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Risk of Traumatic Brain Injury in Deployment and Nondeployment Settings Among Members of the Millennium Cohort Study

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Objective: To describe and quantify the prevalence and risk of deployment and nondeployment service-related traumatic brain injury (TBI) among participants of the Millennium Cohort Study. **Setting:** Survey data. **Participants:** 28 759 Millennium Cohort Study participants who were active duty, Reserves, or National Guard at the time of the survey. **Design:** Cross-sectional secondary data analysis. **Main Measures:** Estimates of prevalence and rates of TBI were calculated. Multivariable Poisson regression estimated rate ratios of TBI overall and stratified by deployment and nondeployment settings. **Results:** The rate of TBI over the 362 535 person-years (PY) was 2.95 p/100 PY. the nondeployment rate was 2.15 p/100 PY, with a significantly higher rate (11.38 p/100 PY) in deployment settings. Bullets/blasts were the most common TBI mechanisms in deployed settings, while sports/physical training and military training were common in nondeployed settings. **Conclusions:** The risk of TBI as well as its mechanism varies by deployment and nondeployment, suggesting that targeted prevention strategies are needed to reduce the risk for TBI among military personnel based on their deployment status. **Key words:** *brain trauma, epidemiology, occupational injury, traumatic brain injury*

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A data sharing agreement must be executed with the original data owner (The Naval Health Research Center, San Diego) to obtain the data with appropriate permissions. The code is available in R format from the primary author.

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BACKGROUND

From 2000 to 2022, approximately 458 894 US active duty military service members experienced a traumatic brain injury (TBI).[1] Studies have suggested that the prevalence of TBI in military service members ranges between 12% and 23%,[2–5] with 80% of military TBI categorized as mild TBI.[1–4] TBI has been considered the "signature injury" of the post-9/11 conflicts in Iraq and Afghanistan due to increased contact with improvised explosive devices.[6]

To date, limited research has been published that examines differences in risk and risk factors for TBI in deployed and nondeployed environments. Deployment settings are places outside of continental US military permanent bases where there is a movement of armed forces.[7] While personnel may be deployed to combat zones, they can also be deployed for other, noncombat purposes, such as humanitarian efforts, evacuation of US citizens, peacekeeping, or bolstering global security. Nondeployed settings are US military permanent bases located throughout the world.[8]

At present, most military TBI studies have focused on injuries that occurred during deployment. Studies have indicated that up to 23% of deployed service members experience a TBI during deployment,[4,5,9] with exposure to blasts during combat as the most significant risk factor.[6] Many studies examining deployment-related TBI have used only binary categorizations of "blast" and "non-blast" to describe injury mechanisms, with few details beyond these categories.[10–14] The few studies that have characterized non-blast–related deployment TBI have found motor vehicle crashes and falls to be the next most common mechanisms of injury.[2,3,15]

In contrast to deployment, studies have shown that a larger proportion of all TBIs (80%-85%) occur among service members in nondeployment environments.[15,16] While approximately 1.3 million individuals were serving in the US Armed Forces as of 2016, the bulk of military TBI studies have focused on the small proportion (15%, or approximately 194 000) who are deployed annually.[17] Studies examining rates of nondeployment-related TBI have had missing data[8] or have not provided the number of individuals affected by the listed mechanisms of injury.[16] For example, a surveillance study by Williams et al[8] reported missing mechanism of TBI data for up to 82% of all injuries, with "miscellaneous" as the second most common known mechanism. The only example, to our knowledge, of a study that captured nondeployment mechanisms of TBI and did not have a significant amount of missing data reported "moving motor vehicle" as the most common cause of TBI (17.7%), followed by sports-related injuries (14.9%), parachute accident (14.7%), and struck by an object (14.5%).[18]

The literature is also limited by a lack of studies considering service member time at risk for TBI when deployed vs nondeployed, with only a few studies identified.[8,15,18,19] Cameron et al observed that 80% of all TBIs between 1997 and 2007 were incurred while active duty US service members were not deployed, but rates of TBI among nondeployed personnel were significantly lower relative to those deployed as part of Operation Iraqi Freedom in that same time frame.[15] These findings suggest that analyses stratified by deployment status are needed to better examine demographic and occupational risk factors of TBI in these different settings.

The purpose of this study was to fill some of the existing gaps by examining the prevalence and time at risk of TBI by deployment status, taking into consideration military occupation, as well as to describe the mechanism of injury for each among a large cohort of US active duty military service members who participated in the Millennium Cohort Study.

METHODS

Study sample

This study was approved by the institutional review board. Data for this cross-sectional study were obtained from the Naval Health Research Center's Millennium Cohort Study, an ongoing US Department of Defense (DoD) study. Sampling and recruitment methods have been described elsewhere.[20–24] In brief, the Millennium Cohort Study enrollment began in 2001, with a new round of service members recruited in panels every 3 years until 2011, for a total of 4 panels.[24,25] These analyses include participants from panels 2 (2004), 3 (2007), and 4 (2011). To be included in the Millennium Cohort Study, panel 2 required service members to have 1 to 2 years in service, panel 3 required 1 to 3 years, and panel 4 required 2 to 5 years. The current study used data from the most recent follow-up survey (wave 4 for panel 2, wave 3 for panel 3, and wave 2 for panel 4) conducted in 2014, which was the first to assess TBI. To be included in these analyses, service members needed to be on active duty or in the Reserves/National Guard (eg, not veterans) and have complete TBI data.

Participants were included in these analyses if they were still active duty or Reserve/National Guard personnel because their likely time in service could be calculated. We excluded those no longer actively serving in a military role. There were 112 654 participants who completed the 2014 survey, 29 286 (26.0%) of whom were active duty/Reserve/Guard members. A total of 83 368 participants were excluded because they were no longer in active service. Among those included in

these analyses, 5100 (17.4%) were from panel 2, 8565 (29.2%) from panel 3, and 15 621 (53.3%) from panel 4. Of those, 527 were missing TBI data and were excluded from these analyses, resulting in a final sample size of 28 759 participants.

Data collection

TBI was assessed by participant response to the following question: "Have you ever had an injury, such as from a fall, blow to the head, blast exposure, motor vehicle crash, sports, or any other cause, that resulted in any of the following?: (a) Being dazed or confused right after the injury?; (b) Being confused or not thinking clearly right after the injury?; (c) Not remembering the actual injury right after it happened?; (d) Not remembering things that happened right after the injury?; (e) Losing consciousness or being knocked out?" Participants were categorized as ever having a TBI if they answered "yes" to any of these choices. Participants were asked to provide details for up to 5 of their most recent TBIs, including if the injury occurred during deployment (yes/no), and the TBI had to have occurred after the service member entered active military service.

Person-time at risk for TBI was calculated separately for time spent deployed vs nondeployed, using military entrance date based on the earliest possible fiscal year each panel could have enrolled in the military, including September 1, 2001, for panel 2; September 1, 2003, for panel 3; and September 1, 2005, for panel 4. The survey wave utilized for these analyses ended in 2016, so December 31, 2016, served as the end date for person-time for all participants. Deployment data were from the Millennium Cohort Study and included start and stop dates for each deployment for each participant. Any deployments prior to the estimated start date were excluded from the analysis. We initially calculated the total person-years spent in the military from the estimated start date to the end of our follow-up in 2016. We then summed the duration of person-years spent deployed during this same time period. Total nondeployed person-years were calculated by subtracting the total deployed person-years from the total person-years. A participant could contribute to both deployment and nondeployment person-years based on their deployment data.

Covariates included age (years), sex (male/female), race/ethnicity (White, Black, Hispanic, Asian/Pacific Islander, and American Indian/Other), and military rank (enlisted/officer). Military occupational category (MOC; Administration and Executives, Infantry/Tactical Operations, Electronics Repair and Engineering, Communications and Intelligence, Health Care, Technical and Professional, Craftworkers and Supply, Other/Not Specified), military status (active duty, Reserve/Guard), and military branch (Air Force, Army, Coast Guard, Marine Corps, and Navy).

Statistical analysis

Frequencies and means described demographic and occupational characteristics of participants, mechanisms of injury, overall prevalence of TBI, and prevalence of TBI stratified by deployment status. Person-years deployed and not deployed were used to calculate crude rates of TBI by dividing the total number of TBIs by the total person-years at risk, multiplied by 100. To examine the risk of TBI by deployment status, we calculated unadjusted and adjusted rate ratios (RRs) and 95% confidence intervals (CIs). Unadjusted negative binomial regression models calculated RRs and 95% CIs assessing the relationship between TBI and each covariate individually with an offset variable for the log of total person-years. An adjusted model was then built to assess the relationship between TBI and MOC, stratified by setting. For the adjusted model, covariates were individually introduced into the model containing MOC and the offset variable and were retained if they changed any covariate by more than 10% or if they improved the model fit. A deviance goodness-of-fit test was used to test model fit. Statistical analyses were conducted using R statistical software (R Core Team).[26]

RESULTS

Overall, the 28 759 participants contributed a total of 362 535 person-years of service time. Participants contributed an average 12.6 person-years (SD = 1.5) overall, 11.5 (SD = 1.6) nondeployment person-years, and 1.1 (SD = 0.9) deployment person-years. The average age of the sample was 34.3 (SD = 5.5) years, and participants were predominately male (70.5%), White (74.5%), enlisted (66.9%), on active duty status (67.2%), and serving in the Army (40.8%), Air Force (35.5%), Navy (14.6%), Marines (6.1%), and Coast Guard (3.0%). Most of the sample worked in the following MOCs: Electronic Repair and Engineering (17.2%), Infantry/Tactical Operations (15.7%), Craftworkers and Supply (13.3%), Health Care (11.9%), Communications and Intelligence (11.5%), Administration and Executives (10.0%), and Technical and Professional (5.5%), with 15.0% in an unspecified occupation (eg, students and patients) (Table 1).

TBI frequencies and rates overall and by deployment status are described in Table 2. A total of 6499 individuals self-reported having experienced TBI; the prevalence of any TBI was 22.6%. The total number of TBIs reported was 10 709, with a rate of any TBI over the follow-up period of 2.95 (95% CI, 2.90-3.01) per 100 person-years. In nondeployment settings, the prevalence of TBI was 16.6%, with 4767 individuals reporting 7123 total TBIs,

TABLE 1 *Characteristics of a sample of Millennium Cohort participants who completed the 2014-2016 survey (N = 28 759)*

Characteristics	No. (%)
Age, y, mean (SD)	34.3 (5.5)
Ever deployed	
Yes	23 453 (81.6)
No	5306 (19.4)
Traumatic brain injury	
Yes	6499 (22.6)
No	22 260 (77.4)
Sex	
Female	8498 (29.5)
Male	20 261 (70.5)
Race/ethnicity	
White	21 432 (74.5)
Black	2571 (8.9)
Hispanic	2282 (7.9)
Asian/Pacific Islander	1708 (5.9)
American Indian/Other	766 (2.6)
Rank	
Officer	9526 (33.1)
Enlisted	19 233 (66.9)
Service branch	
Air Force	10 209 (35.5)
Army	11 724 (40.8)
Navy	4211 (14.6)
Marine Corps	1735 (6.1)
Coast Guard	867 (3.0)
Military status	
Reserve/Guard	9439 (32.8)
Active duty	19 320 (67.2)
Military occupational category	
Administration & Executives	2867 (10.0)
Infantry/Tactical Operations	4518 (15.7)
Electronic Repair & Engineering	4927 (17.1)
Communications & Intelligence	3294 (11.5)
Health Care	3428 (11.9)
Technical & Professional	1577 (5.5)
Craftworkers & Supply	3827 (13.3)
Not Specified	4321 (15.0)

and a rate of 2.15 (95% CI, 2.10-2.20) per 100 person-years. Among those who ever deployed, 2548 individuals experienced at least 1 TBI, with a total of 3586 TBIs reported in deployment settings. The prevalence of TBI in deployment settings was 10.9%, and TBI occurred at a rate of 11.38 (95% CI, 11.00-11.75) per 100 person-years.

The unadjusted multivariable negative binomial regression models for overall, deployment only, and nondeployment only TBI are reported in Table 3. Per every additional person-year, the risk of TBI increased 6% overall, 5% in nondeployment, and 89% in deployment settings. Regarding sociodemographic characteristics, for overall TBI and TBI in nondeployment settings, per 1-year increase in age, the risk of TBI decreased by 2% (RR = 0.98; 95% CI, 0.98-0.99, 0.97-0.99). Age was not associated with TBI in deployment settings. Males were at higher risk of TBI overall and in both settings compared with females, with deployment settings posing the highest risk for TBI (RR = 2.06; 95% CI = 1.84–2.32). Generally, Black, Hispanic, and Asian/Pacific Islander service members had less risk of TBI overall and in both settings compared with White service members.

Regarding occupational military characteristics, enlisted service members were at increased risk of TBI overall and in both settings, with risk highest in deployment settings (RR = 1.57; 95% CI, 1.43-1.72). Marine Corps service members were at the highest risk of TBI compared with Air Force service members overall in deployment settings, with a risk of TBI more than 4 times (RR = 4.02; 95% CI, 3.36-4.80) that of Air Force service members in deployment settings. Compared with Air Force service members, deployment settings were associated with the largest risk of TBI in all other service branches (Navy RR = 1.58, 95% CI, 1.33-1.87; Army RR = 3.64, 95% CI, 3.25-4.09; Coast Guard RR = 3.83, 95% CI, 2.06-6.75). Branch of service

TABLE 2 *Unadjusted service-related TBI prevalence and rates stratified by deployment status, Millennium Cohort participants, 2014-2016 survey (N = 28 759)*

Deployment status	Individuals with TBI	Total TBI[a]	TBI prevalence	TBI ratea	95% CI	Total PY
Any (N = 28 759)	6499	10 709	22.60	2.95	2.90-3.01	362 535
Nondeployment (N = 28 759)	4767	7123	16.58	2.15	2.10-2.20	331 014
Deployment (N = 23 453)	2548	3586	10.86	11.38	11.00-11.75	31 521

Abbreviations: CI, confidence interval; PY, person-years; TBI, traumatic brain injury.

[a]Rate per 100 person-years.

TABLE 3 *Unadjusted negative binomial regression models of service-related TBI, by deployment status, 2014 Millennium Cohort participants (N = 28 759)*[a]

	Any TBI RR (95% CI)	Nondeployment TBI RR (95% CI)	Deployment TBI[b] RR (95% CI)
Person-years	**1.06 (1.04-1.08)**	**1.05 (1.00-1.10)**	**1.89 (1.81-1.98)**
Age	**0.98 (0.98-0.99)**	**0.98 (0.97-0.99)**	1.00 (1.00-1.01)
Sex			
Female	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
Male	**1.57 (1.48-1.67)**	**1.24 (1.07-1.44)**	**2.06 (1.84-2.32)**
Race/ethnicity			
White	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
Black	**0.73 (0.66-0.81)**	0.81 (0.63-1.04)	**0.61 (0.52-0.72)**
Hispanic	0.95 (0.86-1.05)	0.90 (0.70-1.16)	1.03 (0.89-1.20)
Asian/Pacific Islander	**0.65 (0.57-0.74)**	**0.57 (0.40-0.79)**	**0.63 (0.51-0.78)**
American Indian/Other	0.95 (0.80-1.12)	1.19 (0.83-1.71)	0.86 (0.64-1.15)
Rank			
Officer	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
Enlisted	**1.42 (1.34-1.50)**	**1.39 (1.20-1.63)**	**1.57 (1.43-1.72)**
Service branch			
Air Force	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
Army	**2.35 (2.21-2.51)**	**1.70 (1.41-2.05)**	**3.64 (3.25-4.09)**
Navy	**1.27 (1.16-1.39)**	**1.37 (1.09-1.71)**	**1.58 (1.33-1.87)**
Marine Corps	**2.33 (2.09-2.60)**	**2.10 (1.56-2.83)**	**4.02 (3.36-4.80)**
Coast Guard	**1.39 (1.17-1.63)**	**1.51 (1.19-1.92)**	**3.83 (2.06-6.75)**
Military status			
Reserve/Guard	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
Active duty	**1.15 (1.09-1.22)**	1.04 (0.91-1.20)	**0.81 (0.74-0.88)**
Military occupational category			
Administration & Executives	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
Infantry/Tactical Operations	**1.61 (1.44-1.79)**	1.12 (0.83-1.53)	**1.61 (1.36-1.92)**
Electronic Repair & Engineering	**1.15 (1.03-1.28)**	**1.35 (1.04-1.75)**	**0.78 (0.64-0.94)**
Communications & Intelligence	**1.27 (1.12-1.42)**	1.31 (0.98-1.76)	1.01 (0.83-1.22)
Health Care	**1.13 (1.01-1.28)**	0.90 (0.69-1.17)	**1.34 (1.10-1.64)**
Technical & Professional	**1.22 (1.05-1.40)**	0.87 (0.62-1.23)	**1.32 (1.04-1.67)**
Craftworkers & Supply	**1.30 (1.16-1.46)**	1.29 (0.97-1.71)	1.19 (0.99-1.43)
Not Specified	1.08 (0.97-1.22)	0.95 (0.72-1.25)	1.00 (0.83-1.20)

Abbreviations: CI, confidence interval; RR, rate ratio; TBI, traumatic brain injury.
[a]Bold indicates $P < .05$.
[b]Only includes those individuals who ever deployed; N = 23 453. Not all participants had documented deployments.

was also associated with increased risk in nondeployment locations, with Army (RR = 1.70; 95% CI, 1.41-2.05), Navy (RR = 1.37; 95% CI, 1.09-1.71), Marine Corps (RR = 2.10; 95% CI, 1.56-2.83), and Coast Guard (RR = 1.51; 95% CI, 1.19-1.92) service members at increased risk compared with Air Force service members. Compared with Reserve/Guard status, active duty status was associated with increased risk of TBI overall (RR = 1.15; 95% CI, 1.09-1.22), not significantly different in nondeployment settings, and decreased in deployment settings (RR = 0.81; 95% CI, 0.74-0.88). MOC was significantly associated with increased risk of TBI, with the Infantry/Tactical Operations MOC at highest risk overall (RR = 1.61; 95% CI, 1.44-1.79) compared with Administration and Executive MOCs. Infantry/Tactical Operations (RR = 1.61; 95% CI, 1.36-1.92) and Technical and Professional (RR = 1.44; 95% CI, 1.19-1.74) MOCs were associated with the highest risk in deployment settings compared with Administration and Executive MOCs. Electronic Repair and Engineering MOCs were associated with the highest increased risk of TBI (RR = 1.26; 95% CI, 1.14-1.39) compared with Administration and Executives in nondeployment settings.

In the adjusted model (Table 4) per every 1 year increase in person-years, the risk of TBI increases 9% overall and 10% in nondeployment, and 53% in deployment settings. Relationships between rates of TBI and MOC remained like the unadjusted model with risk remaining elevated, but attenuated, for Infantry/Tactical Operations, Communications & Intelligence, and Craftworkers & Supply, while decreased risk became no longer significant for Electronic Repair &

TABLE 4 *Adjusted negative binomial regression models assessing the association between service-related TBI and military occupation, by deployment status, 2014 Millennium Cohort participants (N = 28 759)*[a]

	Any TBI RR (95% CI)	Nondeployment TBI RR (95% CI)	Deployment TBI[b] RR (95% CI)
Military occupational category			
Administration & Executives	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
Infantry/Tactical Operations	**1.38 (1.24-1.54)**	1.14 (0.83-1.56)	**1.38 (1.16-1.64)**
Electronic Repair & Engineering	**1.20 (1.07-1.33)**	**1.36 (1.04-1.77)**	0.83 (0.69-1.00)
Communications & Intelligence	**1.17 (1.04-1.31)**	1.33 (0.99-1.78)	0.92 (0.75-1.11)
Health Care	**1.18 (1.05-1.32)**	0.99 (0.64-1.27)	**1.36 (1.12-1.66)**
Technical & Professional	**1.29 (1.12-1.49)**	0.90 (0.64-1.27)	**1.46 (1.15-1.85)**
Craftworkers & Supply	**1.21 (1.08-1.35)**	1.21 (0.91-1.61)	1.08 (0.90-1.30)
Not Specified	**1.20 (1.07-1.35)**	1.09 (0.82-1.45)	1.12 (0.93-1.36)

Abbreviations: CI, confidence interval; RR, rate ratio; TBI, traumatic brain injury.
[a]Bold indicates $P < .05$.
[b]Only includes those individuals who ever deployed; N = 23 453. Not all participants had documented deployments.
All models were adjusted for age, sex, race/ethnicity, rank, service branch, and military status.

Engineering in deployment settings. Risk increased slightly for Technical & Professional and Health Care overall (RR = 1.29; 95% CI, 1.05-1.40 and RR = 1.18; 95% CI, 1.05-1.32, respectively) and in deployment settings (RR = 1.46; 95% CI, 1.15-1.85 and RR = 1.36; 95% CI, 1.12-1.66). Risk was also increased for Electronic Repair & Engineering.

The types and frequencies of TBI mechanisms by deployment status are described in Table 5. In deployed settings, the largest proportion of TBI (53.8%) was due to blast or bullets, followed by other/don't know (15.7%), falls (10.8%), motor vehicle crashes (6.6%), sports/physical training (6.2%), military training (5.8%), and fighting with someone (1.1%). In nondeployment settings, sports/physical training (26.1%) accounted for the largest proportion of nondeployed TBI, followed by other/don't know (18.8%), military training (18.4%), motor vehicle crash (15.9%), falls (12.6%), blast/bullet (4.1%), and fighting with someone (4.1%).

TABLE 5 *Mechanism of TBI for a sample of Millennium Cohort Study members who experienced a service-related TBI between 2000 and 2016, by deployment status (N = 10 709)*

Mechanism of injury	Deployed TBI (N = 3586) No. (%)	Nondeployed TBI[a] (N = 7123) No. (%)
Blast/bullet	1928 (53.8)	292 (4.1)
Motor vehicle crash	236 (6.6)	1135 (15.9)
Military training	209 (5.8)	1310 (18.4)
Sports/physical training	222 (6.2)	1860 (26.1)
Fall	387 (10.8)	901 (12.6)
Fighting (noncombat)	40 (1.1)	289 (4.1)
Other/don't know	564 (15.7)	1336 (18.8)

Abbreviations: TBI, traumatic brain injury.
[a]Not mutually exclusive.

DISCUSSION

This study examined the relationship between time in the military and risk of TBI, overall and by deployed and nondeployed locations. Approximately 23% of participants experienced at least 1 TBI during the study period. While the prevalence of TBI was higher in nondeployment locations, the rate of TBI per 100 person-years was over 5 times greater in deployment locations than in nondeployment settings. Compared to a surveillance study that used medical record diagnoses and calculated a TBI incident rate of 1.14 per 100 person-years, we calculated a rate of 2.15 per 100 person-years.[8] The difference in rates may be due to differences in how TBI was measured. Also, the rates in the surveillance study were unadjusted and did not consider possible confounding factors. The findings of this study generally agreed with the existing literature in terms of TBI risk in the military. However, uniquely this study addressed and compared rates of TBI, included nondeployment settings, and included a greater stratification of military occupations than previously investigated.

Additionally, this is one of only 2 studies, to our knowledge, that has described the mechanism of TBI in nondeployment settings among such a large sample of participants. Sports/physical training and military training accounted for almost 45% of all nondeployment TBI

within this sample. Regasa et al[18] found moving motor vehicle, sports-related injuries, and parachute accidents to be the most common nondeployment mechanisms of TBI. Both this study and Regasa et al's study highlight the importance of targeting prevention strategies in nondeployment locations, especially because the adverse, long-term effects of TBI are nearly indistinguishable from each other, regardless of mechanism.[28] While the frequency of non-blast mechanisms was lower in deployment settings, those mechanisms still caused TBI. Thus, it is conceivable that TBI prevention efforts in nondeployment locations may reduce the risk of TBI in deployment settings and vice versa.

Occupational risks of TBI overall and by deployment status were also examined in this study. This is the first study to examine these differences using multivariable modeling and stratification of deployment settings. Enlisted service members were at higher risk for TBI overall, in deployment and nondeployment settings, compared with officers. This is similar to findings in studies examining TBI risk overall[10,15,16,27] and among those who have deployed.[2–4,15] Those in MOCs significantly associated with increased risk of TBI in nondeployment locations had higher risk in deployment locations, except for those serving in Electronic Repair and Engineering and Communications and Intelligence roles. For those 2 MOCs, the relationship flipped from increased risk to decreased risk and was no longer significant. The sample sizes for these MOCs remained large, so statistical power was likely not an issue. This deserves further investigation. Interestingly, when compared with Air Force service members, all branches of military service were at significantly higher risk for TBI in both deployment and nondeployment locations. When comparing the TBI frequencies of MOCs across service branches (data not shown) within the sample, the proportion of Air Force service members serving in the highest risk MOCs was comparable to that of the other branches. It is possible the additional time at risk in deployment locations could play a role in the protective nature of Air Force service. This finding should also be examined further.

Based on the most recent DoD demographics survey, the study population was demographically similar to the military community at large as there were only minor differences between our study sample's demographics and those of the US military.[29] The sample was older, with an average age of the participants of approximately 34 years, while DoD reported an average age of 28 years.[29] Except for age, the remaining demographics of general US military personnel were similar to those of the 2018 survey, with service members who were mostly male (71%), White (75%), enlisted (67%), and serving in the Army (36%).[29] Even though the study population was similar to the military population generally, it is important to discuss that data for those service members who were veterans by completion of the 2014 Millennium Cohort Survey would not have been included. Service members who completed their enlistment or left military service for any other reason (eg, administrative separations for behavior and medically separated) would not have been included in this analysis. This could have impacted the results by biasing toward the null, as those with more severe medical issues that may or may not be related to TBI would not have been included.

There are methodological limitations to this study that should be considered. First, the TBI dates and details were self-reported. This was a cross-sectional survey, so self-reported TBI details can be subject to recall bias. Further, dates and locations given by participants could have been incorrectly remembered. Also, the survey only allowed for reporting up to 5 TBIs per participant. This may have resulted in under-reporting TBI, thereby introducing bias into the study and potentially reducing the true burden of TBI in either location. Person-time was estimated based on the enrollment criteria for the Millennium Cohort Study, which may have led to reduced risk windows. Additionally, for service members who are reservists or National Guard, deployment time was accurately assessed, but their service obligations in a nondeployment setting may be as limited as 1 weekend a month and 2 weeks in the summer, which could misclassify their risk for TBI as compared to active duty service members engaging in military activities daily as their occupation. These data are also somewhat dated, in that combat operations have greatly decreased in deployment locations, potentially lowering the risk of bullets and blasts in deployment locations today. Still, it is important to report these results as they can be used by the appropriate stakeholders should new conflicts arise. Finally, it is important to discuss how TBI was defined in this study. This analysis defined TBI based on a series of questions with self-reported answers. Past studies have measured TBI in different ways to include using validated survey instruments, clinical assessments, and diagnostic data from existing health records. This could result in differing levels of misclassification bias. As such, this may be a reason for differences in TBI rates in our study as compared to others using different methods of assessment. In fact, we would expect studies using gold-standard interview methods for TBI capture to have slightly different results.

There are many strengths to this study. First, person-time data for deployment locations made it possible to estimate person-time data for nondeployment settings. This allowed TBI risk to be more accurately described by location. Most importantly, TBI rates were able to be calculated and presented, an important addition to the epidemiological data that exist for military TBI. Additionally, risk was described across military occupations in both settings. To our knowledge, this is the first study to describe occupational risk by location using multivariable modeling. Further, the large sample size was a diverse cross-section of military service members from all branches. This not only included Coast Guard service members but also provided rate estimates to be compared with the other service branches, contributing data to an existing gap in the scientific literature.

CONCLUSIONS

The findings from this study suggest that risk of TBI increases as time in military service increases. While the rate of TBI was higher in deployment settings, the prevalence of TBI was higher in nondeployment settings. These findings highlight the importance of investigating TBI in nondeployment and deployment locations using robust, longitudinal studies that can consider all TBI experienced over the course of military service. When developing prevention efforts for TBI and assessing risk, public health professionals should consider factors specific to deployment and nondeployment settings to best mitigate risk as the effects of TBI can have long-term, debilitating consequences. This makes primary interventions even more important.

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