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Association between traumatic brain injury and depression stratified by veteran status: Findings from the National Health Interview Survey

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Abstract

Globally, traumatic brain injury (TBI) is one of the major causes of morbidity and mortality, with increased incidence reported among veterans. In this study, we explored the relationship between TBI and subsequent screening of depressive symptoms, with further analysis stratified by veteran status. For this study, the National Health Interview Survey data for 2023 was used, which was conducted among 29,522 non-institutionalized U.S. adults aged 18 and older. The patient health questionnaire-2 was used to screen for depression. Self-reported incidence of lifetime TBI was documented. From a Chi-square test, a significant association was observed between TBI and depression (p<0.05), with TBI more commonly being reported among veterans compared to non-veterans. Our regression model indicated that, when adjusted for sociodemographic and health variables, TBI was associated with 1.80 times higher odds of depression among the whole sample population (adjusted odds ratio [aOR] = 1.80; 95% confidence interval [CI] 1.61 – 2.02, p<0.05). When stratified by veteran status, veterans with TBI had 2.92 times higher odds of depression (aOR = 2.92; 95% CI 2.05 – 4.14, p<0.05). Compared to the whole general population, veterans with a brain injury history have higher odds of depression, identifying them as a key group in prioritizing depression management in the United States population.

Keywords: Concussion; Depression; Head injury; Mental health; Military; Traumatic brain injury; Service member; Veteran

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1. Introduction

Depression ranks fourth in the list of diseases causing the most death and disability, only behind other serious medical conditions such as cardiac disease, stroke, and acquired immunodeficiency syndrome.[1] Traumatic brain injury (TBI) is defined as an injury caused to the brain by an outside force such as blows, jolts, or a forceful bump. TBI, at any point in life, can be a risk factor for future psychiatric complications including depression and anxiety. TBI is usually classified into three broad categories – mild, moderate, and

severe based on clinical presentations, which at times are non-specific and non-predictive of future disease course.[2] Nevertheless, TBI is the principal cause of mortality and morbidity among people under the age of 45 years globally.[3] Despite major advancements in TBI treatment and long-term management, a significant number of people still suffer from long-term sequelae. According to prior research, in 2014 alone, the United States (U.S.) documented 2.53 million emergency department visits due to some form of TBI along with 288,000 hospitalizations and 56,800 subsequent deaths.[4] TBI is cited as one of the most common injuries with lifetime prevalence of 22% across a population.[5] It is important to note that not all cases of TBIs are formally diagnosed in the hospital setting. This number excludes military veterans who are thought to be at an elevated risk of suffering from TBI.

There is support that psychological symptoms associated with TBI, such as depression and anxiety, are alleviated within 12 weeks of injury.[6] Recently, researchers have been discussing about a more transient nature of depression following acute injury that re-emerges as a chronic medical condition later in life.[7] In line with recent thoughts, new evidence illustrated that approximately 25 – 50% of people suffer from depression of varying severity within 1 year of a TBI, 60% within the first 7 years, and the heightened risk persists even after 50 years of the initial injury.[8] In another study, researchers recorded a 40% prevalence of depression along with a 7.5 relative risk among participants, irrespective of TBI severity.[9]

In a previously conducted study, it was demonstrated that veterans are 31% more likely to suffer from major depression at any point in their life, which is significantly higher than the general population.[10] In a subsequent study, increased frequency of depressive episodes among veterans was also linked to higher rates of suicide.[11] This is compounded by the fact that veterans usually have worse health outcomes compared to the general population.[12] Veterans who were deployed overseas were twice more likely to get diagnosed with depression compared to others.[13] While veterans have a higher odds of suffering life threatening injuries, previous studies indicate that, just like the general population, most of the brain injuries suffered by veterans are mild in nature.[14] Another interesting aspect is the assumption that mode of injury might be an important indicator of higher prevalence of depression among military veterans. In a recent study, researchers found that veterans with blast or non-blast injuries had quite similar post-traumatic outcomes.[15] This highlights the complex causal mechanism of depression among veterans. While frequent TBI contributes significantly to depression, other factors such as living away from family, multiple combat missions, job stress, and cultural differences might also contribute to higher prevalence of depression among veterans.[16]

Previous studies have identified a relationship between the incidence of TBI and diagnosis of subsequent mental health disorders among the general population. For this research, we are focusing our attention solely to TBI and depression. There remains limited research examining this association among veterans, especially using a large nationally representative U.S. sample. Therefore, in our present study, we analyze the association between TBI and depression, stratifying this relationship by veteran status.

2. Materials and methods

2.1. Data source

We retrieved data of 29522 participants from the National Health Interview Survey (NHIS) administered by the Centers for Disease Control and Prevention (CDC) National Center for Health Statistics in 2023. Starting in 1957, the NHIS is one of the largest datasets in the U.S. that annually collects data on a broad range of health topics across the country using a geographically clustered sampling technique through face-to-face interviews with non-institutionalized civilians.

2.2. Depression

The dependent variable was depression, measured using the two-item patient health questionnaire (PHQ-2), a subset of the larger PHQ-8 scale used to screen for depression.[17] Participants were asked during the past 2 weeks whether they have been bothered by the following problems – "little interest or pleasure in doing things" and "feeling down, depressed, or hopeless." Scores ranged from 0 ("not at all") to 3 (nearly every day). Based on scores, results are categorized as either "positive" or "negative," with a score of 3 or higher being identified as "positive" for depression screening. Despite the shorter scale, the diagnostic performance is comparable to longer scales. The PHQ-2 has been previously tested to have a sensitivity of 87% and a specificity of 78% for major depressive disorder.[18]

2.3. TBI history

The independent variable was a history of TBI. Participants were asked, "In your lifetime, have you ever had a significant head injury or concussion?." This question was asked to only adults 18 years and older who did not experience any loss of consciousness or head injury symptoms within the past 12 months. Responses were either "yes" or "no."

2.4. Veteran status

Sample adults aged 18 and older were asked if they had ever served on active duty in the U.S. Armed Forces,

military reserve, or the National Guard. Responses were either "yes" or "no."

2.5. Covariates

Several sociodemographic variables and chronic diseases were included as covariates in the regression model. Age was continuous and top-coded to 85+ years. Sex was categorized as either "male" or "female." Race and ethnicity were categorized into four categories – "White," "African American," "Hispanic," and all other races into the "other" category. Education was coded into "below high school," "12th grade, GED, or equivalent," "associate degree," "bachelor's degree," and finally "postgraduate degree (Master's/PhD/Professional)." General health was categorized into five categories from poor to excellent. Participants were asked whether, at any point in their lives, they were diagnosed with hypertension, cardiovascular disease, cancer, and diabetes. These chronic conditions were also adjusted for as covariates. All variables with the "unknown," "refused," or "not ascertained" entries were coded as missing values.

2.6. Data analysis

A Chi-square test was performed to evaluate the association between TBI and depression. For continuous variables, a t-test was used, and for categorical variables chi-square test was employed. For the multiple logistic regression, a model was constructed using the whole sample population adjusting for sociodemographic and chronic diseases. Subsequently, the regression was performed again stratified by veteran status. When testing for multicollinearity, no individual variance inflation factor (VIF) value was >10, and the average VIF value of all variables was 2.75, indicating no violation of this assumption. All the analyses in this research were conducted with two-tailed tests using IBM Statistical Package for the Social Sciences Statistics version 29, with $p<0.05$ indicating statistical significance.

3. Results

3.1. Sample characteristics

From a total of 28,623 participants, 1,988 (6.7%) were screened as positive for depression based on the PHQ-2 (Table 1). Among the study participants, 66% (n = 19,495) identified themselves as White, followed by 10.9% as African American (n = 3,216), 15% as Hispanic (n = 4,418), and 8.1% as others (n = 2,393). Regarding education, 40.1% (n = 1,853) of study participants had a high school diploma or equivalent and formed the largest group in the education category. People who reported to have at least a bachelor's degree were the second largest group (23%, n = 6,792). Regarding general health, more than half of the participants (54%) reported their health status as either "excellent" or "very good," with only 3.8% (n = 1,111) reported their health status as "poor." Regarding the history of comorbidities, 37.6% (n = 11094) were reported to be diagnosed with hypertension, followed by 6.2% (n = 1,833) with cardiovascular disease, 12.7% (n = 3762) with cancer, and finally 11.2% (n = 294) of participants were diagnosed with diabetes. Among the participants, 18.7% (n = 5,533) reported to have suffered TBI at least once in their lifetime. From the Pearson Chi-square test, a significant association was observed between positive results in depression screening and TBI across the whole sample ($\chi^2[^1 = 171.20$, $p<0.05$) (Table 1).

3.2. Multiple logistic regression

In our multiple logistic regression model, a statistically significant association was observed between TBI and depression (Table 2). When adjusted for sociodemographic and chronic disease variables, participants with a TBI history had 1.80 times higher odds of depression compared to participants with no brain injury record (adjusted odds ratio [aOR] = 1.80; 95% confidence interval [CI] 1.61 – 2.02, $p<0.05$).

When stratified by veteran status, adjusting for other covariates, veterans with a brain injury history had 2.92 times higher odds of depression compared to veterans without TBI history (aOR = 2.92; 95% CI 2.05 – 4.14, $p<0.05$) (Table 2). On the other hand, non-veterans had 1.68 times higher odds of depression compared to non-veterans without TBI history (aOR = 1.68; 95% CI 1.49 – 1.90, $p<0.05$).

4. Discussion

This study probed the relationship between TBI and depression among the whole sample as well as veterans. In both the bivariate test and multiple regression models, a significant association was observed between TBI and depression among the whole sample. In addition, it was found that the magnitude of the TBI-depression association was higher among veterans compared to non-veterans, with 2.9 increased odds versus 1.7 increased odds, respectively. In comparison, a recently published meta-analysis revealed that the odds of depression were highest at 4.1 1 to 2 years after the injury, but decreased to 3.2 after 10 years of the original injury. Interestingly, the researchers did not find any statistically significant difference between post-TBI depression and injury etiology.[5] While the researchers included studies conducted on military personnel in their meta-analysis, no specific odds ratio for depression among veterans was provided.

A recently published meta-analysis on depression prevalence among veterans worldwide demonstrated that veterans, due to their unique nature of work, sleep

Table 1. Sample characteristics stratified by veteran status and depression

Variable	Whole sample		Veteran		Non-veteran	
	Depression (*n*, %)	No depression (*n*, %)	Depression (*n*, %)	No depression (*n*, %)	Depression (*n*, %)	No depression (*n*, %)
TBI history						
No	1180 (5.4)	20602 (94.6)	93 (12.9)	77 (4.6)	1098 (5.5)	18890 (94.5)
Yes	564 (10.2)	4941 (89.8)	629 (87.1)	1596 (95.4)	469 (9.9)	4290 (90.1)
Age, mean±SD	51.84±18.86	53.22±18.52	59.06±16.53	64.80±16.13	51.05±18.94	52.17±18.36
Sex						
Male	848 (6.5)	12239 (93.5)	177 (7.9)	2054 (92.1)	656 (6.2)	9986 (93.8)
Female	1139 (7.3)	14392 (92.7)	26 (9.2)	256 (90.8)	1092 (7.3)	13906 (92.7)
Race and ethnicity						
White	1289 (6.8)	17719 (93.2)	145 (7.3)	1836 (92.7)	1127 (6.7)	15658 (93.3)
African American	273 (9)	2766 (91)	31 (11.5)	239 (88.5)	233 (8.7)	2448 (91.3)
Hispanic	282 (6.6)	3991 (93.4)	17 (9.8)	156 (90.2)	259 (6.5)	3753 (93.5)
Other	144 (6.3)	2159 (93.7)	10 (11.2)	79 (88.8)	130 (6.0)	2037 (94.0)
Education status						
Below high school	247 (10.2)	2179 (89.8)	6 (7.3)	85 (93.4)	235 (10.3)	2052 (89.7)
12th grade/GED/ Equivalent	982 (8.6)	10489 (91.4)	121 (10.7)	1005 (89.3)	841 (8.3)	9294 (91.7)
Associate degree	259 (7)	3445 (93)	33 (8.2)	369 (91.8)	223 (6.9)	3030 (93.1)
Bachelor's degree	323 (4.9)	6298 (95.1)	29 (5.6)	489 (94.4)	291 (4.8)	5722 (95.2)
Postgraduate degree	164 (3.8)	4111 (96.2)	13 (3.5)	358 (96.5)	148 (3.8)	3698 (96.2)
General health status						
Excellent	137 (2.3)	5732 (97.7)	13 (3.7)	342 (96.3)	121 (2.2)	5288 (97.8)
Very good	361 (3.7)	9302 (96.3)	26 (3.4)	737 (96.6)	328 (3.7)	8436 (96.3)
Good	568 (6.7)	7876 (93.3)	51 (6.1)	784 (93.9)	507 (6.8)	6964 (93.2)
Fair	543 (15.2)	3041 (84.8)	57 (13.8)	356 (86.2)	476 (15.3)	2632 (84.7)
Poor	378 (36.1)	670 (63.9)	56 (38.9)	88 (61.1)	316 (35.8)	566 (64.2)
Hypertension	910 (8.4)	9866 (91.6)	121 (8.9)	1232 (91.1)	771 (8.3)	8519 (91.7)
Cardiovascular disease	190 (10.7)	1588 (89.3)	40 (12)	293 (88)	147 (10.3)	1280 (89.7)
Cancer	258 (7)	3407 (93)	35 (6.3)	523 (93.7)	221 (7.2)	2839 (92.8)
Diabetes	354 (11.1)	2832 (88.9)	49 (11.1)	393 (88.9)	299 (11.1)	2404 (88.9)

Abbreviations: SD: Standard deviation; TBI: Traumatic brain injury.

deprivation, exertion, and nutritional deficiency, often develop psychological disorders later in their lives.[19] This is often compounded by TBI suffered by veterans on active duty as many of them suffer from post-traumatic stress disorder, cognitive deficits, and suicidal thoughts.[20] Affected persons might suffer from other symptoms alongside depression including chronic pain and loss of employment.[21] In addition, an increased incidence of brain cancer was reported among veterans suffering from moderate-to-severe head injury.[22]

The higher odds of depression and incidence of TBIs reported among veterans contribute to a major public health issue that may have debilitating effects both on the healthcare system and the personal lives of the affected individuals. This requires urgent intervention from public health organizations both among the general population and veterans. Most of the cases of depression among veterans are resolved after psychotherapy and pharmacological management. Cognitive behavioral therapy and interpersonal therapy help people manage negative thoughts and suicidal ideation, as well as help developing coping skills.[23] Patients unresponsive to psychological therapy are often treated with antidepressants and mood stabilizers.[24] At present, available antidepressants are highly effective, reducing symptoms by more than 50%

Table 2. Association between TBI history and depression stratified by veteran status

Variable	Whole sample aOR (95% CI), p	Veteran aOR (95% CI), p	Non-veteran aOR (95% CI), p
TBI history	1.80 (1.61 – 2.02), <0.05	2.92 (2.05 – 4.14), <0.05	1.68 (1.49 – 1.90), <0.05
Age	0.98 (0.97 – 0.98), <0.05	0.97 (0.96 – 0.98), <0.05	0.98 (0.977 – 0.984), <0.05
Sex			
Female	Reference	Reference	Reference
Male	0.79 (0.71 – 0.87), <0.05	0.71 (0.42 – 1.18), >0.05	0.78 (0.70 – 0.87), <0.05
Race and ethnicity			
White	Reference	Reference	Reference
African American	1.15 (0.98 – 1.34), >0.05	1.62 (0.99 – 2.66), >0.05	1.10 (0.93 – 1.30), >0.05
Hispanic	0.75 (0.64 – 0.88), <0.05	1.09 (0.58 – 2.02), >0.05	0.73 (0.62 – 0.86), <0.05
Other	0.92 (0.75 – 1.12), >0.05	1.63 (0.73 – 3.62), >0.05	0.89 (0.72 – 1.09), >0.05
Education status			
Below high school	Reference	Reference	Reference
12th grade/GED/Equivalent	1.00 (0.84 – 1.19), >0.05	1.54 (0.57 – 4.14), >0.05	0.96 (0.80 – 1.14), >0.05
Associate degree	0.81 (0.65 – 1.0), <0.05	1.00 (0.34 – 2.94), >0.05	0.80 (0.64 – 0.99), <0.05
Bachelor's degree	0.75 (0.62 – 0.92), <0.05	0.98 (0.34 – 2.82), >0.05	0.74 (0.60 – 0.91), <0.05
Postgraduate degree	0.64 (0.51 – 0.81), <0.05	0.75 (0.24 – 2.36), >0.05	0.64 (0.50 – 0.81), <0.05
General health status			
Excellent	0.04 (0.03 – 0.05), <0.05	0.04 (0.02 – 0.10), <0.05	0.04 (0.03 – 0.05), <0.05
Very good	0.06 (0.05 – 0.08), <0.05	0.04 (0.02 – 0.08), <0.05	0.06 (0.05 – 0.08), <0.05
Good	0.12 (0.10 – 0.14), <0.05	0.08 (0.05 – 0.14), <0.05	0.12 (0.10 – 0.15), <0.05
Fair	0.31 (0.26 – 0.36), <0.05	0.19 (0.11 – 0.32), <0.05	0.32 (0.26 – 0.39), <0.05
Poor	Reference	Reference	Reference
Hypertension	1.05 (0.93 – 1.19), >0.05	1.08 (0.73–1.60), >0.05	1.04 (0.91 – 1.18), >0.05
Cardiovascular disease	1.08 (0.89 – 1.31), >0.05	1.14 (0.69 – 1.19), >0.05	1.07 (0.87 – 1.33), >0.05
Cancer	0.82 (0.70 – 0.97), <0.05	0.73 (0.45 – 1.19), >0.05	0.85 (0.71 – 1.02), >0.05
Diabetes	0.98 (0.84 – 1.14), >0.05	1.09 (0.69 – 1.71), >0.05	0.96 (0.82 – 1.14), >0.05

Abbreviations: aOR: Adjusted odds ratio; TBI: Traumatic brain injury.

within 8 weeks after treatment initiation. However, some cases advance to chronic conditions and require extensive management straining the already fragile healthcare system.[25] Nurses, medics, corpsmen, and primary healthcare providers should be included in a holistic treatment approach where education and monitoring would be considered as integral components. Any suspicion of depression among veterans with recent TBI should be addressed with utmost caution.[26] Previous research demonstrated that females are more likely to get diagnosed with depression compared to males.[27] For future research, it remains to be seen whether gender of veterans has any interacting effect on the association between TBI and depression.

From a public health perspective, our study offers important contributions in shaping intervention strategies for people with a history of TBI. This is even more impactful for veterans who are more prone to TBI due to the nature of their prior service and subsequent depression diagnosis. Nonetheless, the ramifications of depression are not solely confined to the health of the affected individual as it has ripple effects for the society more broadly due to increased healthcare utilization.[28] The robust association between TBI and positive screening for depression among veterans in later life underscores the necessity for implementing targeted mental health screening for vulnerable individuals. Since the incidence of depression among veterans are higher than the general population, routine screening after each TBI incident might alleviate the risk up to a certain extent.[29] This would improve long-term outcomes and reduce the burden on already scarce healthcare resources. While the PHQ-2 is a useful screening tool for depression among individuals, the longer and more robust PHQ-9 could also provide more data and clarity while screening for depression in high-risk groups.[30]

Veterans are a unique subpopulation with cumulative exposure to multiple stressors including blast injury, long overseas deployment, and other psychological stressors, that coupled with TBI may exacerbate depression among veterans.[31] Veterans Affairs initiatives such as telepsychiatry and trauma informed therapy could lessen the psychological impacts post-TBI and reduce depression incidence among veterans.[32,33]

Policy makers and health care providers should consider implementing longitudinal surveillance due to the unpredictable and often late-onset nature of depressive symptoms post-TBI. Patients should be monitored over a long period of time, and health records should be stored electronically.[32,33] There should be a policy where the Department of Defense, Department of Veterans Affairs, and public health agencies relating to veteran health should operate on a common platform where they can share data across providers to ensure continuity of care and identification of each high-risk individual.[34,35]

At the federal level, the government should allocate sufficient funds for treatment and prevention of TBI associated depression. At present, there is a shortage of staff and services geared toward minimizing post-TBI sequelae among affected individuals.[36] Non-governmental organizations dealing with mental health issues should also come forward and include post-TBI depression prevention in their organizational framework. While treatment and management of post-TBI depression warrants significant resources, efforts should also be directed toward formulation and implementation of preventive strategies. Approaches such as an evidence-based resilience training, a post-deployment debriefing program, and a peer support network could be adopted to reduce post TBI morbidity in addition to traditional psychotherapies such as CBT.[37] Furthermore, a large scale destigmatization program should be conducted among both military individuals and civilians regarding mental health treatment, as stigmatization is hitherto a significant barrier to accessing care.[38] Finally, people of color as well as individuals from socioeconomically disadvantaged backgrounds traditionally face significant hurdles while accessing mental health care. Ensuring equal opportunity and equity of access for all the people would be a key determinant while seeking successful outcomes at the population level.[39]

There are several limitations to our study. First, the two-item questionnaire used to screen for depression is not a clinical depression diagnosis among study participants. This is originally part of a larger PHQ-8 questionnaire that also commonly screens for depression. While the two-item questionnaire was tested for sensitivity and specificity, further evaluation is required to reach a definitive conclusion regarding the presence and severity of depression among study participants. Second, all the data included in the analysis are self-reported and cross-sectional, making them susceptible to information or recall bias. For example, participants were asked about whether they had suffered significant brain injury or concussion in their lifetime. Injuries sustained in early life might not be reported properly, and the definition of "significant brain injury" might be open to interpretation. Finally, brain injuries were reported on a lifetime basis but excludes recent TBI incidents, along with source and severity of the injury. Further research is warranted to investigate how these TBI characteristics may influence mental health. Nonetheless, measurement of lifetime TBI history strengthens our findings by lending temporality to our analysis of the association between TBI and depression. In addition, the cross-sectional nature of the study design does not allow us to establish causality between TBI and depression, even though TBI is often associated with increased prevalence of mental health issues and health resource utilization.[40] Despite these limitations, we analyzed a large nationally representative U.S. sample and applied a rigorous analysis adjusting for many possible covariates that may confound the association between TBI and depression.

5. Conclusion

Our study sheds light on the association between TBI and depression in the general population, as well as veterans. The findings of our study reveal that veterans with head injuries are more susceptible to depression compared to the general population. This establishes veterans as priority groups for future intervention programs aimed at reducing the burden of depression among the U.S. population.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

Conceptualization: All authors
Formal analysis: Md Maruf Ahmed Molla
Investigation: Md Maruf Ahmed Molla
Methodology: All authors
Writing–original draft: Md Maruf Ahmed Molla
Writing–review & editing: All authors

Ethics approval and consent to participate

This project was determined to be exempt from approval by the Institutional Review Board (IRB) of SUNY Upstate Medical University. Ethical review and approval were waived for this study because it meets IRB exemption category #4(i) – identifiable private information or identifiable biospecimens used in this study are publicly available. Patient consent for this study was not required due to the approval of IRB exemption. There was no potential for harm to subjects in the database and the data were used without identifying information.

Consent for publication

Not applicable.

Availability of data

This study uses public data, which may be obtained through the CDC and is publicly available at: https://www.cdc.gov/nchs/nhis/documentation/2023-nhis.html

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