

# Traumatic Brain Injury and Post-Deployment Binge Drinking among Male and Female Army Active Duty Service Members Returning from Operation Enduring Freedom/Operation Iraqi Freedom

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## Abstract

This study examines whether the relationship between traumatic brain injury (TBI) and post-deployment binge drinking is independent of screening positive for mental health problems among male and female service members. Data are from the Substance Use and Psychological Injury Combat Study of Army members returning from deployment to Afghanistan or Iraq in fiscal years 2008–2011. The sample consists of 240,694 male and 26,406 female active duty members who completed initial and follow-up questionnaires. The initial questionnaire, completed at the end of deployment, included screens for TBI and mental health problems (post-traumatic stress disorder, depression, harmful thoughts). The dependent variable, frequent binge drinking (six or more drinks on one occasion, at least monthly), was assessed on the follow-up questionnaire on average 3–9 months post-deployment. More than 21% of males and 7% of females reported frequent binge drinking. Male members were more likely to screen positive for TBI, compared with females (7.5% vs. 4.4%). Females with both TBI and mental health positive screens had more than double the risk of frequent binge drinking, compared with those without either problem (15.8% vs. 6.6%), and males with both problems had almost double the risk, compared with males with neither problem (33.6% vs. 19.7%). In multivariable logistic regression models, having a TBI and a comorbid positive mental health screen was associated with increased odds of frequent binge drinking among both males and females (adjusted odds ratio [AOR]=1.59, CI: 1.50-1.69, and AOR=2.11, CI: 1.57-2.83, respectively), compared with those with neither condition. More research is needed on the interaction of gender and binge drinking, especially when TBI and mental health problems co-exist.

**Keywords:** binge drinking; gender; post-deployment; traumatic brain injury

## Introduction

**B**INGE DRINKING, frequently defined as consuming five or more (5+) drinks on one occasion for males, and four or more (4+) drinks for females, has been common historically among military service members.<sup>1–4</sup> With more than a decade of deployments supporting Operation Enduring Freedom in Afghanistan and Operation Iraqi Freedom (OEF/OIF), studies have found that those who have been on a combat deployment or have experienced combat are at increased risk for binge drinking and problem alcohol use.<sup>5–7</sup> A study of more than 300,000 Army active duty members returning from OEF/OIF deployments in fiscal years (FYs) 2008–2011 found that 38% reported binge drinking, using a higher and non-gender specific definition of six or more (6+) drinks on one occasion for males and females, when completing a U.S. Department of Defense (DoD)

questionnaire at the end of their deployment.<sup>7</sup> Prevalence of binge drinking is higher when assessed on DoD anonymous surveys, with 54% of active duty members returning from a combat deployment in 2007–2008 reporting binge drinking.<sup>8</sup> Binge drinking is associated with negative drinking-related consequences among military members, including drinking-related injuries and job-performance problems.<sup>9–12</sup> Female members represent approximately 10% of OEF/OIF deployments.<sup>13</sup> DoD population-based surveys show that females binge drink less frequently than males, yet these studies have not analyzed differences in binge drinking by gender with a post-deployment cohort.<sup>3,14</sup>

Understanding deployment-related risk factors for post-deployment binge drinking is important for targeted prevention strategies. Studies suggest that experiencing a traumatic brain injury (TBI) while deployed increases the risk for post-deployment

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frequent (at least monthly) binge drinking,<sup>8,15</sup> alcohol misuse,<sup>16</sup> and negative drinking-related consequences.<sup>9</sup> It is well-established that a TBI of sufficient force will damage the frontal lobes, ventral medial prefrontal cortex, and orbital frontal cortex regardless of the location of head impact.<sup>17</sup> Neural networks connecting these areas of the prefrontal cortex to the basal ganglia and midbrain constitute the so-called “reward circuit,” which is implicated in substance abuse.<sup>18,19</sup> In particular, damage to the orbital frontal cortex has been associated with reduced ability to inhibit impulsive behavior,<sup>20</sup> which may be a factor when self-regulating drinking levels. Further, there may be an interaction between neuroinflammation caused by a TBI and increased post-injury drinking.<sup>21</sup>

Both psychosocial and biological differences by gender have been observed after TBI, including differences in executive function.<sup>22–26</sup> Even though females have been excluded from direct ground combat until recent DoD policy changes,<sup>27</sup> they have not been shielded from combat exposures while deployed.<sup>28,29</sup> We do not know what portion of Army females experienced a TBI during an OEF/OIF deployment and whether TBI is a risk factor for post-deployment binge drinking among females.

Further complicating the relationship between TBI and post-deployment binge drinking are common comorbidities, including post-traumatic stress disorder (PTSD), depression, and harmful thoughts.<sup>8,30–35</sup> In particular, TBI and PTSD are commonly comorbid within this population,<sup>32,35–37</sup> and PTSD is a known risk factor for unhealthy drinking.<sup>33,38,39</sup> One study of active duty members examined whether experiencing a TBI on a deployment ending in 2007–2008 was associated with post-deployment binge drinking, independent of PTSD, and found that both TBI and PTSD had direct effects on binge drinking.<sup>8</sup> Yet almost 70% of the total effect of TBI on binge drinking was from the direct effect, with only 30% represented through the indirect effect through PTSD. It is unknown if these relationships were impacted by gender.

The purpose of this study was to first establish the prevalence of TBI positive screens and post-deployment binge drinking among Army female service members, compared with male members, returning from OEF/OIF deployments in FYs 2008–2011. Second, we examined if the relationship between TBI and post-deployment binge drinking differed between male and female members. Third, we investigated if the relationship between TBI and post-deployment binge drinking was independent of screening positive for mental health problems, by gender. Research that informs our understanding of risk factors for post-deployment binge drinking by gender will provide the DoD with gender-specific information to improve prevention efforts and responsiveness to unhealthy post-deployment drinking.

## Methods

### *Study design and data sources*

This study used data from the Substance Use and Psychological Injury Combat Study, a longitudinal, observational study of post-deployment substance use and mental health problems and outcomes. Rationale, methods, and a description of the main cohort are described elsewhere.<sup>13</sup> We analyze data from a subsample of Army active duty members who completed both an initial and follow-up questionnaire as part of the DoD’s post-deployment health surveillance program.<sup>40</sup> Initial questionnaires, known as the Post-Deployment Health Assessment (PDHA; Form DD 2796), were completed within 60 days before or after the return from deployment, and follow-up questionnaires, referred to as the Post-Deployment Health Re-Assessment (Form DD 2900), were completed on average within 3–9 months post-deployment.<sup>41</sup> Questionnaires include a section where a clinical provider reviews

items, asks additional questions, and can refer members for care. Members’ self-reported post-deployment behavioral health problems and deployment exposures, including TBI, were drawn from the initial questionnaire, and the dependent variable, frequent binge drinking, was assessed on the follow-up questionnaire. This study used the updated 2008 versions of the questionnaires. Additional data sources included deployment information from the Contingency Tracking System, DoD occupation specialty from the Defense Manpower Data Center, and demographic and military characteristics from the Defense Enrollment Eligibility Reporting System.<sup>13</sup>

From the main cohort of Army active duty members with an index (first) deployment ending in FY 2008–2011 ( $N=434,986$ ), we selected a subsample who had an initial questionnaire matched to a deployment ( $n=333,803$ ) using an algorithm described elsewhere.<sup>13</sup> From this sample, we selected members who completed the follow-up questionnaire, resulting in analysis samples of 240,694 males and 26,406 females. We included follow-up questionnaires that were completed within 30–300 days of the end date of deployment: more than 90% occurred within 3–9 months post-deployment (data not shown).

### *Measures*

Binge drinking was identified on the follow-up questionnaire when members were asked to report, “how often do you have 6+ drinks on one occasion.” This definition is non-gender specific and less conservative than the definition endorsed by the National Institute on Alcohol Abuse and Alcoholism, which defines binge drinking as five or more drinks for males and four or more drinks for females.<sup>42</sup> The dependent variable, frequent binge drinking, captured members who reported binge drinking at least monthly. We constructed a measure of any binge drinking, which included members with any report of binge drinking.

A TBI positive screen was based on self-reported items of at least one injury event during the index deployment (blast or explosion; vehicular accident/crash; fragment wound or bullet wound above the shoulders; fall; other event), accompanied by either an alteration or loss of consciousness (lost consciousness or got knocked out; felt dazed, confused or saw stars; didn’t remember the event). This is consistent with the American Congress of Rehabilitation Medicine’s definition.<sup>43</sup>

**Mental health problems.** We constructed the variable any mental health positive screen as an indicator of a positive screen for PTSD, depression, and/or harmful thoughts. A positive screen for PTSD was assessed with the Primary Care-PTSD (PC-PTSD), a four-item screen that measures symptoms of re-experiencing, avoidance, hyperarousal, and numbing in the past 30 days. Endorsement of three or more symptoms was considered positive.<sup>44–46</sup> The two-item Patient Health Questionnaire (PHQ-2) screened for depression by assessing how emotional problems impacted members’ functioning in the past month; a score of 3 or more was considered positive.<sup>47</sup> A positive screen for harmful thoughts was met when members reported “yes” or “unsure” to either of two items that providers directly administered: if they had been bothered by thoughts of being “better off dead or hurting yourself in some way” or “thoughts or concerns that you might hurt or lose control with someone” in the past month.

For analysis, we combined the TBI and any mental health problems variables to make four mutually exclusive and exhaustive categories: 1) neither, 2) TBI positive screen only, 3) mental health positive screen only (a positive screen to PTSD, depression and/or harmful thoughts), and 4) both TBI and mental health positive screens.

Demographic variables, measured at the beginning of the index deployment, consisted of: rank (junior enlisted, senior enlisted, officer), gender, race/ethnicity (White, Black, Asian/Pacific Islander,

American Indian/Alaskan Native, Hispanic, and other/unknown), marital status (married, divorced, other, never married), if members had child dependent(s) eligible for Military Health System benefits (a proxy for being a parent), and DoD occupational specialties (combat specialist; healthcare; functional support, services and supply; mechanical, electrical, engineering; other). Deployment events were based on self-report about the index deployment and included being wounded, injured, assaulted, or hurt; and combat exposure score (0–3; encountered dead bodies or saw people/killed wounded, engaged in direct combat/discharged a weapon, felt in great danger of being killed). We included length of index deployment (1–11, 12, > 12 months), any prior deployment to the index deployment, and fiscal year end date of the index deployment.

### Statistical analysis

Chi-square tests of independence were used to test for associations between gender and member characteristics. Multivariable logistic regression was used to model the association between TBI, mental health, and binge drinking with adjustment for demographic and deployment characteristics, and the number of months between completion of the initial and follow-up questionnaires. Regression diagnostics including multi-collinearity diagnostics were performed. We report adjusted odds ratios (AORs) and 95% confidence intervals (CIs). The *p* values were two-sided.

Analyses were stratified by gender because the distributions of demographic and deployment characteristics varied by gender in this sample, and because we hypothesized that the factors associated with binge drinking may differ by gender. Finally, the threshold used to define binge drinking on the follow-up questionnaire (6+) was not gender-specific; thus, findings for males and females may not be exactly comparable. We conducted a sensitivity analysis in the female sample using the any binge drinking measure as the dependent variable to determine whether the association between TBI and binge drinking depended on how binge drinking was defined.

All calculations were performed using SAS/Base and SAS/STAT software (version 9.2; SAS Institute Inc., Cary, NC). Brandeis University's Committee for Protection of Human Subjects and the Human Research Protection Program at the Office of the Assistant Secretary of Defense for Health Affairs/Defense Health Agency conducted the human subjects review. The Defense Health Agency's Privacy and Civil Liberties Office executed the data use agreements.

### Results

To assess for possible selection bias, we compared service members who completed the initial questionnaire to those who completed both questionnaires, by gender (Supplementary Table 1; see online supplementary material at [www.liebertpub.com](http://www.liebertpub.com)). There were no large differences among members in the analysis sample who completed both questionnaires ( $n=276,100$ ) and the larger sample of members that completed the initial questionnaire ( $n=333,803$ ) in terms of prevalence of TBI, mental health problems, demographics, or deployment characteristics (Supplementary Table 1). In the analysis sample, respondents were less likely to have an index deployment ending in FY 2011.

In the analysis sample of service members who completed both questionnaires, male and female members differed on many demographic and deployment characteristics (Supplementary Table 1). Compared with females, males were more likely to be White, married, have a child dependent eligible for Military Health System benefits, have an enlisted pay-grade, and have less than a college degree. Males were more likely to have had a deployment prior to the index deployment and higher combat exposure scores. Of note, both males and females had similar reports (almost 17%) of being wounded, injured, assaulted, or hurt. Male members were more likely to screen positive for TBI on their index deployment, compared with females (7.5% vs. 4.4%). Males had similar estimates of PTSD (5.3% vs. 5.7%) and harmful thoughts (1.5% vs. 1.8%) as females, and slightly lower estimates for depression (7.4% vs. 8.9%). The median number of days between the end date of deployment and completion of the follow-up questionnaire did not differ by gender: 129 days for males and 130 days for females (data not shown).

Males were more likely to report binge drinking than females on the follow-up questionnaire (Table 1). More than 52% of males and 26% of females reported any binge drinking, and 21.2% and 7.4%, respectively, reported frequent binge drinking (at least monthly). Figure 1 illustrates the relationship between the key independent variable of positive screens for TBI and/or mental health problems with post-deployment frequent binge drinking. Females with both TBI and mental health positive screens had more than double the risk of frequent binge drinking, compared with those without either

TABLE 1. PREVALENCE OF SELF-REPORTED BINGE DRINKING ON THE FOLLOW-UP QUESTIONNAIRE AMONG MALE AND FEMALE SERVICE MEMBERS RETURNING FROM OEF/OIF DEPLOYMENTS IN FYS 2008–2011<sup>a</sup>

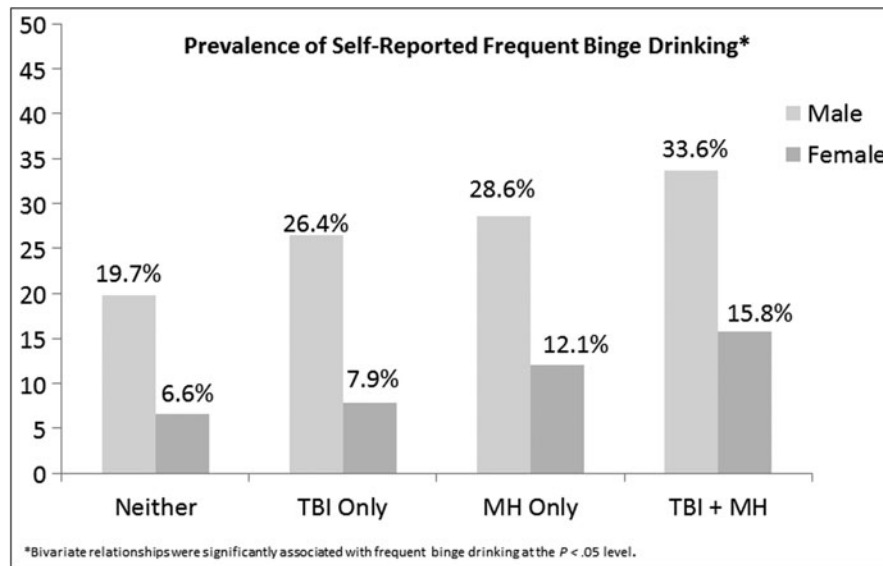
	Self-reported binge drinking total (% of total)			
	Males		Females	
	n	%	n	%
	n = 240,694		n = 26,406	
Frequency of binge drinking <sup>b,*</sup>				
Not a current drinker	38,970	16.2%	6,343	24.0%
Drink, but never 'binge'	75,759	31.5%	13,117	49.7%
Less than monthly bingeing	75,064	31.2%	4,982	18.9%
Monthly bingeing	30,420	12.6%	1,296	4.9%
Weekly bingeing	19,284	8.0%	636	2.4%
Daily bingeing	1,197	0.5%	32	0.1%
Any occasion of binge drinking*	125,965	52.3%	6,964	26.3%
Frequent binge drinking (at least monthly)*	50,901	21.2%	1,964	7.4%

<sup>a</sup>The follow-up questionnaire was completed 30–300 days after the end of the index deployment.

<sup>b</sup>Binge drinking is defined as drinking six or more drinks on an occasion.

\*Association between drinking and gender, chi-square test,  $p < 0.0001$ .

OEF/OIF, Operation Enduring Freedom in Afghanistan and Operation Iraqi Freedom; FY, fiscal year.



**FIG. 1.** Frequent binge drinking among male and female service members on the follow-up questionnaire, by traumatic brain injury (TBI) and mental health positive screens.

problem (15.8% vs. 6.6%), and males with positive screens for both TBI and a mental health problem had almost double the risk, compared with males with neither problem (33.6% vs. 19.7%).

Among all members, frequent binge drinking was more prevalent among those younger (ages 17–24), American Indian/Alaskan Native, never married, junior enlisted (E1–E4), and without a college degree (Table 2). Male and female members with a deployment longer than 12 months, or those who were wounded, injured, hurt, or assaulted were more at risk for frequent binge drinking. Males with a combat specialist occupation and females with a mechanical, electrical, or engineering occupation specialty were more likely to be frequent binge drinkers. As combat exposure score increased, the likelihood of frequent binge drinking increased in a dose–response relation for both males and females.

#### *Factors associated with frequent binge drinking among males and females*

Table 3 presents the characteristics associated with the odds of post-deployment binge drinking among males and females. In Model 1, males who reported both TBI and mental health positive screens had increased odds of frequent binge drinking, compared with those without either condition, when controlling for demographics and deployment variables (AOR = 1.59, 95% CI: 1.50–1.69). Similarly, males with a mental health problem only or with a TBI only, had increased odds of frequent binge drinking, compared with those without either condition, even though the AORs were smaller than among those with both TBI and mental health positive screens.

Model 2 revealed that among female members, having a TBI in combination with a mental health problem (AOR = 2.11; 95% CI: 1.57–2.83) or a positive mental health screen only was significantly associated with frequent binge drinking (AOR = 1.73; 95% CI: 1.53–1.97). Yet, having a TBI only did not increase the odds of frequent binge drinking for females.

Model 3 depicts a sensitivity analysis for females with any binge drinking as the dependent variable, a less conservative measure of binge drinking. Females who reported both TBI and mental health positive screens had increased odds of binge drinking, compared

with those without either condition (AOR = 1.51; 95% CI: 1.21–1.89). Similarly, females with only a mental health positive screen or with only a TBI positive screen had increased odds of binge drinking, compared with those with neither condition, even though the AORs were smaller than among those with both TBI and a mental health problem.

In all multivariable models, having a higher combat score, being a combat specialist, having a longer index deployment, and having had a prior deployment were significantly associated with increased odds of binge drinking.

#### **Discussion**

Binge drinking post-deployment can lead to reintegration problems, especially when members drink to reduce symptoms associated with psychological problems or injuries.<sup>9,11</sup> Prior to this study, prevalence estimates of binge drinking stratified by gender were largely unavailable for those returning from OEF/OIF. This study found that among Army active duty members returning from OEF/OIF deployments in FYs 2008–2011, 21.2% of males and 7.4% of females reported frequent (at least monthly) binge drinking. These estimates are much lower than the 53.7% of active duty members, males and females combined, from all service branches with a past year combat deployment who reported at least monthly binge drinking (defined as five or more drinks for males and four or more drinks for females) on an anonymous DoD survey.<sup>8</sup> It is unclear how much of this difference is attributable to the slightly different cut-offs used to define binge drinking, or due to the non-anonymous nature of the DoD's post-deployment health surveillance program.

Over 52% of males and 26% of females reported any occasion of binge drinking on the follow-up questionnaire. When combining males and females, the combined prevalence of 49.8% was higher than the 37.6% of members who reported any binge drinking on the initial questionnaire in a prior study utilizing a similar sample of Army active duty members and both studies using the six or more non-gender specific binge drinking definition.<sup>7</sup> This increase suggests that either the prevalence of binge drinking among members

TABLE 2. PREVALENCE OF MALE AND FEMALE SERVICE MEMBER SELF-REPORTED FREQUENT BINGE DRINKING ON FOLLOW-UP QUESTIONNAIRE, BY DEMOGRAPHICS AND DEPLOYMENT CHARACTERISTICS<sup>a</sup>

Characteristics <sup>b</sup>	Active duty sample (N=267,100)			
	Males n = 240,694, 90.1%		Females n = 26,406, 9.9%	
	Size of subgroup	Prevalence in subgroup	Size of subgroup	Prevalence in subgroup
<b>Dependent variable</b>				
Frequent binge drinking, <i>n</i> (%)	50,901	21.2%	1,964	7.4%
<b>Demographic</b>				
Age, <i>n</i> (%)				
17–24	112,007	26.0%	11,941	9.8%
25–29	58,444	21.2%	6,575	7.4%
30–39	56,289	14.5%	6,050	4.6%
40+	13,954	9.3%	1,840	2.0%
Race/ethnicity, <i>n</i> (%)				
White, non-Hispanic	133,484	22.2%	8,978	7.6%
Black, non-Hispanic	37,698	16.6%	9,090	6.7%
Asian/Pacific Islander	37,237	21.3%	3,965	8.1%
American Indian/Alaskan Native	2,169	24.3%	395	12.2%
Hispanic	26,877	22.3%	3,391	7.8%
Other/unknown	3,229	15.4%	587	6.6%
Marital status, <i>n</i> (%)				
Never married	89,016	25.8%	11,106	8.8%
Married	141,619	18.2%	11,831	6.6%
Divorced	9,400	21.0%	3,248	5.7%
Other	659	22.6%	221	9.5%
Any child dependent eligible for Military Health System benefits, <i>n</i> (%)				
Has child dependent(s)	109,172	17.2%	10,098	5.8%
Does not have child dependent(s)	131,522	24.4%	16,308	8.5%
Rank, pay grade, <i>n</i> (%)				
Junior enlisted (E1-E4)	135,030	24.4%	14,155	9.6%
Senior enlisted (E5-E9)	75,442	18.8%	7,599	5.9%
Officers	30,222	12.6%	4,652	3.4%
Education, <i>n</i> (%)				
Less than college degree	207,043	22.4%	20,719	8.4%
College degree	30,426	12.9%	5,394	3.6%
Occupation specialty, <i>n</i> (%)				
Combat specialist	83,891	23.7%	969	6.2%
Healthcare	13,765	16.9%	4,285	6.5%
Functional support, service, and supply	52,230	18.6%	14,130	7.5%
Mechanical, electrical, engineering	51,053	20.6%	3,803	8.5%
Other	39,076	21.5%	3,165	7.4%
<b>Deployment</b>				
Length of index deployment (months), <i>n</i> (%)				
1–11	82,432	18.8%	9,703	6.1%
12	81,040	21.6%	8,557	7.8%
>12	77,222	23.2%	8,146	8.7%
Any prior deployment to index, <i>n</i> (%)				
Has a prior deployment	111,343	19.9%	9,447	6.9%
Does not have a prior deployment	129,351	22.3%	16,959	7.7%
Combat Exposure Score, <i>n</i> (%)				
0	138,088	18.9%	18,813	7.0%
1	52,436	22.1%	5,612	8.0%
2	30,498	24.8%	1,786	9.8%
3	19,672	28.7%	195	14.4%
Wounded, injured, assaulted or hurt on most recent deployment, <i>n</i> (%)				
Was wounded, injured, assaulted, or hurt	40,233	23.3%	4,374	9.2%
Was not wounded, injured, assaulted, or hurt	200,461	20.7%	22,032	7.1%
TBI positive screen, <i>n</i> (%)				
Screened positive for TBI	18,088	28.7%	1,152	10.5%
Did not screen positive for TBI	222,606	20.5%	25,254	7.3%

<sup>a</sup>The follow-up questionnaire was completed 30–300 days after the end of the index deployment. All other variables were assessed on the initial questionnaire (completed within 60 days of the deployment end date).

<sup>b</sup>All variables shown were significantly associated with frequent binge drinking at the  $p < .05$  level with the exception of Hispanic ethnicity within the female sample.

TBI, traumatic brain injury.

TABLE 3. CHARACTERISTICS ASSOCIATED WITH THE ODDS OF POST-DEPLOYMENT BINGE DRINKING ON THE FOLLOW-UP QUESTIONNAIRE AMONG MALE AND FEMALE SERVICE MEMBERS RETURNING FROM OEF/OIF DEPLOYMENTS IN FYS 2008–2011<sup>a</sup>

Characteristics	Multivariable logistic regression model <sup>b,c</sup>					
	Model 1		Model 2		Model 3	
	Frequent binge drinking among males		Frequent binge drinking among females		Any binge drinking among females	
	AOR	CI	AOR	CI	AOR	CI
TBI and any mental health problem <sup>d</sup>						
Neither (reference group)	1.00		1.00		1.00	
TBI only	1.19***	1.14, 1.24	1.03	0.78, 1.35	1.19*	1.01, 1.40
Mental health only	1.49***	1.44, 1.53	1.73***	1.53, 1.97	1.39***	1.27, 1.51
Both	1.59***	1.50, 1.69	2.11***	1.57, 2.83	1.51***	1.21, 1.89
DoD occupation specialty						
Other occupation (reference group)	1.00		1.00		1.00	
Combat specialist	1.14***	1.11, 1.16	1.39*	1.04, 1.85	1.40***	1.20, 1.64
Functional support, services, and supply	0.91***	0.89, 0.94	0.97	0.88, 1.07	0.80***	0.76, 0.85
Length of index deployment (months)						
1–11 (reference group)	1.00		1.00		1.00	
12	1.19***	1.16, 1.22	1.28***	1.14, 1.44	1.24***	1.16, 1.33
> 12	1.21***	1.18, 1.25	1.29***	1.13, 1.47	1.21***	1.12, 1.31
Any prior deployment to index						
Does not have a prior deployment (reference group)	1.00		1.00		1.00	
Has a prior deployment	1.14***	1.11, 1.16	1.16**	1.04, 1.29	1.12***	1.05, 1.20
Wounded, injured, assaulted, or hurt on most recent deployment						
Was not wounded, injured, assaulted, or hurt (reference group)	1.00		1.00		1.00	
Was Wounded, injured, assaulted, or hurt	1.02	0.99, 1.05	1.16*	1.03, 1.31	1.05	0.97, 1.14
Combat Exposure Score						
0 (reference group)	1.00		1.00		1.00	
1	1.17***	1.14, 1.20	1.12	1.00, 1.26	1.12***	1.05, 1.21
2	1.25***	1.21, 1.29	1.29**	1.08, 1.53	1.19**	1.06, 1.33
3	1.35***	1.30, 1.40	1.65*	1.09, 2.51	1.55**	1.15, 2.08

<sup>a</sup>The follow-up questionnaire was completed 30–300 days after the end of the index deployment. All other variables were assessed on the initial questionnaire (completed within 60 days of the deployment end date).

<sup>b</sup>AOR, adjusted odds ratio; CI, 95% confidence interval.

<sup>c</sup>Models also control for the time between the two questionnaires, rank, race/ethnicity, marital status, any child dependent eligible for Military Health System benefits, and FY end date of index deployment.

<sup>d</sup>Any positive mental health is defined as a positive screen for post-traumatic stress disorder, depression, and/or harmful thoughts.

\* $p < 0.05$  level, \*\* $p < 0.01$  level, \*\*\* $p < 0.001$  level.

OEF/OIF, Operation Enduring Freedom in Afghanistan and Operation Iraqi Freedom; TBI, traumatic brain injury.

increases in the initial months post-deployment or that members are less willing to report binge drinking on the initial questionnaire.

This study is one of the first to examine the prevalence of OEF/OIF-related TBIs among females. We found that 7.5% of males and 4.4% of females had a TBI positive screen on their index deployment. These estimates, even among males, are lower than reported in studies that elicited a history of TBI from all previous deployments<sup>35,48</sup> or those that relied on smaller, non-representative samples.<sup>32,35,36,49,50</sup> In addition, some studies were conducted anonymously,<sup>15,32,35,50</sup> as opposed to the current study, which used DoD post-deployment health surveillance data that can be shared with commanders. Similar to binge drinking, reports of TBIs that occurred during a deployment may be higher when assessed further after the end date of deployment. A study of one National Guard brigade combat team in 2007 found that when members were surveyed 1 month before leaving Iraq, and again 1 year later, self-reported rates of TBI were 9.2% while still deployed and 22.0% post-deployment.<sup>36</sup> This suggests that members may be hesitant to

report TBIs near the end of a deployment, or that members may feel more comfortable reporting health concerns once back at home.<sup>36</sup> Hence, our study may underestimate of the prevalence of TBI because history of TBI was assessed around the end of deployment.

This longitudinal study uniquely examined the interaction between TBI and any positive mental health screen (PTSD, depression, or harmful thoughts) and found that male and female members who screened positive for both TBI and any mental health problem had the highest odds of binge drinking, compared with those with neither problem. The odds of post-deployment binge drinking more than doubled for females with positive TBI and mental health screens, compared with females with neither condition, and was 59% higher for males with positive TBI and mental health screens, compared with those with neither problem. This study also suggests that having experienced a TBI on an OEF/OIF deployment, with or without a comorbid mental health problem, is a risk factor for post-deployment binge drinking among both males and females. These findings are consistent with results from other studies that found

TBI had an independent association with increased post-deployment binge drinking, after controlling for mental health problems including PTSD.<sup>8,15</sup> To our knowledge, this was the first study to examine these relationships by gender.

Our findings are consistent with previous reports that almost twice as many males binge drink, compared with females.<sup>51</sup> When comparing Models 1 and 2, even though confidence intervals for males and females often overlapped, females showed a somewhat greater risk of frequent binge drinking if they had longer deployments; were exposed to more combat; were wounded, injured, assaulted, or hurt; or had either a mental health problem alone or in combination with a TBI. However, if female members experienced only a TBI, they were not significantly more likely to report frequent binge drinking. Risk factors related to gender were essentially equivalent when frequent binge drinking for males was compared with any binge drinking among females (Model 3). The greater risk for binge drinking observed in our study is likely multifactorial. Regardless the cause, alcohol screening results may require gender-specific interpretation when used to initiate preventive strategies.<sup>42</sup>

The differential prevalence of occupation specialty and combat exposure score by gender is not surprising given differences in combat roles among males and females deployed during the study window. Further studies are needed to examine how DoD occupation specialty and combat exposure are related to prevalence of TBI and post-deployment binge drinking when some females achieve assignment to direct combat occupations.<sup>27</sup>

As with most military studies,<sup>15,32</sup> the occurrence of TBI was operationalized based on retrospective self-report. The limitations of self-report as elicited by the PDHA include potential over-identification due to mistaking a stress response to the events surrounding an injury with the alteration of consciousness due to the physical effect on the brain. The PDHA elicitation procedure also risks under-identification due to a bias toward minimization of problems when the assessment is completed. Both sources of bias increase error associated with the TBI variable, which in turn attenuates observable effects. We also were unable to explore the possible connection between frontal lobe deficits associated with a TBI, or to draw conclusions about such deficits and binge drinking after a TBI. The relationship between TBI experienced during combat deployment and post-deployment alcohol misuse will require replication via other methodologies in order to characterize its full nature and extent.

Lack of anonymity may contribute to underreporting on these self-report measures, which may lead to our results being an underestimate of problems. Also, we did not know lifetime history of TBI, which may complicate recovery from the recent TBI or use of substances,<sup>52-55</sup> nor did we know history of drinking prior to the deployment.<sup>56</sup> Additionally, we excluded members who completed the older version of the initial questionnaire (before 2008) and those respondents with date fields on the deployment record and initial questionnaire that were a poor match (i.e., outside a 60-day window), which reduced inclusion of many 2008 cohort members. Yet, respondents in the analysis sample did not differ from those in the larger sample that completed the initial questionnaire on key characteristics (Supplementary Table 1).

Our findings confirm that post-deployment binge drinking is common. Results suggest that post-deployment screening and preventive interventions should incorporate risk due to combat exposure, length of deployment, injury while deployed, having incurred a TBI, or experiencing mental health concerns. However, mild TBI may not require or result in the initiation of a treatment

episode; thus, population-based prevention messages and programs to reduce binge drinking may be more effective. More research is needed on the interaction of gender with risks for binge drinking, especially when TBI and mental health issues co-exist. Further study of how TBI influences binge drinking is also needed. Does TBI increase stress and thus drive unhealthy coping strategies, or does poor impulse control affect the decision to initiate or continue drinking? A better understanding of the relationship between these conditions would help inform preventive strategies. Finally, this study once again underscores the prevalence of binge drinking among male and female military members and the need to better understand intra-personal and interpersonal drivers of the behavior, as well as cultural influences that maintain it.

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### Author Disclosure Statement

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