ARTICLE

Sex, race, and risk of dementia diagnosis after traumatic brain injury among older veterans

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Abstract

Objective

To investigate whether sex and race differences exist in dementia diagnosis risk associated with traumatic brain injury (TBI) among older veterans.

Methods

Using Fine-Gray regression models, we investigated incident dementia diagnosis risk with TBI exposure by sex and race.

Results

After the exclusion of baseline prevalent dementia, the final sample (all veterans ≥55 years of age diagnosed with TBI during the 2001–2015 study period and a random sample of all veterans receiving Veterans Health Administration care) included nearly 1 million veterans (4.3% female; 81.8% White, 11.5% Black, and 1.25% Hispanic), 96,178 with TBI and 903,462 without TBI. Compared to those without TBI, Hispanic veterans with TBI were almost 2 times more likely (17.0% vs 10.3%; hazard ratio [HR] 1.74, 95% confidence interval [CI] 1.51–2.01), Black veterans with TBI were >2 times more likely (11.2% vs 6.4%; HR 2.15, 95% CI 2.02–2.30), and White veterans with TBI were nearly 3 times more likely to receive a dementia diagnosis (12.0% vs 5.9%; HR 2.71, 95% CI 2.64–2.77). A significant interaction between TBI and race for dementia diagnosis was observed ($p < 0.001$). Both male and female veterans with TBI were more than twice as likely (men 11.8% vs 5.9%, HR 2.60, 95% CI 2.54–2.66; women 6.3% vs 3.1%, HR 2.36, 95% CI 2.08–2.69) to receive a diagnosis of dementia compared to those without. There was a significant interaction effect between sex and TBI ($p = 0.02$), but the magnitude of differences was small.

Conclusions

In this large, nationwide cohort of older veterans, all race groups with TBI had increased risk of dementia diagnosis, but there was an interaction effect such that White veterans were at greatest risk for dementia after TBI. Further research is needed to understand the mechanisms for this discrepancy. Differences in dementia diagnosis risk for men and women after TBI were significant but small, and male and female veterans had similarly high risks of dementia diagnosis after TBI.

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Go to Neurology.org/N for full disclosures. Funding information and disclosures deemed relevant by the authors, if any, are provided at the end of the article.

Glossary

CI = confidence interval; **HR** = hazard ratio; **ICD-9** = International Classification of Disease, 9th Revision; **TBI** = traumatic brain injury; **VA** = Veterans Affairs; **VHA** = Veterans Health Administration.

Traumatic brain injury (TBI), including mild TBI,[1] is a well-known risk factor for dementia.[2–8] Veterans are particularly at risk for TBI and therefore may be more vulnerable to developing dementia.[9] Most existing research on TBI and risk of dementia diagnosis in veterans has been conducted with predominately male and White participants. As the US military becomes more diverse, understanding the outcomes that female and non-White service members may face after TBI is essential. Women are increasingly involved in combat and at risk for TBI,[10] and the number of female veterans, particularly those >55 years of age, is expected to rise sharply in the coming years.[11] The proportion of Black, Hispanic, and other (including American Indian/Alaska Native, Asian, and Pacific Islander) minority veterans is also expected to climb.[12]

The few studies that directly examine the effect of sex on risk of dementia diagnosis after TBI[2,13,14] have shown small increases in risk for men but not women. Most existing studies of risk for dementia diagnosis after TBI do not directly examine race differences, and many do not report the racial makeup of their samples.[15] Understanding the possible impact of sex- and race-based health differences on dementia diagnosis risk is key to improving care for the growing population of diverse older veterans with TBI.

The goal of our study was to examine whether differences in TBI-associated risk of dementia diagnosis by sex and race exist among a large cohort of older veterans and to evaluate the impact of other demographic factors, medical comorbid conditions, and psychiatric conditions on this relationship.

Methods

Standard protocol approvals, registrations, and patient consents

All study procedures were approved by the institutional review boards of the University of California, San Francisco and San Francisco Veterans Affairs (VA) Medical Center and by the US Army Medical Research and Material Command, Office of Research Protections, Human Research Protection Office. Informed consent was waived because of the use of deidentified archival data. In addition, many participants were deceased or no longer receiving medical care through the VA at the time of study completion.

Study population

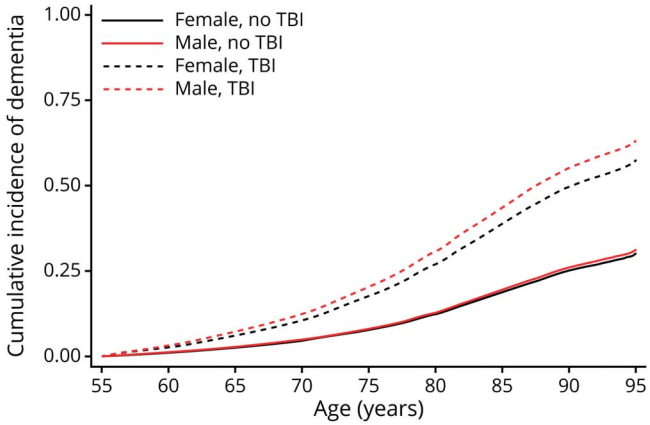
We identified all Veterans Health Administration (VHA) patients ≥55 years of age who received a TBI diagnosis between October 1, 2001, and September 30, 2015, and a 2% random sample of patients who received VHA care within the same time frame (n = 1,024,601). Data were sourced from 2 nationwide VHA system databases: the inpatient and outpatient visits database (National Patient Care Database) and the Vital Status File. We excluded veterans with prevalent dementia during the 2-year baseline period (defined as within 2 years before the index date, i.e., the date of TBI diagnosis or random selection date) (n = 24,959). The final sample size was 999,642.

We identified all VHA patients who received an inpatient or outpatient TBI diagnosis using the Defense and Veterans Brain Injury Center list of ICD-9 codes for TBI surveillance (data available from Dryad, appendix 1, doi.org/10.7272/Q6V69GSD). We next identified prevalent dementia at baseline using the VA Dementia Steering Committee's recommended list of ICD-9 codes (2016 version)[16] (data available from Dryad, appendix 2). For incident dementia diagnoses during the follow-up period, we used a modified version of the same list that excluded prion disease and alcohol- or drug-induced dementia.

Biological sex data were also taken from VHA inpatient or outpatient files in which each veteran was coded as male or female. Two participants had missing sex data, and the final sample size was 999,640 for sex analyses. Race and ethnicity were retrieved from VHA inpatient and outpatient files (supplemented with Medicare data after 2004). Veterans were coded as non-Hispanic Black, non-Hispanic White, Hispanic, or other/unknown. The other/unknown race category was removed from the final unadjusted and adjusted race models because of the likelihood of missing data in the unknown group confounding interpretation of information about respondents in the other category. These codes are based on self-report of patient sex and race. The final sample size was 937,380 for race analyses, reflecting 62,262 participants with missing data (other/unknown) for race.

We obtained data on demographics, medical comorbid conditions, health care visits, and psychiatric conditions using VHA inpatient and outpatient files. Zip codes and 2016 American Community Survey data were used to categorize veterans' residences into educational and income categories (for education, ≤25% of the adult population has a bachelor's degree or higher vs >25%; income was categorized into median income tertiles). Medical and psychiatric comorbid conditions as identified by ICD-9 codes were assessed during the 2-year baseline. Comorbid conditions included hypertension, diabetes mellitus, myocardial infarction, TIA/stroke, chronic pain, posttraumatic stress disorder, depression, drug/alcohol abuse, and tobacco use or smoking. Health care visits

Figure 1 Adjusted* cumulative incidence of dementia



Age at dementia diagnosis with and without traumatic brain injury (TBI), accounting for mortality in male and female veterans. *Adjusted for demographic and health characteristics.

were defined as any inpatient or outpatient visit from VA medical records and included information on date of visit and diagnosis.

Baseline characteristics of veterans in each race and sex group were compared by TBI status with *t* tests for continuous variables and χ^2 tests for categorical variables. Although TBI prevalence by race and sex is reported, these data points represent estimates only; because of the oversampling of patients with TBI in our sample, these figures lack precision. We used Fine-Gray proportional hazards regression models, accounting for the competing risk of death, to examine time to dementia diagnosis according to TBI status for each sex and race group with age as the time scale. Models were unadjusted and adjusted for demographics and medical/psychiatric comorbid conditions that significantly differed between sex/race groups at $p < 0.01$ (age, race or sex, education, income, hypertension, diabetes mellitus, myocardial infarction, TIA/stroke, chronic pain, posttraumatic stress disorder, depression, drug/alcohol abuse, and tobacco use/smoking). For cumulative incidence graphs (figures 1 and 2), we used 95 years of age as a cutoff point, and 1% of data (n = 9,751) were truncated. Assumptions of the Fine-Gray models were examined and found to be satisfied. We used the cumulative residuals with respect to time (SAS ASSESS statement) to test the proportional hazards assumption.

We also separately examined the interaction effect of TBI with sex and with race on risk of dementia diagnosis in adjusted models and subsequently conducted stratified analyses to examine the interactions. Finally, in sensitivity analyses, we (1) conducted models in which we excluded veterans receiving a dementia diagnosis within 1 year of TBI diagnosis for a washout period to address concerns about reverse causation and etiology (TBI vs neurodegenerative) and (2) examined the impact of number of health care visits during the follow-up period to determine whether increased involvement in/access to health care accounted for some of the race-based differences in dementia diagnoses we identified. Statistical significance was set at $p < 0.05$ (2 sided). SAS version 9.4 (SAS Institute Inc, Cary, NC) was used for all analyses.

Data availability

The data are derived from VHA electronic health records and contain protected health information; therefore, the data cannot be placed in a public repository. Please contact the authors for additional details on the process of accessing these data.

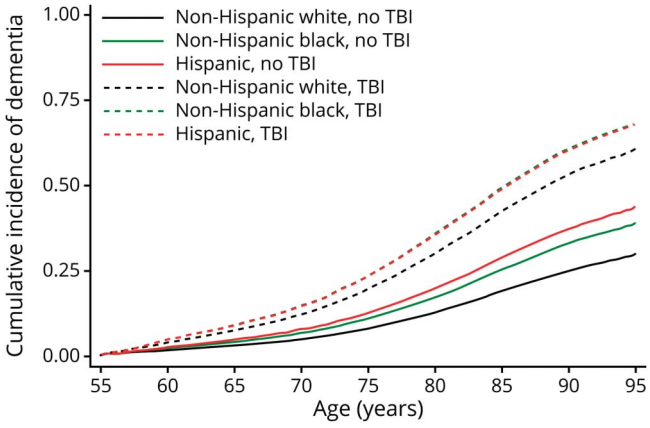
Results

The final analytic cohort (all veterans ≥55 years of age with TBI during the study period and a 2% random sample of all veterans in the VHA) included 96,178 veterans with TBI and 903,464 veterans without TBI (4.3% female; 81.8% White, 11.5% Black, and 1.25% Hispanic). The median follow-up was 4.3 years (interquartile range 1.9–7.6 years).

TBI risk for dementia diagnosis by sex

Table 1 shows characteristics of male and female veterans with and without TBI. Male veterans were older ($p < 0.001$). All veterans with TBI regardless of sex had a higher prevalence of medical and psychiatric comorbid conditions compared to those without TBI history. Among male veterans, those with TBI were more than twice as likely to receive a dementia diagnosis (hazard ratio [HR] 2.87, 95% confidence interval [CI] 2.81–2.94) compared to those without a TBI diagnosis. Among women, those with TBI vs no TBI were more than twice as likely to receive a dementia diagnosis (HR 2.51, 95% CI 2.22–2.84). The difference lessened somewhat after adjustment for demographics and comorbid conditions (men: HR 2.60, 95% CI 2.54–2.66; women: HR 2.36, 95% CI

Figure 2 Adjusted* cumulative incidence of dementia



Age at dementia diagnosis with and without traumatic brain injury (TBI), accounting for mortality in White, Black, and Hispanic veterans. *Adjusted for demographic and health characteristics.

Table 1 Baseline characteristics of male and female veterans with and without TBI

	Male (n = 956,622)		Female (n = 43,018)	
	No TBI (n = 866,208)	TBI (n = 90,414)[a]	No TBI (n = 37,254)	TBI (n = 5,764)[b]
Age, mean (SD), y	70.03 (9.53)	68.76 (10.43)	65.07 (9.86)	65.63 (10.53)
Race, n (%)				
Non-Hispanic White	719,105 (83.0)	69,860 (77.3)	24,641 (66.1)	3,954 (68.6)
Non-Hispanic Black	90,589 (10.5)	11,860 (13.1)	4,847 (13.0)	766 (13.3)
Hispanic	9,250 (1.1)	2,182 (2.4)	265 (0.7)	60 (1.0)
>25% College educated in zip code, n (%)	355,716 (42.2)	38,466 (44.1)	16,755 (46.9)	2,673 (48.1)
Low-income tertile (<$43,018), n (%)	277,115 (33.0)	31,432 (36.3)	11,684 (33.4)	1,770 (32.5)
Follow-up time, mean (SD), y	5.06 (3.69)	3.65 (3.19)	4.01 (3.47)	3.31 (3.03)
Total follow-up visits, n	60.96 (83.86)	88.54 (114.61)	46.00 (75.56)	80.20 (115.91)
Follow-up visits, n/y	15.23 (28.42)	34.09 (50.02)	17.80 (45.10)	34.89 (63.79)
Hypertension, n (%)	161,449 (18.6)	14,024 (15.5)	4,356 (11.7)	724 (12.6)
Diabetes mellitus, n (%)	74,690 (8.6)	7,252 (8.0)	1,873 (5.0)	350 (6.1)
Myocardial infarction, n (%)	19,428 (2.2)	3,162 (3.5)	286 (0.8)	90 (1.6)
TIA/stroke, n (%)	33,166 (3.8)	11,402 (12.6)	778 (2.1)	410 (7.1)
Chronic pain, n (%)	2,452 (0.3)	1,094 (1.2)	167 (0.5)	120 (2.1)
PTSD, n (%)	21,699 (2.5)	6,027 (6.7)	652 (1.8)	347 (6.0)
Depression, n (%)	47,416 (5.5)	10,629 (11.8)	2,152 (5.8)	599 (10.4)
Drug/alcohol abuse, n (%)	27,678 (3.2)	7,525 (8.3)	511 (1.4)	217 (3.8)
Tobacco use/smoking, n (%)	58,787 (6.8)	7,754 (8.6)	1,512 (4.1)	297 (5.2)

Abbreviations: PTSD = posttraumatic stress disorder; TBI = traumatic brain injury.
[a] For all comparisons TBI vs no TBI, $p < 0.001$.
[b] For all comparisons TBI vs no TBI, $p < 0.001$ except age ($p = 0.07$), >25% college educated in zip code ($p = 0.09$), low-income tertile (<$43,018) ($p = 0.35$), and hypertension ($p = 0.06$).

2.08–2.69). There was a significant interaction effect of sex and TBI on dementia diagnosis risk ($p = 0.02$) such that men with TBI demonstrated slightly increased risk of receiving a dementia diagnosis compared to women. The interaction between sex and TBI on dementia diagnosis risk remained significant after adjustment ($p = 0.03$). Adjusted cumulative incidence curves for age at dementia diagnosis accounting for competing risk of mortality are shown in figure 1 for male and female veterans.

TBI risk for dementia diagnosis by race

Table 2 shows characteristics of White, Black, and Hispanic veterans with and without TBI. Across all race groups, those with TBI were generally younger, more likely to be female, better educated, more likely to fall in the low-income group, and less likely to be diagnosed with hypertension and diabetes mellitus but otherwise had more health and psychological comorbid conditions compared to those without TBI history. The Hispanic group was unique, however, in that Hispanic veterans with TBI were older ($p < 0.001$) and did not differ from Hispanic veterans without TBI on sex ($p = 0.78$). All veterans with TBI were much more likely to fall in the low-income group, but low-income group membership was most likely in the Black and Hispanic groups (31.6% of White veterans with TBI compared to 58.1% of Black veterans and 70.1% of Hispanic veterans with TBI).

White veterans with TBI had an almost 3-fold increased risk of dementia diagnosis (HR 2.93, 95% CI 2.86–3.00) compared to those without TBI, while Black and Hispanic veterans with TBI had an ≈2-fold increased risk (Blacks: HR 2.27, 95% CI 2.13–2.41; Hispanics: HR 1.98, 95% CI 1.74–2.24). There was a significant interaction between TBI and race on risk of receiving a dementia diagnosis ($p < 0.001$) such that White veterans with TBI were at the highest risk for dementia diagnosis with similar risks for Blacks and Hispanics. After adjustment for demographics and medical and psychiatric conditions, White veterans with TBI remained at higher risk (HR 2.71, 95% CI 2.64–2.77) compared to Black and Hispanic veterans with TBI (Blacks: HR 2.15, 95% CI 2.02–2.30;

Table 2 Characteristics of veterans with and without TBI by race

	Non-Hispanic White (n = 817,561)		Non-Hispanic Black (n = 108,062)		Hispanic (n = 11,757)	
	No TBI (n = 743,747)	TBI[a] (n = 73,814)	No TBI (n = 95,436)	TBI [a] (n = 12,626)	No TBI (n = 9,515)	TBI[b] (n = 2,242)
Age, mean (SD), y	70.74 (9.42)	69.55 (10.43)	66.45 (8.90)	66.21 (9.63)	70.91 (10.61)	72.69 (11.64)
Female, n (%)	24,641 (3.3)	3,954 (5.4)	4,847 (5.1)	766 (6.1)	265 (2.8)	60 (2.7)
>25% College educated in zip code, n (%)	314,585 (43.4)	32,598 (45.6)	31,135 (33.8)	4,418 (36.4)	2,953 (33.3)	830 (41.0)
Low-income tertile (<$43,018) , n (%)	215,604 (29.9)	22,430 (31.6)	51,410 (56.1)	7,015 (58.1)	5,455 (62.1)	1,404 (70.1)
Follow-up time, mean (SD), y	5.15 (3.70)	3.68 (3.21)	4.91 (3.67)	3.73 (3.26)	4.89 (3.76)	3.47 (3.14)
Total follow-up visits, n	58.61 (79.12)	87.68 (111.10)	83.13 (114.24)	103.55 (141.07)	77.87 (101.98)	88.96 (124.60)
Follow-up visits, n/y	14.34 (27.00)	33.76 (50.63)	20.33 (32.01)	36.52 (49.13)	19.55 (29.10)	35.74 (46.30)
Hypertension, n (%)	139,748 (18.8)	11,256 (15.3)	16,890 (17.7)	2,024 (16.0)	1,479 (15.5)	296 (13.2)
Diabetes mellitus, n (%)	62,412 (8.4)	5,801 (7.9)	9,344 (9.8)	1,102 (8.7)	940 (9.9)	171 (7.6)
Myocardial infarction, n (%)	16,969 (2.3)	2,716 (3.7)	1,744 (1.8)	320 (2.5)	236 (2.5)	76 (3.4)
TIA/stroke, n (%)	28,786 (3.9)	9,117 (12.4)	3,653 (3.8)	1,646 (13.0)	395 (4.2)	384 (17.1)
Chronic pain, n (%)	2,054 (0.3)	950 (1.3)	332 (0.4)	142 (1.1)	22 (0.2)	17 (0.8)
PTSD, n (%)	16,813 (2.3)	4,661 (6.3)	3,679 (3.9)	944 (7.5)	267 (2.8)	108 (4.8)
Depression, n (%)	40,448 (5.4)	8,634 (11.7)	5,682 (6.0)	1,411 (11.2)	586 (6.2)	239 (10.7)
Drug/alcohol abuse, n (%)	20,344 (2.7)	5,519 (7.5)	5,190 (5.4)	1,263 (10.0)	319 (3.4)	170 (7.6)
Tobacco/smoking, n (%)	49,132 (6.6)	6,083 (8.2)	7,247 (7.6)	1,133 (9.0)	490 (5.2)	155 (6.9)

Abbreviations: PTSD = posttraumatic stress disorder; TBI = traumatic brain injury.
[a] For all comparisons TBI vs no TBI, $p < 0.001$.
[b] For all comparisons TBI vs no TBI, $p < 0.001$ except female ($p = 0.78$), hypertension ($p = 0.01$), diabetes mellitus ($p = 0.001$), myocardial infarction ($p = 0.02$), and tobacco use/smoking ($p = 0.001$).

Hispanics: HR 1.74, 95% CI 1.51–2.01). The interaction between TBI and race on risk of dementia diagnosis remained after full adjustment ($p < 0.001$). Adjusted cumulative incidence curves for age at dementia diagnosis accounting for competing risk of mortality are shown in figure 2 for White, Black, and Hispanic veterans. Results of 1-year lag washout sensitivity analyses showed slightly attenuated HRs, but the pattern of sex and race results was identical. Additional adjustment for number of clinic visits slightly attenuated risk estimates but did not change the pattern of results (Whites: HR 2.33, 95% CI 2.26–2.39; Blacks: HR 1.94, 95% CI 1.82–2.08; and Hispanics: HR 1.63, 95% CI 1.41–1.89).

Discussion

In this diverse sample of older veterans, we show an increased risk of dementia diagnosis in those with a diagnosis of TBI compared to those without for veterans of both sexes and all major race groups, consistent with previous work on this topic in the veteran population.[9] We also identified differences in the risk of dementia diagnosis after TBI according to race. Specifically, older White veterans appear to have an elevated risk of receiving a dementia diagnosis after TBI compared to Blacks and Hispanics. Sex differences in dementia diagnosis risk after TBI observed in this large sample, although statistically significant, were small and of unclear clinical significance.

The limited available data on the effect of sex on dementia risk after TBI show increased risk for men but not women. For example, an older meta-analysis of 11 case-control studies conducted before 1991 suggested that there is an increased risk of dementia (specifically Alzheimer disease) after TBI for men but not women[2]; another meta-analysis published in 2003 examining 7 additional studies replicated that finding.[13] A recent population-based study in Denmark conducted in 2018 similarly found a slightly increased risk of dementia after TBI in men compared to women (30% vs 19% increased risk).[14] Our results showing a similarly high risk for both men and women are inconsistent with this prior work. Therefore, further exploration of sex-based differences in dementia risk after TBI for veterans is indicated. For example, it is possible that although the TBIs of female civilians may be less severe

on average than those of male civilian, male and female veterans may have TBIs of similar severity. In addition, women in the military may experience a unique profile of injuries in which repeated injuries caused by intimate partner violence are superimposed on single or multiple concussive or subconcussive head injuries, conferring elevated dementia risk compared to female civilians.

Most existing studies of the risk for dementia after TBI do not directly examine race differences, and many do not report the racial makeup of their samples.[15] For example, in a recent review of the evidence for the association between TBI and dementia, race was not listed as a known demographic factor affecting that relationship.[17] Therefore, our finding that White veterans may be at increased risk for dementia after TBI is intriguing. Our findings stand in contrast to previous research that has shown that Black and Hispanic adults have worse functional outcomes (as defined by standardized measures such as the Disability Rating Scale, Functional Independence Measure, and Community Integration Questionnaire) compared to White adults 1 year after moderate to severe TBI.[18] However, the different methodologic approach in our work, which uses medical record data including diagnostic codes rather than standardized measures of functional outcome, may account for some of these discrepancies. Our results may also be explained by race-based differences in the documentation of dementia diagnoses by health care providers; if providers are, for example, more likely to consider dementia as a diagnosis for White patients, that could account for our findings of increased dementia diagnosis risk for White veterans.

It is clear that more research is needed to understand the impact of race on dementia diagnosis risk after TBI. Differential risk for dementia by race among veterans is unknown and a topic of current ongoing research, and it may be the case that non-White veterans have higher baseline risk such that having a TBI may not lead to increased risk for these race groups as it does for Whites. Health disparities research suggests that White individuals may be more likely to interact with health care and to receive a diagnosis,[19,20] which may result in inflated rates of TBI and dementia diagnoses for White veterans compared to other groups. However, in our sample, White veterans had fewer follow-up visits compared to Black and Hispanic veterans, and after adjustment for number of visits, the increased risk of dementia after TBI for White veterans persisted. It is also possible that Black and Hispanic individuals, who are significantly more likely to live in multigenerational households with high levels of family support compared to White individuals,[21] may function well independently in the community for longer because of this increased support and therefore delay receiving a dementia diagnosis. However, all veterans were followed up at VA; therefore, cognitive problems were likely to have been detected, even in the absence of concern from patients or families. In addition, there may be unmeasured and unrecognized social factors affecting differences in medical care and driving differences in outcomes between race groups that deserve further study in the future.

Furthermore, we did not measure *APOE* ε4 allele status, which differs by race and increases risk for dementia.[22] Although the allele is more common among individuals of African descent,[23] White individuals have a greater increased risk for dementia with *APOE* ε4 compared to other racial groups.[24] These findings support our results showing increased risk for White veterans. There is also some evidence that *APOE* ε4 increases risk for negative outcome, including dementia, after TBI,[25–27] which may be related to its decreased ability to effectively protect and repair neural tissue after trauma compared to *APOE* ε3.[28] Other unknown and unmeasured genetic factors may play a role in the race differences and the increased risk of dementia diagnosis for White veterans after TBI seen here, and further research is required to identify such mechanisms.

Although our study was not designed to precisely measure the prevalence of TBI among older veterans, the TBI prevalence estimates we report suggest differential patterns in the prevalence of TBI by both sex and race in our sample that are clinically interesting and bear further study. Our results suggest a greater prevalence of TBI in female veterans compared to male veterans. These results may reflect a departure from civilian findings, which generally show higher rates of TBI in men.[29] Our results also suggest the possibility of increased prevalence of TBI among Hispanic veterans compared to Black and White veterans. This pattern may represent previously unacknowledged health disparity, and in fact there is a dearth of research available on the prevalence or risk of TBI by race among veterans and civilians, an area clearly requiring further study. Existing VA research shows that Hispanic Operation Enduring Freedom/Operation Iraqi Freedom veterans are less likely to receive care for a TBI and that Hispanic veterans of all eras are at higher risk for mortality after a TBI,[30,31] but these studies do not report prevalence of TBI among Hispanic veterans. In contrast, our results suggest that Hispanic veterans receive more follow-up care compared to White veterans but less than Black veterans. These patterns demonstrate that further research focused specifically on investigating race and sex differences in TBI prevalence among veterans is clearly indicated.

There are some important limitations to our study that affect the interpretation and generalizability of our results. For example, sex and race were based on self-report, and sex was coded as a binary variable only (i.e., transgender individuals were not captured), likely excluding some of the true complexity of this variable. Furthermore, our sample had some limitations: we were unable to examine Asian veterans and veterans identifying their race/ethnicity as other because of small sample size. Further research focused on Asian Veteran samples and those who identify their race as other would be helpful and would provide insights for treatment planning and prevention as this growing cohort of veterans ages. Moreover,

because of oversampling of patients with TBI, we are unable to precisely measure TBI prevalence in veterans. Although TBI prevalence by race and sex is reported, these data points represent estimates only. In addition, because of our use of medical record data, there are likely to be differences between the sex and race groups studied that we were not able to measure but that are driving differences in risk of dementia after TBI. In addition, we used ICD-9 codes in existing medical records for dementia diagnoses, which may result in less accurate categorization of participants compared to studies in which participants were given a comprehensive dementia examination. Because we included veterans in our sample who may have received a dementia diagnosis shortly after their TBI diagnosis, we are not able to draw conclusions about causality of dementia diagnoses or to make inferences about neurodegenerative vs traumatic etiology. Finally, results may not generalize to veterans who do not receive VA health care.

This is one of the first studies to examine differential risk for dementia diagnosis after TBI according to sex and race. Key contributions of this study include the large sample size and the direct, explicit consideration of race and sex and their impact on dementia risk after TBI among veterans. Our results show a doubling of dementia diagnosis risk after TBI for both men and women and an interesting difference by sex that is small and of unclear clinical significance. Risk of dementia diagnosis was also approximately doubled for all veterans across race categories after TBI, with White veterans showing an even greater increased risk. These findings suggest that understating the possible differential impact of TBI on dementia diagnosis risk according to race is worth exploring. This is of particular importance given the increasing diversity and rapid aging of our military and veteran populations and may provide the VA with an important opportunity to identify and correct possible health disparities in TBI and dementia identification and care.

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Disclosure

E. Kornblith, C.B. Peltz, F. Xia, B. Plassman, and T. Novakovic-Apopain report no disclosures relevant to the manuscript. K. Yaffe serves on Data Safety Monitoring boards for Eli Lilly and several National Institute on Aging–sponsored studies, serves on the board of directors for Alector, Inc, and is member of the Beeson Scientific Advisory Board. Go to Neurology.org/N for full disclosures.

Publication history

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Appendix Authors

Name	Location	Contribution
Erica Kornblith, PhD	SFVA/UCSF, San Francisco	Designed and conceptualized study; interpreted data; prepared initial manuscript draft
Carrie B. Peltz, PhD	SFVA/NCIRE, San Francisco	Acquired and interpreted data; contributed to preparation, review, and revision of manuscript
Feng Xia, MS, MPH	SFVA/NCIRE, San Francisco	Analyzed the data; contributed to preparation, review, and revision of manuscript
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