.0	0.0	7.0	15.2	7.3	2.9	3.6
Education, years	14.0 (2.52)	13.01 (1.75)	13.84 (1.67)	13.4 (2.25)	13.6 (3.46)	13.85 (3.76)	14.03 (2.40)	17.2 (18.05)
Medical comorbidities								
Hypertension	67.1	75.6	70.4	63.8	50.6	51.7	32.8	64.4
Diabetes	34.7	19.2	25.9	26.9	21.1	45.8	15.8	26.7
Cancer	34.1	31.8	18.1	14.3	8.1	11.5	0.0	9.4
Lung disease	9.8	19.9	17.2	9.7	5.6	9.3	0.0	9.7
Heart disease	40.8	44.5	38.5	38.5	14.1	26.0	11.2	27.8
Stroke	13.0	1.4	0.0	8.5	4.9	3.6	0.0	5.3
Arthritis	58.6	48.5	66.7	71.4	30.0	47.9	54.9	57.4
Neurobehavioral conditions								
Pain	35.1	30.6	60.9	49.9	13.9	47.7	48.6	42.9
Sleep problems	42.5	41.0	46.1	37.8	27.6	38.2	28.9	44.9
Depression	6.8	9.9	11.6	19.8	9.5	26.3	26.5	10.1
Subjective memory impairment	28.6	16.3	20.9	25.2	22.2	30.3	26.7	30.6

$P < 0.01$ for all head injury status comparisons.

Percentages are based on weighted data, but sample sizes are 62 veterans with no injury, 38 veterans with single NTI, 19 veterans with multiple NTI, 69 veterans with TBI, 187 civilians with no injury, 46 civilians with single NTI, 22 civilians with multiple NTI, and 156 civilians with TBI.

NTI, non-TBI head/neck injury; SD, standard deviation; TBI, traumatic brain injury.

Table 3. Weighted Relative Risk of Injury Severity among Male Veterans Compared with Civilians[a]

Severity	N	*Veteran*	*Civilian*	*Relative risk (95% CI)*
Lifetime history of head/neck injury (Ref: no injury of any kind)				
Any injury NTI or TBI	599	71.1	58.4	1.76 (1.75-1.77)
NTI only (single or repetitive)[b]	374	54.7	23.6	3.92 (3.90-3.95)
TBI	474	55.6	52.3	1.15 (1.14-1.15)
NTI and TBI	599	15.3	14.1	1.11 (1.10-1.11)
Lifetime history of TBI (Ref: no TBI; Ref category includes respondents with NTI)	599	36.2	45.5	0.68 (0.675-0.682)
Frequency				
Lifetime history of head/neck injury (Ref: no head/neck injury of any kind)				
Multiple NTI only[b]	374	22.5	8.8	3.01 (2.98-3.04)
1 TBI only[c]	383	40.9	35.7	1.23 (1.23-1.25)
>1 TBI[d]	340	36.1	35.0	1.05 (1.04-1.06)

$P < 0.001$ for all comparisons.
Percentages and relative risks are based on weighted data.
[a]Reference = civilian; [b]TBI group excluded; [c]NTI and >1 TBI groups excluded; [d]NTI and single TBI groups excluded.
CI, confidence interval; NTI, non-TBI head/neck injury; TBI, traumatic brain injury.

service members compared with civilians[21–24]; in addition to the role of military combat and training in increasing TBI exposure, this is also accounted for by the overwhelmingly male composition of the armed forces and the fact that TBI risk is high for young men (<35 years of age), who make up the largest proportion of the military.[25] However, our results suggest that with aging comes increased risk of TBI exposure for male civilians, which surpasses that of their veteran peers.

The reason for this finding is unclear, but it is possible that veterans' military training and experiences may increase awareness of head injury risk, and/or introduce them to strategies that protect against head injuries following their military careers. Additionally, civilians may report TBI at higher rates compared with veterans because they are more aware of health status.[26] Finally, demographic variables such as race/ethnicity, which were not analyzed here due to small cell sizes, may also mediate the relationship between veteran status and lifetime TBI exposure. There is a dearth of research on race and ethnicity differences in TBI risk and prevalence. However, there is some evidence that black and Hispanic individuals may be at higher risk for TBI and/or poor outcomes after TBI among both veterans and civilians,[4,27–29] and our civilian sample included a higher percentage of non-white respondents compared with the veteran sample. Further research is needed to explore these possibilities.

Importantly, it would be premature to conclude on the basis of these findings from a small survey study that TBI is less of a health concern for veterans versus civilians. This is because it is also possible that veterans may be underreporting their TBI exposure. Underreporting of symptoms after head injury has been documented in civilian, active duty military,[30] and athlete[31] samples. Veterans, who have often been characterized as stoic,[32] may also underreport symptoms after an injury or may be less likely to recall a remote injury as having met criteria for a TBI. Additionally, for combat veterans, who may experience psychological as well as physical trauma simultaneously, identifying altered mental status and attributing it to a head injury could be challenging,[33] and this may be even more true for blast-related injuries, which were particularly common among our veteran sample. Therefore, some of the NTIs identified among veterans in the current study may in fact be TBIs. However, financial incentives in the form of compensation and pension and service connection systems within the VA represents an argument against underreporting in veterans, and studies of TBI prevalence in veterans and service members alone do document high rates of TBI endorsement.[13,34–37] In sum, the finding of lower TBI prevalence in veterans compared with civilians in our study is noteworthy and requires additional follow-up research to clarify the drivers of this observed difference.

Our results show a high prevalence of head/neck injury caused by blast among veterans, compared with a relatively low prevalence among civilians. This finding provides additional support and validation for the self-report methodology employed herein, given that veterans are known to be at high risk for blast injury.[34,35] Blast injuries are strongly associated with NTIs, including asymptomatic head injuries,[38] and a solider exposed to multiple blasts on deployment or during training may experience multiple NTIs without suffering an injury meeting criteria for TBI. Therefore, the high prevalence of blast injury among veterans is likely to be in part responsible for the high rates of NTI we observed in the veteran sample.

Our secondary finding of high prevalence of NTI among veterans, which requires further study, may have scientific and administrative relevance for VA and other health-care systems. Studying only history of TBI among veterans may mischaracterize the full burden of head injury in this population, miss important health consequences, and even misrepresent risks. However, current VA TBI screening procedures, which include the VA TBI Clinical Reminder and TBI Second Level Screen, only capture TBI during military service among veterans of the recent Operation Enduring Freedom/Operation Iraqi Freedom conflicts. These measures do not capture lifetime history of TBI or NTI,[36] and veterans of earlier conflicts are not systematically screened. Additionally, although the OSU-TBI-ID is the gold standard for identifying self-reported history of TBI, it was not designed to identify non-TBI injuries and may lack specificity for querying NTI in veterans. Thus, a military modification may be warranted. Our results suggest that research aimed at developing more detailed head/neck injury screening procedures for veterans as well as understanding the characteristics and epidemiology of NTIs is therefore required. These studies should address key questions such as whether these NTIs are primarily neck injuries, asymptomatic head injuries, or possibly TBIs that veterans either underreport or describe differently as compared with civilians.

The high prevalence of NTIs among veterans may also be important clinically because our results show that veterans with multiple NTIs are more likely to have neurobehavioral comorbidities, including pain and sleep problems, compared with veterans with other head injury statuses. Our findings raise the possibility that NTIs, which are extremely common, may be associated with multiple adverse health outcomes in older veterans even though veterans are not reporting LOC or PTA from these injuries. Evidence exists showing asymptomatic blast exposure is associated with adverse health outcomes among young service members,[37] but risks and outcomes as these service members age are as yet unknown. Additional work on the long-term effects of NTI and multiple NTI, in addition to lifetime history of TBI, is also required to improve treatment for older veterans.

This study has many strengths, including the use of a validated TBI exposure screen that is recommended by NINDS. To our knowledge, this is the first study to report comparative prevalence of lifetime history of head injury subtypes among older male veterans versus civilians using a nationally representative sample and one of the first to examine NTI in older veterans. Limitations of this survey study include small sample size and the potential for recall bias of injury history as well as self-report of medical comorbidities and neurobehavioral symptoms. In addition, our definitions of injury subtypes are impacted by the wording of the OSU-TBI-ID, which queries history of injury to the head or neck. This may result in ambiguity about the location and source of some injuries (i.e., head vs. neck). Further, because of the small number of female veterans in our sample, we were only able to examine men. Similarly, although stratification by race and ethnicity is of interest and important when considering prevalence and risk of head/neck injury, we were unable to do so because of small cell sizes; further research examining these questions stratified by race/ethnicity is needed.

Our results confirm, in accordance with previous research,[2,4,39] that TBI is extremely common among older men and is a key health issue for the aging population of the United States. In addition, we found that civilian men are more likely to report a lifetime history of TBI compared with older veterans. Older male veterans, however, are more likely to report a lifetime history of any injury to the head/neck and any blast injury. Importantly, our sample does not include veterans from the more recent conflicts, for whom TBI is the signature injury.[40] Therefore, TBI prevalence among older veterans, which is already high, is likely to increase over time. More research on head injury is required to meet the health-care needs of older Americans.

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Author Disclosure Statement

No competing financial interests exist.

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