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Examining the Influence of Mild Traumatic Brain Injury and Posttraumatic Stress Disorder on Alcohol Use Disorder in OEF/OIF Veterans

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ABSTRACT Objectives: Examine (1) impact of mild traumatic brain injury (mTBI) on posttraumatic stress disorder (PTSD) symptoms, (2) frequency of alcohol use disorder in male and female combat Veterans, and (3) influence of PTSD and mTBI on alcohol use disorder. Method: A retrospective medical-record review extracted the following data for Operation Enduring Freedom/Operation Iraqi Freedom Veterans (N = 1,278) who completed a semi-structured mental health evaluation: alcohol use disorder diagnoses, PTSD symptom criteria, and Brief Traumatic Brain Injury Screen. Logistic regressions tested if PTSD and mTBI predicted which Veterans had an alcohol use disorder diagnosis. Results: Veterans with mTBI had more re-experiencing, avoidance, and hyperarousal symptoms than Veterans without mTBI. Men and women differed regarding alcohol use. For men, PTSD predicted alcohol use diagnosis while mTBI did not. For women, neither mTBI nor PTSD predicted alcohol use diagnosis. Conclusion: Findings from this study can inform treatment providers by alerting them to the possibility of subthreshold PTSD in Veterans with mTBI. Providers may begin PTSD treatments or consider targeting hyperarousal symptoms early in treatment to reduce distress. PTSD is also uniquely associated with alcohol use disorder in male Veterans, while more research on predictors of alcohol use disorder is needed for female Veterans.

INTRODUCTION

Over two million troops have been deployed to Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF).[1,2] Physical injuries sustained during deployment are usually visually recognizable, but many service members also experience less obvious but equally distressing psychological injuries. Since 2002, 53.3% of OEF/OIF Veterans seeking services through the Veterans Affairs (VA) have been diagnosed with a mental disorder.[2]

Posttraumatic stress disorder (PTSD) is a common psychiatric condition found among Veterans. According to the fourth edition of the "Diagnostic and Statistical Manual of Mental Disorders" (DSM-IV-TR), an individual experiences a traumatic event and then later develops three clusters of symptoms: reexperiencing, avoidance/emotional numbing, and hyperarousal.[3] In 2013, the DSM-5[4] updated the PTSD diagnostic criteria to include a cluster which captures negative alterations in cognitions and mood, along with refining the definition of trauma. However, given the recent transition to the DSM-5, most prevalence rates are still based on the DSM-IV-TR, thus this manuscript will examine DSM-IV-TR clusters. DSM-IV-TR PTSD rates for OEF/OIF Veterans range from 4% to 17%[5] and are higher (21.8%) for Veterans seeking health care from VA centers.[6,7] An estimated 226,000 OEF/OIF Veterans currently have PTSD,[8] which is disconcerting

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because PTSD often leads to psychological impairment and poor physical health outcomes.[9,10]

Among service members, traumatic brain injury (TBI) frequently co-occurs with PTSD.[11] TBI is a brain insult that causes a change in consciousness and can lead to an onset of immediate physical (e.g., headaches, nausea, fatigue, sleep difficulties, sensitivity to light/sounds) and cognitive (e.g., difficulty remembering or concentrating) symptoms.[12] Between 10% and 20% of service members deployed OEF/OIF meet criteria for TBI of various severity levels,[11] and 6.7% of the 327,388 Veterans who used VA health care in 2009 had a TBI diagnosis.[1]

There are different degrees of TBI severity, with mild TBI (mTBI) being the most common among returning Veterans. Deployed service members report blast-related injuries resulting from explosives as the most common mTBI cause.[13] Fortunately, mTBI symptoms alleviate rapidly, usually within 6 months[14]; however, up to 76% of persons who sustain a mTBI continue to have at least one symptom 1 year past the original injury.[15]

CONSEQUENCES OF COMORBID mTBI AND PTSD

Examining the combined influence of PTSD and mTBI is important for prognosis and treatment recommendations. PTSD and mTBI tend to co-occur and share overlapping symptoms including sleep difficulties, memory problems, concentration difficulties, poor judgment (impulsivity), anger/irritability, and anxiety. Thus, Veterans with mTBI may present with these symptoms, and clinicians may correctly attribute them to the brain injury. However, these symptoms may also be indicative of subthreshold PTSD, which may dictate a different course of treatment. Subthreshold PTSD has been related to increased rates of depression, disability,[16] and impairments comparable to those associated with full PTSD.[17]

Research on comorbid PTSD and mTBI has produced equivocal findings. The few studies examining the cumulative effects of PTSD and mTBI have found increased medical costs and PTSD symptom severity[1,18] but not other cognitive and psychological outcomes. A possible explanation of why mTBI is related to greater PTSD severity is that emotion-regulation centers of the brain may be damaged by the mTBI[19]; consequently, the Veteran may experience increased difficulties with trauma-related emotions. Other research has not found additive effects of comorbid PTSD and mTBI on functional outcomes, including suicide risk,[18] cognitive ability,[20] physical health outcomes (with the exception of headaches),[21] and risk of being arrested.[22]

Alcohol Misuse With PTSD and mTBI

Individuals with PTSD may engage in excessive alcohol use to self-medicate their symptoms.[23,24] In a sample of returning National Guard Soldiers, individuals who developed an alcohol-use disorder (AUD) after deployment had more severe PTSD than soldiers who developed an AUD before deployment.[25] This finding suggests that Veterans may use alcohol in an attempt to alleviate combat-related distress. Long-term consequences of excessive alcohol use include increased aggression[26] and withdrawal symptoms that can mimic and exacerbate PTSD symptoms.[27]

Alcohol use is also related to TBI. However, alcohol use tends to be a precursor to TBI in civilian samples,[28] unlike the self-medication with alcohol that can occur after an individual develops PTSD.[23] Veterans may present with a different initial pattern than civilians because they are likely to sustain a TBI while in combat, which reduces the chances of alcohol being a precipitating factor. Of Veterans seeking VA services during 2009, about 20% who had sustained a TBI also had a comorbid substance-disorder diagnosis.[1] Regardless of civilian or Veteran samples, treatment recommendations are clear that using alcohol after a brain injury should be avoided because it can delay healing and increase the risks of seizures and additional brain injuries.[29]

Because of the independent relationships between alcohol use and mTBI and PTSD, in addition to the high comorbidity between mTBI and PTSD, research has begun to examine the combined effects of PTSD and mTBI on alcohol use. Similar to other research on mTBI and PTSD, results are equivocal. In a sample of active duty airmen, mTBI was related to an increased risk of alcohol dependence post brain injury even after controlling for PTSD.[30] However, other research found that in a sample of OEF/OIF Veterans selected for their heavy alcohol use, Veterans with mTBI did not differ from Veterans without mTBI in regards to drinking-related consequences, quantity or frequency of use, and episodes of binge drinking.[31] In addition, longitudinal research showed when PTSD and mTBI were examined simultaneously, only PTSD predicted dangerous alcohol use after deployment.[32]

The purpose of this study was to examine PTSD, mTBI, and AUD in a sample of OEF/OIF Veterans. The first aim examined if Veterans with mTBI presented with more PTSD symptoms than Veterans without mTBI. Our second aim was to describe the rate of AUD in male and female returning combat Veterans. The final aim was to examine whether PTSD and mTBI could predict which Veterans have an AUD while separately considering male and female Veterans. To our knowledge, no studies have independently examined the gender-specific differences in mTBI, PTSD, and AUD for combat Veterans.

METHOD

Participants

All returning OEF/OIF Veterans who were home for at least 1 month and served one or more tours in Afghanistan or Iraq were scheduled for a routine, mandatory mental health evaluation (lasting approximately 1.5 hours) when they enrolled at a large urban VA medical center (VAMC). Veterans were referred for their required evaluation from the following

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sources: standard OEF/OIF screening appointment (new enrollment at VA; 74.1%), hospital triage (10.2%), primary care clinics (8.7%), other nonVA sources (4.7%), and a source not documented in the patient's chart (2.3%). Clinical psychologists, psychiatrists, and social workers from a Trauma and Anxiety Specialty Program conducted the evaluations, consisting of a full diagnostic clinical interview that assessed for the presence of psychiatric disorders, mTBI, and postdeployment adjustment. Between May 2004 and March 2008, 1,740 OEF/OIF Veterans were interviewed. Likely due to the fact that the evaluation was mandatory at the time of VA enrollment, less than 1% of referred Veterans failed to complete the evaluation.

Because this study focused on PTSD, history of mTBI, and AUD, we excluded Veterans who were not given the TBI screen ($n = 462$). The final sample consisted of 1,278 Veterans. Veterans in this sample did not differ from excluded Veterans in terms of sex, ethnicity, marital status, education level, and student status. This sample was 1.16 years older than the excluded sample [$t(1738) = -2.83$, $p = 0.005$], had a 9% higher mean service connection percentage [$t(1670) = -6.66$, $p < 0.001$], and were more likely to be employed [67.1% versus 59.1%; χ^2 $(1, N = 1735) = 9.92$ $p \leq 0.002$].

Variables of Interest

PTSD

During the evaluation, trauma-specialty clinicians assessed Veterans for PTSD. Clinicians determined the presence or absence of a PTSD diagnosis using the 17 individual symptom criteria from the DSM-IV-TR.[3] Veterans met PTSD criteria if they experienced a trauma that produced fear, helplessness, or horror and endorsed at least one reexperiencing, three avoidance, and two hyperarousal symptoms. Five variables were used to examine PTSD symptoms. The first was the DSM-IV-TR categorical PTSD diagnosis used to separate Veterans with PTSD from those without PTSD. Three other continuous variables were created by summing the number of symptom criteria met for each PTSD cluster. The last PTSD variable was a continuous, proxy variable for PTSD severity called PTSD-total that was computed by summing the PTSD reexperiencing, avoidance, and hyperarousal criteria (17 items; range 0–17).

TBI

The presence of mTBI was determined using the Brief TBI Screen,[33,34] which is the mandated screener for OEF/OIF Veterans.[34,35] A Veteran met mTBI criteria by endorsing all of the following questions: (1) Were you exposed to an event that could cause a TBI? (2) Did you have immediate symptoms after the causal event (loss of consciousness, feeling dazed/confused, not remembering event, concussion, or head injury)?, and (3) Did you experience worsening symptoms following exposure (sensitivity to bright light, irritability, headaches, sleep problems, balance problems, memory problems)? The sample contained only mTBI cases, as moderate and severe TBI cases were typically referred to specialty programs within the VA network. mTBI was a categorical variable and was indicated as being either present or absent.

Alcohol Use

Similar to PTSD, AUDs were assessed by the clinicians using the DSM-IV-TR criteria for alcohol abuse and alcohol dependence. Since alcohol use is a normative experience in service member populations,[36] we only identified Veterans who were severe enough to warrant a diagnosis of abuse or dependence. We combined the two diagnoses into a single AUD variable, which is consistent with the DSM-5 diagnosis of AUD.[4] Alcohol use diagnosis was a categorical variable and was indicated as either being present or absent.

PROCEDURE

The VA maintains all health information in electronic medical records. A medical record review was conducted to extract pertinent data for a database that examined postdeployment adjustment. First, an extraction form was created that identified each variable of interest and its coding options. Second, data extraction raters were trained on a set selection of 10 files using the data extraction form to allow for refinement of data interpretation and calculation of intraclass correlations (ICC). ICCs were calculated both individually and overall for all extracted variables, including demographic, diagnostic, and PTSD symptoms. Initially, four raters independently extracted the data and produced high inter-rater reliability (ICC for the database = 0.988 [95% CI: 0.980–0.994], $p < 0.001$). Two other raters were added for additional data extraction, and following training, they were extracting data using the data extraction form consistently with the original raters (ICC = 0.980 [95% CI: 0.970–0.988], $p < 0.001$). The individual item ICC's for the diagnostic variables varied between 0.698 and 0.828. ICCs for the PTSD criterion reexperiencing, avoidance/numbing, and hyperarousal symptoms ranged from 0.779 to 0.893 and was 0.738 for the alcohol abuse/dependence diagnostic variable. The current study examined a subset of the larger database. It was approved by the local institutional review board and VA Research and Development Committee.

Data Analyses

To test whether Veterans with mTBI had more PTSD symptoms than Veterans without mTBI, an independent samples t test (equal variances not assumed) was conducted. Three additional independent sample t tests were used to identify if Veterans with mTBI endorsed more PTSD symptoms in each cluster than Veterans without mTBI. In addition, to determine if Veterans who had PTSD accounted for the level of PTSD symptoms in the mTBI group, we removed Veterans with PTSD from the mTBI group and re-ran four independent samples t tests between Veterans with and without mTBI.

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TABLE I. Demographic Information for Returning OIF/OEF Veterans

		Total N = 1,278
	Mean Age in Years (SD)	29.75 (7.71)
	Mean Service Connection Percentage (SD)	17.64 (26.42)
Gender (%)	Male	88.7
Education (%)		
	High School/GED	32.3
	College (1–3 years)	55.7
	Completed College	12.0
Race/Ethnicity (%)		
	Caucasian	48.3
	Hispanic/Latino	19.2
	African American	27.4
	Other	5.1
Marital Status (%)		
	Married	42.7
	Divorced/Separated/Widowed	21.0
	Never Married	35.8
	Unknown	0.5
Employment Status (%)		
	Currently Employed (%)	67.1
	Currently Student (%)	26.7
Psychiatric Diagnoses (%)		
	Anxiety (Other Than PTSD)	27.7
	PTSD	30.5
	Mood Disorder	41.5
	Bipolar Disorder	0.8
	Alcohol Use disorder	18.8
	Substance Use disorder	20.2
	mTBI	31.5

GED, General Educational Development; PTSD, posttraumatic stress disorder, mTBI, mild traumatic brain injury.

Frequencies were used to examine what proportion of the Veterans met criteria for an AUD. Finally, two logistic regressions (men and women in separate models due to different alcohol use rates) examined if mTBI and PTSD severity predicted who would have an AUD, while controlling for age. Age was selected as a covariate because previous research shows that as age increases, alcohol use decreases.[30]

RESULTS

The sample was mostly male (88.7%), with about half (55.7%) having completed at least some college (Table I). The largest represented ethnicity was Caucasian (48.3%), followed by African American (27.4%). Almost 43% of the Veterans were married and 67.1% were currently employed. The most common psychiatric diagnoses were mood disorder (41.5%), PTSD (30.5%), and other anxiety disorders besides PTSD (27.7%).

PTSD Symptoms

Mean PTSD cluster and total scores for Veterans with and without mTBI are displayed in Table II. Veterans with mTBI had statistically higher PTSD severity (M = 8.66) than those without mTBI (M = 4.10; [$t(1275) = -16.35$, $p < 0.001$, $d = 0.99$]). In addition, Veterans with mTBI had statistically more reexperiencing [$t(1275) = -15.26$, $p < 0.001$, $d = 0.94$], avoidance [$t(1275) = -12.95$, $p < 0.001$, $d = 0.79$], and hyperarousal symptoms [$t(1275) = -16.31$, $p < 0.001$, $d = 0.96$] than Veterans without mTBI, equal variances not assumed for the three comparisons. Veterans with mTBI met symptom cluster diagnostic cutoffs for all three PTSD cluster cutoffs, making the symptoms clinically meaningful.

Out of 402 Veterans who had a history of mTBI, 223 (55.5%) were also diagnosed with full PTSD. We reran the independent samples t test to determine if the statistical difference in PTSD symptoms between Veterans with and without mTBI was only due to a large percentage of mTBI Veterans meeting criteria for full PTSD (equal variances not assumed). After removing the 223 Veterans with full PTSD, the mean PTSD total and cluster scores decreased for the mTBI group. However, Veterans with mTBI (and without full PTSD) still had higher PTSD severity (M = 5.01) as compared to Veterans without mTBI, (M = 4.10; [$t(1052) = -2.77$, $p = 0.006$, $d = 0.21$]). Veterans with mTBI (and without full PTSD) also had statistically higher levels of reexperiencing [$t(1052) = -2.49$, $p < 0.013$, $d = 0.20$]; equal variances not assumed] and hyperarousal [$t(1052) = -4.30$, $p < 0.001$, $d = 0.36$], but not avoidance symptoms [$t(1052) = -0.69$, $p = 0.945$, $d = 0.01$] than Veterans without mTBI. The mean number of reexperiencing and hyperarousal symptoms remained clinically meaningful. Thus, PTSD symptoms remained higher in the mTBI group even after removing Veterans with full PTSD, suggesting it is not just comorbidity between mTBI and PTSD accounting for the findings.

Alcohol Use Disorder

About 20% of men (n = 231) and 6% of women (n = 9) met criteria for an AUD. Almost 26% of male Veterans with mTBI had an AUD; 33.7% of male Veterans with PTSD had

TABLE II. Mean Number of PTSD Symptoms for Veterans With and Without mTBI

Group	PTSD Reexperiencing	PTSD Avoidance	PTSD Hyperarousal	PTSD-Total
Total Sample (N = 1,278)	1.22 (1.38)	1.97 (2.13)	2.33 (2.01)	5.53 (5.08)
No mTBI (n = 876)	0.84 (1.20)	1.48 (1.94)	1.79 (1.92)	4.10 (4.64)
mTBI (n = 402)	2.06 (1.38)	3.08 (2.10)	3.52 (1.68)	8.66 (4.58)
	After Removing 223 Veterans With Comorbid mTBI and Full PTSD			
mTBI Without PTSD (n = 179)	1.07 (1.10)	1.49 (1.61)	2.46 (1.80)	5.01 (3.85)

PTSD, posttraumatic stress disorder; mTBI, mild traumatic brain injury.

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TABLE III. Frequency of Alcohol Use Disorder in Veteran With mTBI and PTSD

	Group	Alcohol Use Disorder	No Alcohol Use Disorder	χ^2	*df*	*p* Value
Male	mTBI (*n* = 374)	97 (25.9%)	277 (74.1%)	10.37	1	0.001
	No mTBI (*n* = 756)	134 (17.7%)	622 (82.3%)			
Female	mTBI (*n* = 28)	1 (3.6%)	27 (96.4%)	0.41	1	0.520
	No mTBI (*n* = 117)	8 (6.8%)	109 (93.2%)			
Male	PTSD (*n* = 359)	121 (33.7%)	238 (66.3%)	56.90	1	0.000
	No PTSD (*n* = 771)	110 (14.3%)	661 (85.7%)			
Female	PTSD (*n* = 32)	3 (9.4%)	29 (90.6%)	0.71	1	0.400
	No PTSD (*n* = 113)	6 (5.3%)	107 (94.7%)			

PTSD, posttraumatic stress disorder; mTBI, mild traumatic brain injury. mTBI and PTSD groups are not mutually exclusive.

an AUD (Table III). Two Pearson χ^2 showed that both the mTBI and PTSD male groups had larger frequencies of Veterans with AUDs than the nonmTBI group and nonPTSD group, respectively. The mTBI and PTSD groups were not mutually exclusive. When only male Veterans with an AUD were selected (n = 231), 69 had both mTBI and PTSD. For female Veterans with an AUD (n = 9), only 1 had a mTBI and 3 had PTSD.

To understand the independent contributions of mTBI and PTSD severity on AUD, two logistic regressions (one for men and one for women) were conducted to predict Veterans who received an AUD diagnosis. Both models had mTBI status and PTSD-total as predictors, with age as a covariate. For men, the test of the full model against a constant only model was statistically significant, indicating that as a group the predictors reliably distinguished between Veterans who received an AUD and those who did not (χ^2 [3, N = 1133] = 61.101, $p < 0.001$). See Table IV. Nagelkerke's R^2 was 0.083, indicating the predictors accounted for about 8% of the variance in describing who had an AUD. Prediction success overall was 79.5% and was not improved with the predictors. The Wald criterion demonstrated that PTSD-total and age made statistically significant contributions to the prediction (both $p < 0.05$). Odds ratio [EXP(B)] indicated that, when PTSD severity is raised one unit (one symptom), male Veterans are 1.114 more likely to have an AUD. mTBI was not a significant predictor of whether male Veterans had an AUD.

For women, the test of the full model against a constant only model was not statistically significant, indicating the predictors did not distinguish between female Veterans who had an AUD from those who did not [χ^2 (3, N = 145) = 3.314, p = 0.346)]. See Table V. Nagelkerke's R^2 was 0.061. Prediction success overall was 93.8%. The Wald criterion demonstrated that none of the predictors were statistically significant.

DISCUSSION

This study examined PTSD symptoms, mTBI, and AUD among OEF/OIF Veterans. The first finding demonstrated that Veterans with mTBI had statistically more PTSD symptoms

TABLE IV. Logistic Regression Analysis of 1,133 Male Veterans Predicting Alcohol Use Disorder Diagnoses

Predictor	β	SE β	Wald's χ^2	*df*	*p*	e^{β} (Odds Ratio)
Constant	−1.349	0.364	13.739	1	0.001	0.260
Age	−0.025	0.011	5.029	1	0.025	0.976
PTSD	0.108	0.016	44.282	1	0.001	1.114
mTBI	−0.023	0.170	0.018	1	.894	1.023
Test			χ^2	*df*	*p*	
Goodness-of-Fit Test (Omnibus Test)			61.101	3	0.000	

Nagelkerke R^2 = 0.083. The model correctly classified 79.5% of male Veterans, which was not an increase over the beginning block. PTSD, posttraumatic stress disorder diagnosis total score. mTBI, mild traumatic brain injury. All statistics reported herein use 4 decimal places to maintain statistical precision.

TABLE V. Logistic Regression Analysis of 145 Female Veterans Predicting Alcohol Use Disorder Diagnoses

Predictor	β	SE β	Wald's χ^2	*df*	*p*	e^{β} (Odds Ratio)
Constant	−4.214	1.929	4.773	1	0.029	0.015
Age	−0.009	0.047	0.033	1	0.856	0.991
PTSD	0.125	0.076	2.722	1	0.099	1.134
mTBI	1.178	1.122	1.103	1	0.294	3.249
Test			χ^2	*df*	*p*	
Goodness-of-Fit Test (Omnibus Test)			3.314	3	0.346	

Nagelkerke R^2 = 0.061. The model correctly classified 93.8% of female Veterans, which was not an increase over the beginning block. PTSD, posttraumatic stress disorder total score. mTBI, mild traumatic brain injury. All statistics reported herein use 4 decimal places to maintain statistical precision.

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than Veterans without mTBI, even after removing Veterans with comorbid full PTSD. In addition, Veterans with mTBI met the cutoffs for the reexperiencing and hyperarousal clusters, making the symptoms clinical meaningful.

This finding suggests the mTBI group likely met criteria for subthreshold PTSD. As described above, PTSD hyperarousal symptoms include sleep difficulties, irritability, concentration difficulties, being on guard, and exaggerated startle response. Two clinical implications are important to consider if a client with mTBI is reporting PTSD symptoms. First, Veterans presenting with subthreshold PTSD may still be experiencing significant distress. It is important to identify Veterans with subthreshold PTSD because they are less likely to receive services yet are frequently distressed and functionally impaired.[16,37] Fortunately, Veteran with subthreshold PTSD[38] and Veterans with comorbid PTSD and mTBI[39] accomplish similar treatment gains as Veterans with full PTSD when treated with evidence-based PTSD treatments. However, if Veterans with subthreshold PTSD refuse PTSD treatment, it may be helpful for providers to focus initial treatment efforts on hyperarousal symptoms because Veterans with mTBI reported more of these symptoms than symptoms from other clusters. For example, the provider can first target sleep difficulties which are present in both mTBI and PTSD, and adequate sleep is imperative to healing after a brain injury[14] and decreased psychological distress.[40] Cognitive-behavior therapy for insomnia is effective with Veterans with PTSD[41] and may be more agreeable to Veterans who are worried about the stigma of PTSD treatment.

Another clinical implication is that an accurate diagnosis of subthreshold/full PTSD or mTBI is critical because providers use diagnoses as guides to determine treatment. When working with Veterans, a clinician must determine whether the hyperarousal symptoms are triggered by a brain injury or a traumatic event, which can be difficult if the same event caused both conditions. For a full PTSD diagnosis, the symptoms must be caused by a traumatic event and be accompanied by all three symptom clusters (if using the DSM-5, the patient must meet criteria for four symptom clusters). Assessing the Veteran's emotional response to the trauma and evaluating whether the other PTSD symptom clusters are present—as they relate to the traumatic event, are important to determine the correct diagnosis. In subthreshold PTSD, not all of the symptom clusters may be present, so an accurate timeline of exposure-related symptom onset may assist in diagnostic decision-making. mTBI symptoms should appear immediately after the causal event. PTSD symptoms generally appear after the Veteran returns home and is removed from the stressful environment.[11]

A possible explanation of why Veterans with mTBI may have more PTSD symptoms than Veterans without mTBI is that mTBI can damage brain centers involved in emotion regulatory processes,[19,42] making regulation of the already intense trauma-related emotions even more difficult. Future imaging research may be able to examine if emotion regulation centers are damaged in Veterans with comorbid mTBI and PTSD symptoms, and if the damage is related to greater hyperarousal symptoms.

Finally, we examined if mTBI and PTSD predicted which Veterans were diagnosed with an AUD, while controlling for age. Successful classification of male Veterans into those with and without AUDs was not improved with adding PTSD, mTBI, and age, likely due to the low base rate of AUD. Stated another way, if only 20% of Veterans are diagnosed with an AUD, the base rate would predict that any presenting Veteran would not meet criteria for an alcohol diagnosis. However for male Veterans, PTSD was a significant predictor and accounted for additional variance in the model. Thus, if a male Veteran presents with PTSD, providers should assess for alcohol misuse.

Whereas PTSD was a significant predictor of AUD in male Veterans, mTBI was not. Although this finding was unexpected, it is encouraging and consistent with previous research.[32] If AUD is related to PTSD and not mTBI, there are effective PTSD treatments that can be used to assist Veterans who are presenting with PTSD.[43] These treatments are available at many VAMCs and are effective for Veterans with and without AUD.[44] In addition, health care providers may educate Veterans about the transient nature of mTBI symptoms and available trauma treatments.

Finally, few female OEF/OIF Veterans were diagnosed with AUD. The low frequency of females with AUD is consistent with previous literature that shows fewer women are diagnosed with AUDs as compared to men.[45–47] Possibly due to the low frequency of women with AUD, neither mTBI nor PTSD were significant predictors of AUD in women. It is also possible that there are different AUD risk factors for male and female OEF/OIF Veterans. This has important research implications because there is a general lack of research on female Veterans, yet they are the fastest growing group in the Veteran population.[48] The shortage of research may be due to fewer women than men in the armed forces and because women were only officially allowed in combat roles in 2013. In reality, female Veterans have likely served in combat roles throughout OEF/OIF.[46] Future research should examine the predictors of AUD specific to female Veterans.

Until research can identify predictors of AUD for female combat Veterans, we suggest providers be mindful of conditions that female Veterans are likely to report, such as depression, other anxiety disorders, and eating disorders.[46,47] Eating disorders are rare among male Veterans and providers may not routinely assess for them. Military sexual trauma is another salient concern for female Veterans and is related to increased risk of developing PTSD.[47] Female Veterans encounter unique challenges while serving; being mindful of the challenges will likely improve health care for female Veterans.

Strengths of the Study

A major strength was the large representative sample of returning Veterans evaluated at a VAMC. Both the sample

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size and inclusion of nonhealth care-seeking Veterans increase the study's generalizability to the greater community-dwelling OEF/OIF Veteran population. Another strength is that trained trauma-specialty clinicians assessed mental health symptoms during a semistructured interview. Past studies have relied on self-report checklists that may capture nonspecific symptoms rather than symptoms directly related to mTBI or PTSD. Having clinicians from a trauma specialty clinic conduct the assessments increases the likelihood that PTSD symptoms were related to the traumatic event rather than other environmental stressors. This provides real-world utility and increases the generalizability of our findings beyond typical research samples.

Limitations of the Study

Limitations arise from using archival data and include missing information, such as time since sustaining the mTBI, number of deployments, and branch of service. mTBI symptoms usually improve within months[14]; although the majority of Veterans report having at least one continuing mTBI symptom 1 year after injury.[15] Knowing the time since the mTBI incident would provide a clearer estimate of what symptoms a Veteran might have been experiencing at the time of the evaluation. Another limitation of this study and much of mTBI research[20–22,49] was the use of retrospective reports and a screener to assess for mTBI, which are open to hindsight bias and false positives.[35] Finally, future research should examine if the results from this study generalize to the new DSM-5 PTSD diagnostic criteria.

CONCLUSION

Findings from this study can inform treatment providers by alerting them to the possibility of subthreshold PTSD in Veterans with mTBI. Providers may begin PTSD treatments or consider targeting hyperarousal symptoms early in treatment to reduce distress. In addition for male Veterans, PTSD symptoms predicted who would have an AUD, while mTBI did not. Treatment should emphasize the transient nature of mTBI symptoms, along with how psychological interventions can reduce PTSD symptoms and be of benefit to Veterans who have PTSD and mTBI. Finally, more research is needed to explore correlates of AUD in female Veterans.

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