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Suicide and Traumatic Brain Injury Among Individuals Seeking Veterans Health Administration Services Between Fiscal Years 2006 and 2015

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Objective: Examine associations between traumatic brain injury (TBI) and (1) suicide and (2) suicide method among individuals receiving Veterans Health Administration (VHA) care. **Setting:** VHA, Fiscal Years 2006-2015. **Participants:** Veterans with a TBI diagnosis during/prior to the study window ($n = 215\,610$), compared with a 20% random sample of those without TBI ($n = 1\,187\,639$). **Design:** Retrospective, cohort study. Cox proportional hazards models were fit accounting for time-dependent measures, chronic conditions, and demographics for those with TBI compared with those without. Additional models evaluated the impact of TBI severity on the association between TBI and suicide, and method. **Main Outcome Measures:** Death by and method of suicide. **Results:** The hazard of suicide was 2.19 times higher for those with TBI than for those without TBI (95% CI = 2.02-2.37), and was still significant after accounting for covariates (hazard ratio [HR] = 1.71; 95% confidence interval [CI] = 1.56-1.87). Considering severity, mild TBI compared with no TBI was significantly associated with an elevated hazard of suicide, after adjusting for covariates (HR = 1.62; 95% CI = 1.47-1.78). There was also a significant difference in death by suicide between moderate/severe TBI when compared with no TBI, after adjusting for covariates (HR = 2.45; 95% CI = 2.02-2.97). Moderate/severe TBI was significantly associated with an increase in the odds of suicide by firearm among decedents (odds ratio = 2.39; 95% CI = 1.48-3.87). **Conclusion:** Traumatic brain injury is associated with an elevated risk for suicide. Particular concern is warranted for those with moderate/severe TBI. Lethal means safety should be explored as an intervention. **Key words:** *firearms*, *suicide*, *traumatic brain injury*, *veterans*, *Veterans Health Administration*

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OVER THE PAST 2 DECADES, suicide rates have been rising across the United States, and death by suicide is now the 10th leading cause of death.[1] Compared to civilians, Veterans are at disproportionate risk for suicide.[2] According to U.S. Department of Veterans Affairs (VA) 2018 National Suicide Data Report, in 2016, the suicide rate among Veterans was approximately 1.5 times greater than that among civilian adults, after accounting for age and gender.[3] While the Veterans Health Administration (VHA) has developed numerous selective and indicated prevention strategies to direct clinical services to Veterans at elevated risk for suicide,[4–6] more information is needed to identify and target subgroups at increased risk for suicide.

Several studies among general populations have found an association between a history of traumatic brain injury (TBI) and increased risk for suicide.[7–11] A recent registry-based retrospective cohort study involving all Denmark residents found that over a 35-year period, individuals who received medical attention for TBI were nearly twice as likely to die by suicide as compared with

individuals without a medically treated TBI (adjusted incidence rate ratio, 1.90), and risk of suicide was further increased among those with severe TBIs, as well as among individuals with a pre-TBI psychiatric diagnosis.[7] Similar to civilians, TBI has been associated with increased risk of death by suicide among Veterans,[4,12] yet there have been fewer systematic studies. A study of Veterans using the VHA in fiscal years (FYs) 2001-2006 found that Veterans with a TBI diagnosis were approximately 1.5 times more likely to die by suicide than those without a TBI diagnosis.[12] Importantly, the association between TBI and suicide was significant after adjusting for psychiatric diagnoses and demographics. Moreover, as these data were drawn from the time period surrounding the relative beginnings of the conflicts in Afghanistan and Iraq, injuries sustained overseas were likely not represented. Finally, using predictive modeling to examine VHA data to identify patients at risk for suicide during FYs 2008-2011, McCarthy and colleagues[4] found that Veterans with a TBI diagnosis were more than twice as likely to die by suicide than Veterans without a TBI diagnosis.

High prevalence rates of TBI have been identified among Veterans on whole, as well as among those who deployed to Afghanistan or Iraq. Among Veterans who served in Operation Enduring Freedom/Operation Iraqi Freedom/Operation New Dawn (OEF/OIF/OND), estimates suggest that between 12% and 22% have experienced at least 1 mild TBI (mTBI).[13–17] Moreover, the work by Russell and colleagues[18] suggested that 47% of Veterans seeking homeless services had a probable history of TBI. Similarly, among those seeking VHA mental health services, Brenner et al[19] found the prevalence of probable TBI to be 45%. Notably, 27% of those who completed the Ohio State University TBI Identification Method (OSU TBI-ID)[20,21] indicated a lifetime history of moderate/severe TBI, suggesting that they likely had persistent sequelae.

Suicide risk can be mitigated by implementing interventions aimed at increasing lethal means safety. The most common means for suicide among both civilians and Veterans in the United States is firearms. The use of firearms as a means of suicide has decreased among civilians (2001 to 2014); however, it has remained stable among Veterans overall, with a notable increase in use among female Veterans.[22,23] In 2014, 41% of female and 68% of male Veteran suicides resulted from a firearm injury.[22] To date, there has been a paucity of research examining whether TBI is associated with an increased tendency to use firearms as the mechanism of suicide injury. Specifically, since firearms are associated with the highest case fatality rate compared with other means, more research is needed to examine whether TBI is associated with suicide by firearm, particularly among Veterans, who are more likely to have expertise using firearms and may be more likely to have access to firearms.[2]

The primary objective of this study was to examine the association between receiving a TBI diagnosis and subsequent risk of death by suicide among those using VHA services between FY 2006 and FY 2015, with the expectations that this cohort would include a greater number of OEF/OIF/OND Veterans than in Brenner et al.[12] We hypothesized that there would be a significant relationship between TBI and suicide, but that this relationship would be attenuated after controlling for psychiatric diagnoses, comorbidities, age, and gender. Furthermore, the secondary objective of this study was to examine whether TBI was associated with suicide method (firearm vs other) among Veterans who used the VHA. To our knowledge, the method of suicide among those with TBI using VHA services has yet to be explored.

METHODS

Sample description

A retrospective cohort study of individuals who used the VHA between October 1, 2005 (FY 2006), and September 30, 2015 (FY 2015) was conducted. Those who utilized inpatient or outpatient care provided or paid for by the VA during this timeframe were identified from VA's electronic medical records. Individuals who were identified in the electronic medical records as non-Veterans were removed from the sample.[24] Veterans were also removed from the cohort if their first visit and their last visit within the VA system were not at least 90 days apart, or if their first visit was less than 90 days before the end of the study timeframe. Last, Veterans who had certain neurodegenerative diagnoses (eg, motor neuron diseases, multiple sclerosis[25]) known to increase risk for suicide were not included in the cohort.

Procedures and variable definitions

VHA medical records were searched to identify individuals in the sample who had ever had a diagnosis of TBI, during or prior to the study timeframe, using *ICD-9* (*International Classification of Diseases–9*) codes.[26] The codes used to identify a history of TBI are listed in Supplemental Digital Content Table S1 (available at: http://links.lww.com/JHTR/A307). A total of 215 610 eligible Veterans with a history of TBI were identified. A 20% random sample of eligible VHA Veterans without a TBI diagnosis in their VHA medical record, during or prior to the study timeframe, was used as the unexposed group ($n = 1\,187\,639$).

Traumatic brain injury was also classified on the basis of severity using *ICD-9* codes as listed in Supplemental Digital Content Table S1 available at:

http://links.lww.com/JHTR/A307 (no TBI, mTBI, moderate/severe TBI). There were 385 Veterans who had an *ICD-9* code of 850.1, a code that cannot be clearly classified as either a mild or moderate TBI. These Veterans were therefore removed from analyses that considered TBI severity.

History of psychiatric conditions, prior to or during the study timeframe, were also captured from electronic medical records using *ICD-9* diagnostic codes. The following conditions were captured: depression or other mood disorders, bipolar disorder, psychotic disorder, posttraumatic stress disorder (PTSD), anxiety disorder, and substance use disorder.

Comorbid conditions, during the study timeframe, were captured from the electronic medical record using yearly calculations of the Charlson/Deyo Index.[27,28] Other chronic conditions captured from the electronic medical record using *ICD-9* codes included dementias, plegias/paralyses, epilepsy, and nerve damage/neuropathies.

Death by suicide was captured with *ICD-10* codes X60-X84 and Y87.0 using data from the VA Department of Defense Suicide Data Repository, which contains all-cause mortality data from the National Death Index (NDI). The NDI is considered the gold standard for capturing cause and date of death. For analyses examining suicide method, 2 mutually exclusive suicide outcomes were constructed: (1) firearm suicide (*ICD-10* X72-X74) and (2) suicide by other means (eg, hanging, self-poisoning, drowning; *ICD-10* X60-X71, X75-X84, and Y87.0).

Data analysis

Cox proportional hazards modeling was used to estimate the hazard of suicide for those with TBI relative to those without. The following variables were time-varying: TBI, psychiatric diagnoses, and Charlson/Deyo Index. Age at index date, sex, and having one of the other neurodegenerative conditions prior to or during the study timeframe, were treated as time-constant covariates. The index date for each Veteran was set to the individuals' first visit within the study timeframe. Veterans were followed from index date to death or until the end of the study timeframe, whichever came first. Observations were censored at the end of the study timeframe or at the time of death by any means other than suicide. Veterans were considered exposed to TBI at the date of their first TBI diagnosis and were considered exposed for the remainder of the study. If a Veteran's first VHA-documented TBI diagnosis occurred prior to the study timeframe, then their index date was used as their date of exposure. Psychiatric conditions were considered time-varying in the same manner. The Charlson/Deyo Index was calculated in 1-year increments based on the Veteran's index date. If a Charlson/Deyo Index could not be determined during a specific year because a Veteran stopped seeking services, the previous year's index was carried forward.

A parallel analysis using Cox proportional hazards modeling was conducted considering TBI by severity level. Veterans who met criteria for both mild and moderate/severe TBI were classified as moderate/severe from the date of their first TBI forward, if the moderate/severe code preceded the mild code. However, if the mild code came first, observations were classified as an mTBI until the date of the moderate/severe TBI, at which point their TBI severity level was changed to moderate/severe.

Three Cox proportional hazards models were run: unadjusted; adjusting for age and gender; adjusting for age, gender, psychiatric conditions, comorbidities, and other chronic conditions. These models were run with (1) TBI as a dichotomous exposure (yes/no) and (2) TBI as a categorical exposure (no TBI, mTBI, and moderate/severe TBI).

The relationship between TBI status and method of suicide was also examined using a competing risks analysis. Separate Cox proportional hazards models were fit to estimate the cause-specific hazard of (1) suicide by firearms (all other deaths, including suicide by other means, resulted in censoring); and (2) suicide by nonfirearm means (all other deaths, including suicide by firearms, resulted in censoring). Unadjusted and adjusted models were fit using TBI as both a dichotomous exposure and a categorical exposure, parallel to the models described previously. A nested case-control study was also conducted to directly examine the relationship between TBI and suicide method (firearm vs all other methods) among the subcohort of Veterans who died by suicide. Logistic regression was utilized to model the relationship between TBI exposure and suicide method. Again, unadjusted and adjusted models were fit, and TBI was considered as both a dichotomous exposure and TBI as a categorical exposure by severity, coded as the most severe TBI.

RESULTS

The study sample was mostly male (92.8%) and Caucasian (69.9%) The median age was 56 years (see Table 1). Among the TBI-exposed group, when examining the most severe TBI diagnosis for each individual, the majority had an mTBI (90.1%), with 9.7% receiving a TBI diagnosis classified as moderate or severe. Veterans with a TBI diagnosis were younger than Veterans without a TBI, yet those with a moderate/severe TBI were older (median age 53 years) compared with those with an mTBI (median age 33 years). The greatest variation in age was among the age group of 18 to 29, which represented 40.6% of the mTBI subgroup, 17.9% of the

TABLE 1 *Sample demographics by TBI status and severity*

Variable	All ($n = 1\,403\,249$)	No TBI ($n = 1\,187\,639$)	Any TBI ($n = 215\,610$)	Mild TBI ($n = 194\,337$)	Moderate/severe TBI ($n = 20\,888$)
Age, median (range), y	56 (18-100)	58 (18-100)	35 (18-100)	33 (18-100)	53 (18-98)
Age group					
18-29 y	14.4% (201 955)	10.0% (119 293)	38.3% (82 662)	40.6% (78 917)	17.9% (3732)
30-39 y	10.0% (139 984)	8.4% (99 186)	18.9% (40 798)	19.8% (38 528)	10.6% (2211)
40-49 y	13.7% (192 749)	13.3% (157 312)	16.4% (35 437)	16.6% (32 264)	14.8% (3084)
50-59 y	20.5% (287 174)	21.5% (255 342)	14.8% (31 832)	13.5% (26 276)	26.0% (5420)
60-69 y	20.4% (285 729)	22.9% (271 463)	6.6% (14 266)	5.8% (11 213)	14.4% (2998)
70-79 y	13.2% (184 693)	15.0% (178 101)	3.1% (6592)	2.4% (4572)	9.6% (2000)
80-100 y	7.9% (110 965)	9.0% (106 942)	1.9% (4023)	1.3% (2567)	6.9% (1443)
Gender					
Male	92.8% (1 302 777)	92.7% (1 101 465)	93.4% (201 312)	93.2% (181 037)	95.4% (19 928)
Female	7.2% (100 472)	7.3% (86 174)	6.6% (14 298)	6.8% (13 300)	4.6% (960)
Race					
Caucasian	69.9% (980 639)	69.2% (821 713)	73.7% (158 926)	73.9% (143 562)	72.3% (15 096)
African American	14.8% (208 153)	14.9% (176 812)	14.5% (31 341)	14.4% (28 047)	15.5% (3229)
Asian or Pacific Islander	1.8% (25 827)	1.7% (20 626)	2.4% (5201)	2.5% (4807)	1.9% (387)
American Indian or Alaskan Native	0.7% (10 441)	0.7% (7779)	1.2% (2662)	1.3% (2448)	1.0% (210)
Multiple	0.8% (10 621)	0.7% (8102)	1.2% (2519)	1.2% (2317)	0.9% (190)
Missing	11.9% (167 568)	12.9% (152 607)	6.9% (14 961)	6.8% (13 156)	8.5% (17 76)
Psychiatric diagnosis					
Depression and other nonbipolar mood disorder	37.0% (518 681)	31.5% (373 487)	67.3% (145 194)	68.1% (132 242)	60.8% (12 692)
Bipolar disorder	4.7% (65 690)	3.6% (42 829)	10.6% (22 861)	10.5% (20 490)	11.0% (2290)
Psychotic disorder	4.6% (64 551)	3.7% (43 957)	9.6% (20 594)	9.1% (17 734)	13.4% (2790)
Posttraumatic stress disorder	22.0% (308 764)	15.0% (178 404)	60.5% (130 360)	62.8% (122 035)	39.1% (8156)
Anxiety disorder	23.7% (332 375)	19.5% (231 715)	46.7% (100 660)	47.6% (92 404)	38.7% (8075)
Substance use disorder	37.7% (528 658)	34.2% (405 713)	57.0% (122 945)	56.7% (110 124)	60.2% (12 570)
Charlson/Deyo Index at baseline median (range)	0 (0-20)	0 (0-20)	0 (0-17)	0 (0-14)	0 (0-17)
Other diagnoses					
Nerve damage/neuropathy	3.1% (44 069)	3.2% (37 486)	3.1% (6583)	2.7% (5275)	6.1% (1279)
Plegia/paralysis	0.7% (9224)	0.5% (6096)	1.5% (3128)	1.3% (2438)	3.3% (681)
Dementia	5.6% (77 889)	3.5% (41 549)	16.9% (36 340)	16.4% (31 957)	20.7% (4333)
Epilepsy	1.3% (18 475)	0.7% (8788)	4.5% (9687)	4.2% (8061)	7.7% (1608)

moderate/severe TBI subgroup, and only 10.0% of the non-TBI subgroup.

Veterans with a TBI had significantly higher prevalence estimates of all psychiatric diagnoses examined, with the prevalence of most diagnoses being 2 to 4 times higher among Veterans with a TBI compared with those without a TBI. Most pronounced was PTSD, with 60.5% of Veterans with a TBI also having a PTSD diagnosis, compared with only 15.0% of Veterans without a TBI. For all psychiatric diagnoses examined, there were statistically significant differences in prevalence between those with an mTBI and those with a moderate/severe TBI. From a clinical standpoint, some differences were too small to be meaningful. However, those worth noting included a higher prevalence of depression (68.1% vs 60.8%), PTSD (62.8% vs 39.1%), and anxiety (47.6% vs 38.7%) in the mTBI group, and a higher prevalence of psychotic disorders (13.4% vs 9.1%) in the moderate/severe TBI group. Additionally, as would be expected, Veterans with a TBI were also more likely than Veterans without a TBI to have received a diagnosis for dementia or epilepsy. Proportions of Veterans with dementia, plegias/paralyses, epilepsy, and nerve damage/neuropathies were all higher among those with a moderate/severe TBI than among those with an mTBI.

Traumatic brain injury and suicide

During the study window, the rate of suicide was 86 per 100 000 person-years for those with TBI compared with 37 per 100 000 person-years for those without TBI. The unadjusted hazard of death by suicide for those with a TBI diagnosis, relative to those without TBI, was 2.19 (95% confidence interval [CI]: 2.02-2.37; $P < .0001$). Controlling only for age and gender, those with a history of TBI were 2.15 times as likely to die by suicide (95% CI: 1.97-2.34, $P < .0001$) compared with those without a TBI. After also controlling for psychiatric diagnoses and other chronic conditions, Veterans with a TBI were significantly more likely to die by suicide than those without a history of TBI (hazard ratio [HR]: 1.71, 95% CI: 1.56-1.87, $P < .0001$).

Regarding the association between covariates and the hazard of suicide, in the fully adjusted model, Veterans (controlling for TBI) with the following psychiatric diagnoses had the highest suicide HRs (data not shown): depression (HR = 2.22, 95% CI: 2.06-2.41, $P < .0001$), bipolar disorder (HR = 1.88, 95% CI: 1.70-2.09, $P < .0001$), substance abuse disorder (HR = 1.72, 95% CI: 1.60-1.85, $P < .0001$), and anxiety disorder (HR = 1.41, 95% CI: 1.31-1.53, $P < .0001$). Veterans with a PTSD diagnosis were 0.85 as likely to die by suicide (95% CI: 0.78-0.92, $P < .0001$), compared with those without a PTSD diagnosis. Female Veterans were about 0.42 times as likely to die by suicide than males (95% CI: 0.35-0.50, $P < .0001$).

Traumatic brain injury and suicide by severity

When looking at individuals by TBI severity, the rate of suicide was 81 per 100,000 person-years for those with mTBI compared with 136 per 100,000 person-years for those with moderate/severe TBI. The severity models revealed that Veterans who had a moderate/severe TBI diagnosis versus those with no TBI and mTBI versus no TBI both had significantly higher hazard of suicide, including in the fully adjusted model. Specifically, Veterans with a history of mTBI were 1.62 times as likely to die by suicide (95% CI: 1.47-1.78, $P < .0001$) compared with Veterans without a TBI, after controlling for psychiatric diagnoses, chronic conditions, age, and gender. While Veterans with a history of moderate/severe TBI were 2.25 times as likely to die by suicide (95% CI: 2.02-2.97, $P < .0001$), thereby highlighting the contribution of injury history to suicide risk for those with more severe injuries. Results are displayed in Table 2.

Traumatic brain injury and associations with suicide method

Of those who died by suicide, 68% used firearms. Veterans with moderate/severe TBIs had the highest proportion of suicides by firearms (78%) followed by those with no TBI (70%) and mTBI (61%). For the competing risks analysis, we report the cause-specific HRs for the model that looks at firearm suicide as the event of interest and the model that looks at suicide by all other methods as the event of interest. For each of these models, death by any other means (including the alternative suicide death category) results in censoring at the time of death. After adjusting for all covariates, Veterans with any TBI were 1.79 times as likely to die by a suicide using a firearm as the method, when compared with Veterans without a TBI. For the model specific to suicide by other means, a significant association was also observed for any TBI (HR = 1.57, 95% CI: 1.35-1.82). When considering TBI severity, both mTBI versus no TBI and moderate/severe TBI versus no TBI were associated with suicide by firearm (HR = 1.62, 95% CI: 1.44-1.83, and HR = 3.03, 95% CI: 2.44-3.77, respectively)

In the nested case-control analysis, where we can directly compare firearm suicide decedents to suicide decedents who used other means, there was no evidence of an association between any TBI and method of suicide, after adjusting for all covariates. However, when considering TBI severity, the odds of a firearm suicide for Veterans with a moderate/severe TBI were 2.39 times (95% CI = 1.48-3.87) the odds of a firearm suicide for those without TBI, controlling for all covariates. An increase in odds was not observed for those with mTBI compared with those without TBI (see Tables 3–5).

TABLE 2 *Hazard ratios for suicide by TBI status and severity*

TBI status	Hazard ratio (95% CI)		
	Unadjusted model	Adjusted for gender and age	Full adjusted model[a]
Any TBI vs no TBI	2.19 (2.02-2.37)[b]	2.15 (1.97-2.34)[b]	1.71 (1.56-1.87)[b]
Mild TBI vs no TBI	2.06 (1.89-2.25)[b]	2.01 (1.83-2.21)[b]	1.62 (1.47-1.78)[b]
Moderate/severe TBI vs no TBI	3.36 (2.78-4.06)[b]	3.29 (2.72-3.98)[b]	2.45 (2.02-2.97)[b]

Abbreviations: CI, confidence interval; PTSD, posttraumatic stress disorder; TBI, traumatic brain injury.
[a]Adjusted for age, gender, Charlson/Deyo Index, and the following diagnoses/conditions: depression and other nonbipolar mood disorder; bipolar disorder; psychotic disorder; PTSD; anxiety disorder; substance use disorder; nerve damage/neuropathy; plegia/paralysis; dementia; and epilepsy.
[b]$P < .0001$.

DISCUSSION

Findings from this retrospective cohort study highlight the complex relationship between TBI and suicide among those seeking VHA services. Veterans with a history of TBI were 2 to 4 times more likely to have a psychiatric diagnosis than those without an injury history. Psychiatric conditions are well-known risk factors for suicide among those without a history of TBI. Moreover, recent work by Madsen et al[7] conducted using national registries of those living in Denmark suggested that those with TBI and pre- or postinjury psychiatric diagnoses were more than twice as likely or almost 5 times as likely to die by suicide, respectively. This finding regarding the impact of postinjury psychiatric symptoms, which may also be injury sequelae, calls into question including them in adjusted models. Moreover, there is significant interest in the

TABLE 3 *Method specific hazard ratios for suicide by TBI status*

Model	Hazard ratio (95% CI)	
	Suicide by firearms	Suicide by other means
Any TBI vs No TBI—unadjusted model	1.98 (1.79-2.18)[a]	2.67 (2.33-3.06)[a]
Any TBI vs No TBI—adjusted for gender and age	2.13 (1.91-2.37)[a]	2.17 (1.87-2.51)[a]
Any TBI vs No TBI—Fully adjusted Model[b]	1.79 (1.60-2.00)[a]	1.57 (1.35-1.82)[a]

Abbreviations: CI, confidence interval; PTSD, posttraumatic stress disorder; TBI, traumatic brain injury.
[a] $P < .0001$.
[b]Adjusted for age, gender, Charlson/Deyo Index, and the following diagnoses/conditions: depression and other nonbipolar mood disorder; bipolar disorder; psychotic disorder; PTSD; anxiety disorder; substance use disorder; nerve damage/neuropathy; plegia/paralysis; dementia; and epilepsy.

TABLE 4 *Method specific hazard ratios for suicide by TBI severity*

Model	Hazard ratio (95% CI)			
	Suicide by firearms		Suicide by other means	
	Mild TBI vs no TBI	Moderate/severe TBI vs no TBI	Mild TBI vs no TBI	Moderate/severe TBI vs no TBI
Unadjusted model	1.79 (1.60-2.00)[a]	3.75 (3.03-4.65)[a]	2.70 (2.34-3.11)[a]	2.44 (1.63-3.67)[a]
Adjusted for gender and age	1.92 (1.71-2.16)[a]	3.78 (3.05-4.69)[a]	2.16 (1.85-2.51)[a]	2.24 (1.49-3.37)[a]
Fully adjusted model[b]	1.62 (1.44-1.83)[a]	3.03 (2.44-3.77)[a]	1.58 (1.35-1.85)[a]	1.44 (0.96-2.17)

Abbreviations: CI, confidence interval; PTSD, posttraumatic stress disorder; TBI, traumatic brain injury.
[a] $P < .0001$.
[b]Adjusted for age, gender, Charlson/Deyo Index, and the following diagnoses/conditions: depression and other nonbipolar mood disorder; bipolar disorder; psychotic disorder; PTSD; anxiety disorder; substance use disorder; nerve damage/neuropathy; plegia/paralysis; dementia; and epilepsy.

TABLE 5 *Odds of firearm versus other suicide means by TBI status and severity, among suicide decedents*

TBI status	Odds ratio (95% CI)		
	Unadjusted model	Adjusted for gender and age	Fully adjusted model[a]
Any TBI vs no TBI	0.76 (0.64-0.90)[b]	1.02 (0.85-1.23)	1.10 (0.90-1.34)
Mild TBI vs no TBI	0.68 (0.57-0.81)[c]	0.93 (0.76-1.12)	0.96 (0.78-1.19)
Moderate/severe TBI vs no TBI	1.59 (1.00-2.51)[b]	1.98 (1.24-3.15)[b]	2.39 (1.48-3.87)[b]

Abbreviations: CI, confidence interval; PTSD, posttraumatic stress disorder; TBI, traumatic brain injury.
[a]Adjusted for age, gender, Charlson/Deyo Index, and the following diagnoses/conditions: depression and other nonbipolar mood disorder; bipolar disorder; psychotic disorder; PTSD; anxiety disorder; substance use disorder; nerve damage/neuropathy; plegia/paralysis; dementia; and epilepsy.
[b]$P < .05$.
[c]$P < .0001$.

role that TBI history has on increasing risk for developing a psychiatric condition. Recent work by Sariaslan et al[29] highlighted that sustaining a TBI early in life increased the absolute risk of developing a psychiatric disorder by more than 10%, and additional studies have found that experiencing a TBI during childhood significantly increases the risk for adult substance misuse.[30–33] Similarly, Bryant et al[34] found that among those recently admitted to major trauma hospitals secondary to mTBI, at 12 months postinjury, 31% reported a psychiatric disorder and 22% developed a new psychiatric condition.

In models adjusted for covariates, TBI (any), as well as by severity (mild and moderate/severe), was associated with significantly increased risk for suicide. As has been noted in the previous work,[7] those with a moderate to severe TBI were at greater risk for suicide than those with mild injuries. That is, those with more severe injuries were 2.45 times as likely to die by suicide compared with those without a TBI diagnosis (95% CI: 2.02-2.97) even after adjusting for a number of factors, including psychiatric diagnosis, thereby highlighting the unique contribution of TBI history. Moreover, the odds of using firearms as a means of suicide was significantly increased for those with moderate/severe injuries as compared with Veterans without TBI. This finding alone highlights the need for increased suicide prevention efforts, including lethal means safety interventions among those with moderate to severe injuries. Together, these findings underscore the importance of understanding Veterans' lifetime history of TBI to prevent future deaths by suicide, and support the implementation of screening initiatives for lifetime history of TBI among all individuals utilizing the VHA. For further discussion of this issue, see Bahraini and Brenner.[35]

Overall findings from this study provide additional support for looking at the cumulative impact of exposures (ie, physical and/or psychological), as well as the severity of exposures (eg, moderate to severe TBI), on health-related outcomes, including suicide. As discussed by Bahraini and Brenner,[35] an increased understanding regarding how the accumulation of risk factors (eg, history of psychiatric diagnosis, history of TBI) may shift a person's health trajectory toward chronic illness, disability, and death is indicated. This assertion is supported by the recent work by Lee et al[36] in which those with multiple risk factors were found to be highly vulnerable to suicide attempts. Moreover, Sariaslan et al[29] found that in comparison to one TBI, recurrent TBIs led to poorer outcomes (eg, negative psychiatric outcomes). Finally, to improve functioning among those with TBI, work aimed at increasing understanding of the accumulation of risk will need to focus on the cumulative and/or interactive impact of biological (eg, inflammation) and psychosocial factors (eg, social determinants).

As with all studies, there are limitations to the present work that should be noted. Using the VHA electronic medical record, it was not possible to determine whether psychiatric diagnoses pre- or postdated history of injury. Moreover, delineation of single versus multiple TBIs was not feasible, and we were unable to determine if previous TBIs were combat-acquired, or capture TBI diagnoses that were recorded in the Department of Defense administrative data. As has been previously discussed, there are inherent challenges associated with distinguishing TBI severity with administrative diagnosis codes,[37] and there were likely TBIs, particularly mild injuries, that were not recorded in the medical record. Finally, the VHA population may not be generalizable to the broader civilian population.

In conclusion, this large-scale study supports previous work and indicates that there continues to be risk for both psychiatric conditions and suicide among those

with a history of TBI receiving VHA care. Additional efforts are needed to identify injury histories, as well as to introduce interventions, including lethal means safety, into rehabilitative settings.

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