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Traumatic Brain Injury among US Active Duty Military Personnel and Negative Drinking-Related Consequences

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Abstract

This study used the 2008 Department of Defense Survey of Health Related Behaviors among Active Duty Military Personnel to determine whether traumatic brain injury (TBI) is associated with past year drinking-related consequences. The study sample included currently-drinking personnel who had a combat deployment in the past year and were home for 6 months ($N=3,350$). Negative binomial regression models were used to assess the incidence rate ratios of consequences, by TBI-level. Experiencing a TBI with a loss of consciousness >20 minutes was significantly associated with consequences independent of demographics, combat exposure, posttraumatic stress disorder, and binge drinking. The study's limitations are noted.

Keywords

traumatic brain injury; deployment; combat; military personnel; negative drinking-related consequences; alcohol drinking; alcohol related disorders; posttraumatic stress disorder

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Introduction

Unhealthy alcohol use has been a problem in the United States (U.S.) military for decades (Bray et al., 2010; Institute of Medicine, 2012a). Most recently with respect to the two extended conflicts in Afghanistan and Iraq, deployment and intensity of combat exposure have been associated with increased odds of problem drinking and substance use disorders (Institute of Medicine, 2012a; Jacobson et al., 2008; Larson, Wooten, Adams, & Merrick, 2012; Ong & Joseph, 2008; Shen, Arkes, & Williams, 2012; Spera, Thomas, Barlas, Szoc, & Cambridge, 2010; Wilk, Bliese, et al., 2010). A recent population-based study found that among a cohort of over 7,000 U.S. active duty military personnel returning from a combat deployment in 2007–08, one-quarter reported binge drinking (5 drinks on 1 occasion for men, 4 drinks for women) at least weekly, over the past 30 days (Adams, Larson, Corrigan, Horgan, & Williams, 2012). From 2001–2010, active duty military personnel with combat occupations were at greater risk of being involved in recurrent alcohol-consumption-related encounters compared to those with non-combat occupations (Armed Forces Health Surveillance Center, 2011).

This particularly high level of drinking has consequences. Similar to results found for civilians, binge and frequent binge drinking are posited risk factors for numerous negative drinking-related consequences among military personnel (Mattiko, Olmsted, Brown, & Bray, 2011; Santiago et al., 2010; Stahre, Brewer, Fonseca, & Naimi, 2009). Army military personnel returning from deployment to Iraq, who screened positive for alcohol misuse, had significantly greater odds of driving while under the influence (DUI), and being arrested for a DUI, compared to those who did not screen positive for alcohol misuse (Santiago, et al., 2010). Compared to non-binge drinkers, military personnel who binge drink report higher rates of being hurt in an accident related to their drinking (Stahre, et al., 2009), leading to medical consequences for military personnel, their families, and the Department of Defense (DOD). Similarly, compared to less frequent binge drinkers, male frequent binge drinkers in the military report greater productivity loss (Mattiko, et al., 2011), a military-related consequence that impedes the DOD's mission of maintaining the force readiness of its active duty forces. Moreover, there are additional, avoidable costs associated with the treatment of alcohol abuse within the rapidly growing military health care budget (Harwood, Yiduo, Dall, Olaiya, & Fagan, 2009). Both political and military leadership seek ways to inhibit healthcare cost growth as it consumes a greater proportion of defense spending (Keith, 2011).

Research that helps to identify risk factors for unhealthy alcohol use is an important public health topic with broad implications for the overall health of military personnel and the readiness of the U.S. military. While our understanding of the risks of unhealthy alcohol use after experiencing a combat-acquired traumatic brain injury (TBI) is limited (Adams, Corrigan, & Larson, 2012), recent studies suggest that experiencing a TBI is associated with post-deployment frequent binge drinking, at least weekly (Adams, Larson, et al., 2012), alcohol misuse (Maguen, Madden, Lau, & Seal, 2012; Rona et al., 2012), and higher rates of alcohol or drug use-related diagnoses (Carlson et al., 2010) among military personnel returning from Afghanistan and Iraq. These studies are similar to findings with civilians who have a TBI (Corrigan, Rust, & Lambhart, 1995; Kolakowsky-Hayner et al., 2002; Ponsford, Whelan-Goodinson, & Bahar-Fuchs, 2007).

The standard case definition of TBI is a blow or jolt to the head that results in a loss of memory, a decreased level or loss of consciousness (LOC), a skull fracture, intracranial lesion, or neurological or neuropsychological abnormality (Thurman, et al., 1995). TBIs are categorized on a spectrum of mild to moderate to severe, with the majority of TBIs among military personnel returning from Operation Enduring Freedom (OEF) in Afghanistan and/

or Operation Iraqi Freedom (OIF) being mild (Department of Defense, 2009). Consistent with the Centers for Disease Control and Prevention, the DOD and Veterans Administration (VA) adopted the American Congress of Rehabilitation Medicine's definition of mild TBI, which is defined as an injury to the head followed by an alteration of consciousness or an LOC of up to 30 minutes (Centers for Disease Control and Prevention National Center for Injury Prevention and Control, 2003; Defense and Veterans Brain Injury Center, 2010; Kay, et al., 1993). Combat-acquired TBI is often caused by a blast or explosion, resulting in an alteration of consciousness or LOC (Institute of Medicine, 2010; Shively & Perl, 2012).

Prevalence estimates for combat-acquired TBI among those returning from OEF/OIF range from 12–23% of returning personnel (Adams, Larson, et al., 2012; Carlson, et al., 2010; Hoge et al., 2008; Pietrzak, Johnson, Goldstein, Malley, & Southwick, 2009; Schneiderman, Braver, & Kang, 2008; Tanielian, Jaycox, & eds., 2008; Terrio et al., 2009; Wilk, Thomas, et al., 2010). While several recent studies suggest that experiencing a combat-acquired TBI can be a risk factor for frequent binge and other forms of unhealthy drinking, it is unclear if experiencing a TBI, in itself, is an independent risk factor for negative drinking-related consequences, separate from the higher level of drinking with which it associates.

The purpose of this study is to examine if combat deployment-acquired TBI can be an independent risk factor for negative drinking-related consequences among military personnel returning from a combat deployment. This study is significant because, to our knowledge, it is the first to use a population-based survey of all branches of the active duty component of the military to examine if combat-acquired TBI can be a risk factor for negative drinking-related consequences. Measurement of negative drinking-related consequences is based on a series of 22 items that may have occurred in the past year because of drinking alcohol. The items, categorized as 10 social, 5 medical, and 7 military-related consequences, are summed to form a count variable with a range of 0–22. Study analyses rely on multivariate regression, which take into account important demographic, combat exposure, and psychological health covariates that relate to unhealthy drinking behaviors among military personnel. Specifically, we adjust for posttraumatic stress disorder (PTSD), because PTSD has been associated with greater unhealthy drinking among military personnel (Ramchand et al., 2011), and because the presence of current PTSD symptoms after a TBI may exacerbate or prolong the occurrence of post-concussive symptoms associated with TBI (Brenner et al., 2010; Institute of Medicine, 2012b). We also make use of an ordinal measure of TBI-level in our models in order to examine whether the severity of TBI affects negative drinking-related consequences. This improves upon studies that rely solely on a dichotomous definition of TBI without assessing possible variations of outcomes based on severity of TBI (Carlson, et al., 2010; Tanielian, et al., 2008; Terrio, et al., 2009). We hypothesize that military personnel returning from a recent combat deployment with a TBI will be more vulnerable to negative drinking-related consequences, even after adjustment for demographics, combat exposure, PTSD, and drinking level.

Methods

Data Source

The 2008 Department of Defense Survey of Health Related Behaviors among Active Duty Military Personnel (HRB Survey) is an anonymous, population-based assessment of the active duty component of the U.S. military, conducted under contract for the TRICARE Management Activity (TMA) and the U.S. Coast Guard (Bray et al., 2009). The instrument includes items on drinking behaviors, negative drinking-related consequences, as well as measures of demographics, deployment history, combat exposure, psychological health issues, and TBI screening questions modeled after the Brief Traumatic Brain Injury Screen

(BTBIS) (Schwab et al., 2007), similar to those used by the DOD in its routine post-deployment health assessments (DOD Deployment Health Clinical Center, 2010).

The survey was completed anonymously by 28,546 active duty military personnel from all service branches between May and June of 2008, utilizing a dual-mode administration to capture the worldwide distribution of the U.S. armed forces. Military personnel were selected for the survey by stratifying the population into 12 strata based on gender and pay grade. A two-stage sampling process was used to select from within these 12 strata with a sample of 64 military installations forming the first stage, and individual personnel representing the second. The primary data collection method was in-person group administration at the larger sampled military installations; however, surveys were mailed to sampled personnel at smaller locations. The survey took an hour to complete and had an overall response rate of 70.6%. The respondent sample was provided weights to reflect the composition of the active military at the time of the survey. Details of the stratified multi-stage sampling design, the data collection methods, and the procedure for calculating weights have been published elsewhere (Bray, et al., 2009).

Study Design and Construction of the Analysis Sample

Drinking alcohol is prohibited in war zones, so only unauthorized, and thus very limited, drinking occurs in-theater (McDonald, 2012). For this reason, it was important in our study design to ensure respondents had sufficient time post-deployment to experience possible negative drinking-related consequences (the dependent variable in this study). The study sample, therefore, consisted of all HRB respondents, who reported being combat deployed in the past 12 months, but who had been home from deployment for at least 6 months. Because we were interested in the effect of TBI on drinking consequences, we included in our study sample only HRB respondents who reported drinking in the past year.

Figure 1 describes the selection process of the study sample. Of all HRB survey respondents, 25.1% met the criterion of a combat deployment in the past 12 months. Almost half of those personnel (44.1%) were excluded because they were home from deployment less than 6 months. Among those personnel home at least 6 months in the past year, 16.4% reported that they did not drink alcohol in the past year or do not drink. Among the final study sample ($N=3,350$), almost half (42.8%) were home 6–7 months, 34.9% were home 8–9 months, 11.8% were home 10 months, and the remaining 10.5% were home 11 months of the past year (data not shown).

Measures

Dependent variable—On the HRB Survey, respondents were asked about things that happened “while or after drinking, or because of using alcohol” in the past 12 months. The responses to 22 such questions concerning negative drinking-related consequences were summed to construct the dependent variable for our study. The 22 negative drinking-related consequences are listed in detail in Table 2, organized by domain type (10 social items, 5 medical items, and 7 military items). Social consequences included items such as DUI, being arrested for a non-driving incident, and hitting someone in a fight. Medical consequences included items such as being hospitalized or receiving detoxification treatment, and military items included consequences such as receiving Uniform Code of Military Justice (UCMJ) punishment or lower job performance-ratings.

For each of the items, respondents reported if the consequence had occurred 0, 1, 2, or 3+ times in the past 12 months. Due to the low frequency of reported values greater than one, we transformed each item into a yes/no variable (with 0 = no, and 1, 2, or 3+ = yes), and summed them together to construct a count variable of negative drinking-related

consequences with a range of 0–22. Items that were left blank were defined as zero, which occurred for only 1–2% of respondents for each of the 22 items. The weighted Cronbach alpha for the 22 items was 0.89, denoting a measure with very good reliability.

Key independent variable – TBI-level—The key independent variable is self-reported TBI-level determined by affirmative responses to two item sets on the HRB Survey: 1) an injury event, and 2) definitional symptoms of experiencing a TBI. These two item sets were taken from the Brief Traumatic Brain Injury Screen (BTBIS) (Schwab, et al., 2007), consistent with other military studies (Hoge, et al., 2008; Rona, et al., 2012; Schneiderman, et al., 2008; Tanielian, et al., 2008). Both item sets are asked in relation to the respondent's most recent deployment; TBIs that occurred on prior deployments or during non-deployment periods are not queried on the HRB survey. TBI-level is defined with self-report elicited by the HRB survey and does not represent a clinical diagnosis or an observed event. First, respondents were asked if they experienced an injury event: a blast or explosion, vehicle accident, a fragment or bullet wound above the shoulders, a fall, or other injury. Second, respondents were asked if any injury received on the last deployment resulted in: losing consciousness or getting “knocked out” for less than 1 minute; losing consciousness or getting “knocked out” for 1 to 20 minutes; losing consciousness or getting “knocked out” more than 20 minutes; feeling dazed, confused or seeing stars; not remembering the event; having a concussion; or having a head injury.

Responses to the two item sets allowed us to construct a 4-level ordinal variable to reflect the severity of TBI, guided by the Ohio State University TBI Identification Method (Corrigan & Bogner, 2007). Among respondents that reported at least one injury event and at least one definitional symptom associated with experiencing a TBI (Schwab, et al., 2007), we classified respondents into one of three categories to reflect the severity of TBI reported: 1) altered consciousness, but no actual loss of consciousness (TBI-AC), 2) loss of consciousness (LOC) of up to and including 20 minutes (TBI-LOC ≤20), or 3) loss of consciousness of more than 20 minutes (TBI-LOC>20). The reference group (no TBI) was comprised of either those with no exposure to an injury event or those with exposure but no self-reported definitional symptoms associated with TBI (i.e., AC or LOC). Self-report of concussion or head injury was not used in the definition because they require a clinical interview. When multiple definitional symptoms of experiencing a TBI were reported, the respondents were classified according to their most severe TBI with TBI-LOC>20 having precedence over TBI-LOC ≤20, which in turn had precedence over TBI-AC. Similar to other military studies (Hoge, et al., 2008; Terrio, et al., 2009), we did not require post-concussive symptoms in the past week (i.e., headaches, irritability, dizziness) to qualify for a TBI.

Because the HRB Survey TBI screening questions were modeled after the BTBIS, there was insufficient information to code LOC using the American Congress of Rehabilitation Medicine's definition of mild TBI, which is defined as up to 30 minutes (Kay, et al., 1993). Therefore, the TBI-LOC>20 group may include an unknown number of respondents who experienced a moderate or severe TBI.

Binge and other unhealthy drinking behavior—Frequent binge drinking was defined as reporting at least one binge drinking episode per week, during the past month. Binge drinking was assessed on the HRB survey by asking respondents how many days during the past 30 days they drank five or more drinks on the same occasion, or four or more for women (National Institute on Alcohol Abuse and Alcoholism [NIAAA], 2005). As an alternative representation of unhealthy drinking behavior, we constructed a variable denoting possible alcohol dependence. Using the Alcohol Use Disorders Identification Test (AUDIT) instrument, we identified respondents as at risk for possible alcohol dependence,

indicating a need for further evaluation, if they had a score of 20 or greater (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001).

Comorbidity—Current posttraumatic stress disorder was assessed using the PTSD Checklist-Civilian (PCL-C). Based on the diagnostic definition of PTSD, the PCL-C assesses the presence of 17 symptoms over the previous 30 days, which trace to trauma events during military or non-military experiences. The standard diagnostic cutoff score of 50 or greater was used to classify a positive screen for current PTSD (Bliese et al., 2008; Weathers, Litz, Herman, Huska, & Keane, 1993). We assessed past year depression with the Version A Burnam depression screen, which included one item from the Center for Epidemiologic Studies (Depression Scale) and two items from the Diagnostic Interview Schedule (Bray, et al., 2009; Burnam, Wells, Leake, & Landsverk, 1988; Rost, Burnam, & Smith, 1993). A positive screen for past year depression is indicated, if the respondent reported symptoms for over two weeks in the past year, or reported two or more lifetime years of feeling depressed ‘much of the time’ and reported feeling depressed at least one day in the past week. Past year suicidal ideation was defined if a respondent reported serious consideration of suicide in the past year.

Lifetime combat exposure—Lifetime combat exposure was assessed with 17 questions about different combat experiences including, but not limited to, witnessing or handling dead bodies, witnessing members of a unit being killed, firing a weapon upon the enemy or engaging in combat, caring for injured or dying people, or being injured in combat. Respondents reported the number of times they experienced each of the 17 items encompassing all previous deployments. We classified respondents based on their summary score value as none (0), moderate (1–9), and high (10+) lifetime combat exposure levels (Bray, et al., 2009; Brown et al., 2007). Respondents also reported the number of combat deployments, including peacekeeping missions, which they were on since September 11, 2001, which was defined as 1, 2, or 3 or more.

Covariates—Demographic variables considered in the analysis were sex, age category (17–20, 21–25, 26–34, and 35 and older), service branch (Army, Navy, Marine Corps, Air Force, and Coast Guard), race/ethnicity (White/non-Hispanic, Black/non-Hispanic, Hispanic, Other), marital status (single, married/living as married, and divorced/separated), education level (high school or less, some college, and college graduate), and pay grade (enlisted/E1–E6, enlisted/E7–E9, warrant officer/W1–W5, officer/O1–O10).

Analysis

All analyses were based on weighted data to account for the complex sampling design and controlled for the distribution across the strata of the HRB Survey. Table 1 shows sample characteristics along with tests (weight adjusted) assessing differences in the mean number of negative drinking-related consequences in each group (e.g., among the different service branches, between men and women, among pay grade classifications). In Table 2, we used design-based *F* tests to examine significant bivariate relationships between TBI-level and mean number of negative drinking-related consequences. Similarly, we conducted design-based *F* tests to assess if there were significant bivariate relationships between TBI-level and 1) the reporting of any social, medical, or military consequences, and 2) the mean number of social, medical, or military consequences.

In Table 3 we present findings from a series of negative binomial regression models which estimate incidence rate ratios (IRR) of negative drinking-related consequences associated with TBI-level (Hilbe, 2011; Statistical Consulting Group, 2012). An estimated IRR allows us to measure the effect of each of our TBI classifications on number of negative drinking-

related consequences, controlling for other variables in the models. We used negative binomial regression because the dependent variable is a count variable with a sizable number of zero responses. In all multivariate models, we adjusted for the number of months home in the past year to ensure that the variation in time home (6–11 months) did not impact our estimate of the effect of TBI. We chose to isolate the TBI-LOC>20 group for this study, differing from previous analyses with this study population (Adams, Larson, et al., 2012), because sensitivity analyses on the multivariate models allowed us to determine that those with a TBI-LOC>20 were primarily responsible for the observed differences. Because several military studies report TBI severity with only two levels of severity (AC and TBI with any LOC) (Hoge, et al., 2008; Terrio, et al., 2009), we conducted a post hoc sensitivity analysis on the multivariate models to determine whether the results changed by merging the two TBI-LOC response categories together.

In Model 1, we examine the IRRs of our TBI classifications on negative drinking-related consequences, when they are the only variables in the regression. In Model 2, we added demographic and lifetime combat exposure factors to the model to determine if their inclusion impacted the prior estimates of our TBI variables. Due to its multicollinearity with pay grade, we excluded age and education level from these models. Also, the number of combat deployments since 9/11/01 was excluded because there were no significant differences between sub-groups. In Model 3, we included important measures for comorbidity to the model. Model 3A added PTSD, and Model 3B added depression and suicidal ideation. Due to their high multicollinearity, PTSD and depression were not included in the same model. Finally, in Model 4, we included frequent binge drinking to the model. This inclusion adjusts for the effect of unhealthy drinking behavior on negative drinking-related consequences and in so doing, determines whether TBI exerts an independent impact. The sample sizes for specific multivariate models varied due to non-response to some of the covariates.

All analyses were conducted in STATA 12 using its set of survey (svy) commands to account for weighted data and stratification (StataCorp, 2011).

The HRB Survey was conducted with approval by the DOD/TMA and RTI International Institutional Review Boards. In order to ensure protection of human subjects, this secondary data analysis study was conducted with approval from 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/TMA (OASD/TMA) at the DOD. The TMA Privacy and Civil Liberties Office executed a Data Sharing Agreement for our use of the 2008 HRB survey public use file to ensure compliance with DOD privacy and security regulations.

Results

Sample Characteristics

Table 1 shows the distributions of characteristics of the study population, as well as the mean and confidence intervals for the number of negative drinking-related consequences by characteristics of the full active duty population. The overall sample is comprised of mostly males. The modal race/ethnicity was White/non-Hispanic, the modal marital status was married, the modal educational status was some college or a college degree, and the average age was 29 years old (data not shown). The majority of the sample was enlisted personnel. Most had at least two deployments since 9/11/01, with moderate or heavy lifetime combat exposure. With minor exception, sample personnel were from the Navy, Air Force, or Army. One-fifth of the overall sample reported past year depression, 11.4% had a positive PTSD screen in the past month, and 5.3% reported suicidal ideation in the past year. Over half

reported (56.1%) binge drinking in the past month (data not shown), one-fourth reported frequent binge drinking in the past month, and 5.7% screened positive for possible alcohol dependence.

Overall, 9.7% of the study population reported experiencing a TBI after an injury exposure during their most recent deployment. The most common type of TBI was TBI-AC 5.4%), followed by TBI-LOC ≤ 20 (3.0%), and TBI-LOC >20 (1.3%). Among those with TBI, the majority qualified for a mild-TBI with only an AC or an LOC of under 30 minutes (86.5%). Those in the TBI-LOC >20 group ($N=34$) may include an unknown number with moderate or severe TBI if the LOC was longer than 30 minutes, which cannot be determined due to HRB survey response categories. Among those with TBI, almost three-fourths (73.4%) reported experiencing an injury event that included a blast or explosion, with 88.0% of these individuals reporting both a blast/explosion and other injury event etiology, and the remaining 12.0% reporting only a blast/explosion (data not shown). The remaining military personnel (26.6%) with a TBI reported only a non-blast/explosion injury event (i.e., from a fall or accident that occurred while on a combat deployment). Compared to the larger group of 7,169 who were on a combat deployment in the past 12 months, the study sample of 3,350 had a smaller representation from the Army (27.0% versus 37.3%), a lower percentage of those with high lifetime combat exposure (29.1% versus 40.0%), and a lower proportion of those reporting a TBI on their most recent deployment (9.7% versus 13.8%) (data not shown). Again, in order to focus on characteristics associated with negative drinking-related consequences, our study sample was restricted to respondents who were current drinkers and had at least 6 months home post-deployment.

Bivariate Associations of Characteristics and Negative Drinking-Related Consequences

Over three-fourths (77.7%) of the sample reported zero negative drinking-related consequences in the past year. Of the remaining, 8.6% reported one consequence, 6.4% reported two consequences, and 7.25% reported three or more consequences (data not shown). Each consequence may actually reflect one or more occurrences of the named situation during the past year. Among the study sample personnel, the average number of negative drinking-related consequences was 0.78. In terms of demographics, negative drinking-related consequences were significantly higher among males, those in younger age groups, single personnel, and those with less education. In addition, Hispanic personnel reported significantly higher negative drinking-related consequences compared to White personnel. In terms of military characteristics, Army soldiers reported significantly greater negative drinking-related consequences compared to those in the Navy and Air Force, and those with high lifetime combat exposure reported significantly greater drinking-related consequences compared to those with none or moderate exposure. Similarly, enlisted personnel at the lowest pay grade (E1–E6) reported significantly higher consequences compared to those at higher pay grades. In terms of comorbidities, negative drinking-related consequences were greater among those with a positive screen for current PTSD, those reporting past year depression, and those reporting suicidal ideation in the past year. As expected, frequent binge drinking and screening positive for possible alcohol dependence were associated with greater negative drinking-related consequences.

Bivariate Results Concerning the Association between TBI-Level and Negative Drinking-Related Consequences

Table 2 shows a consistent dose-response relationship between TBI-level and each of the 22 reported negative drinking-related consequences, as well as between TBI-level and consequence type (social, medical, or military). Those with TBI-LOC >20 reported the highest rates for each consequence, followed by TBI-LOC ≤ 20 , and TBI-AC, with those without a TBI consistently reporting the lowest. For instance, 45.5% of those with TBI-

LOC>20 reported any military consequences, compared to only 1.5% of those without a TBI. Similarly, 40.8% of those with TBI-LOC>20 reported any medical consequences, compared to only 2.5% of those without a TBI.

Among the individual social, medical, and military consequences, the two most common were DUI and riding in a car when the driver was under the influence. Compared to those without a TBI, those with TBI-LOC>20 reported a significantly higher proportion of both of these consequence types, with 39.8% reporting a DUI in the past year, compared to 11.5% of those without a TBI. Similarly, 41.5% reported riding in a car when the driver was under the influence in the past year, compared to 11.0% of those without a TBI.

Medical and military-related consequences were less common overall; however, TBI-level was significantly associated with these rates. While only 1.4% of those without a TBI reported being hurt in an accident because of their drinking, 32.2% of those with a TBI-LOC>20 reported this medical consequence. Similarly, while 1.9% of those without a TBI reported trouble with the police related to their drinking, 27.4% of those with a TBI-LOC>20 reported this negative consequence.

Multivariate Results Concerning the Relationship between TBI-Level and Negative Drinking-Related Consequences

Table 3 presents a series of negative binomial regressions, which examine the relationship between TBI-level and negative drinking-related consequences, as additional covariates are included in the models. To help with interpretation, estimated effects are expressed as incidence rate ratios (IRRs), which indicate the ratio by which the number of consequences changes for personnel with the covariate characteristic, compared to those without. In all models, military personnel with a TBI-LOC>20 reported a significantly increased ratio of negative drinking-related consequences compared to those without a TBI, even as increased sets of covariates are included in the model.

Further examination of the results showed that in Model 1, which included only TBI indicators, each higher level of TBI was significantly associated with a higher number of negative drinking-related consequences in the past 12 months. However, Model 2 showed that when demographic characteristics and lifetime combat exposure are added, only the IRR estimate for TBI-LOC>20 remained significant. Model 2 does identify other characteristics that significantly relate with drinking-related consequences. Being in a lower enlistment category and reporting high lifetime combat exposure are each associated with increased IRRs, while being married and being in the Air Force are each associated with fewer negative consequences. While the estimated magnitude of these associations vary somewhat, these characteristics remain significant in most subsequent models.

In Models 3A and 3B, we found that positive screens for comorbidities such as PTSD or depression were significantly associated with a higher rate of negative drinking-related consequences, as was suicidal ideation, yet the IRR estimates for TBI-LOC>20 remained significant. In Models 4A and 4B, we found that as expected, frequent binge drinking was associated with a higher number of negative drinking-related consequences. Of perhaps greater interest, however, the two models showed that even when controlling for frequent binge drinking, both TBI-LOC>20 and the included comorbidity (PTSD in Model 4A and depression in Model 4B) remained significant. Only suicidal ideation in Model 4B lost significance, when the indicator for frequent binge drinking was added.

When we conducted sensitivity analyses by combining the two TBI-LOC categories, the coefficients for TBI-LOC remained significant in all models and had lower IRR estimates than the TBI-LOC>20 in the main study models. In Models 4A and 4B, when controlling for

frequent binge drinking, the IRRs for TBI-LOC remained significant at the $P .05$ level: (Model 4A, IRR, 1.75; 95% CI, 1.01–3.03) and (Model 4B, IRR, 2.12; 95% CI, 1.17–3.84) (data not shown).

Discussion

This study suggests that there may be an association between experiencing a TBI with a loss of consciousness of greater than 20 minutes (TBI-LOC>20) and negative drinking-related consequences. Military personnel returning from a recent combat deployment, who experienced a TBI-LOC>20, were estimated to have 4.10 times as many negative drinking-related consequences as those without a TBI, even after controlling for demographics, lifetime combat exposure, and PTSD. Importantly, this estimate remained essentially the same, when additionally controlling for frequent binge drinking (see Model 4A in Table 3). This suggests that the higher rate of negative drinking-related consequences among those with TBI-LOC>20 was not explained by frequent binge drinking. Of note, experiencing a TBI with an altered consciousness only or with an LOC of up to 20 minutes, which represented the majority of the TBI cases in this sample, was not associated with increased negative drinking-related consequences. Given the small sample of individuals with longer LOC, additional research is needed to replicate these study findings, to examine the relationship of length of LOC and negative drinking-related consequences.

Almost 10% of the study sample reported a combat-acquired TBI on the deployment that ended within the previous year. While this proportion is slightly lower than estimates from other studies (Hoge, et al., 2008; Terrio, et al., 2009; Wilk, Thomas, et al., 2010), many of the prior studies sampled Army members only, while the present study includes all branches. In general, Army soldiers report higher rates of combat-acquired TBI than military personnel in other branches (Adams, Larson, et al., 2012; Spera, et al., 2010). Among Army soldiers in this study, 22% reported experiencing a TBI on their most recent deployment (data not shown), which is much closer to the proportion of other, Army-only studies.

The immediate post-deployment period is a high-risk time as military personnel struggle to reintegrate with their families, and into civilian communities and social networks. Some must cope with combat trauma and diminished psychological health, or heal and adapt to physical health issues. Each of the 22 negative drinking-related consequences examined in this study is problematic for the well-being of military personnel during the reintegration phase, and may present complications for the DOD as it strives to maintain a combat-ready force for future missions. These consequences pose risks of personal harm to self, harm to others, and/or complications that interfere with force readiness (Mattiko, et al., 2011; Stahre, et al., 2009). Unless there are changes in the drinking patterns of the armed forces, and interventions to assist returning personnel with injuries, more social, medical, and military consequences should be expected. Thus, identifying risk factors for these negative drinking-related consequences is important in order for the DOD to design prevention and intervention programs. This study of military personnel who returned from deployment in the past year found that experiencing a TBI with an LOC of greater than 20 minutes was associated with increased likelihood of 22 negative drinking-related consequences, suggesting that selective preventive interventions for those with a combat-acquired TBI with a LOC should be designed, implemented, and evaluated.

We can only speculate on the mechanism by which TBI may increase the risk of negative drinking consequences. One possibility is that there is a continuum of disrupted self-regulation (e.g., the extent to which one is not willing to sacrifice immediate reward despite the prospect of later consequence) and that the number of consequences experienced is associated with the extent to which a person persists in a risky behavior. Binge drinking

itself is associated with negative consequences but presumably the scope and frequency of such consequences is increased even further among personnel with TBI. This is presumably due to greater loss of self-regulation. Indeed, the dose-response relationship between severity of TBI and number of consequences found in this study supports the postulation that perhaps a single continuum of disrupted self-regulation derives from binge drinking and TBI severity together.

A second possibility is that there are different thresholds of impaired self-regulation that result in qualitatively different risky behaviors. In the absence of the specific consequences like those investigated in the current study, binge drinking may only be a trade-off between immediate stress relief and later, non-specific health consequences. Many would find this trade-off reasonable during a period of high post-deployment related stress; and may be more easily justified when there is a residual effect of a mild TBI. But once problems are experienced as a result of the drinking, persisting in the behavior may represent a qualitatively different problem of self-regulation in which the immediate reward is still sought despite specific, recent consequences. As in substance use disorders, greater attraction to positive rewards and/or less sensitivity to negative consequences may drive the persistence of the drinking behavior (Bechara et al., 2001; Bechara, Dolan, & Hindes, 2002). Vulnerability to this pattern of impaired self-regulation may require more severe recent deployment-related TBI to potentiate. The persistence of the effect for TBI when frequency of binge drinking was accounted for may lend some support to the hypothesis that there are qualitatively different problems of self-regulation for bingeing versus experiencing multiple consequences.

Lastly, some experts speculate that experiencing a TBI may lead to a reduced tolerance for processing alcohol, making individuals with TBI more susceptible to negative drinking-related consequences even at the same level of consumption (The Management of Concussion/mTBI Working Group, 2009).

Limitations

This study design permits us to examine the relationship of a combat-acquired TBI and negative consequences of drinking. However, we cannot make strong causal inferences from our findings because they derive from cross-sectional data. Similar to many other studies of combat-acquired TBI, this study must also rely on self-reported and thus 'probable TBI' rather than a clinical confirmed diagnosis. The limitations of self-reported TBI have been discussed elsewhere (Corrigan & Bogner, 2007; Ferguson, Pickelsimer, Corrigan, Bogner, & Wald, 2012; Vanderploeg, Groer, & Belanger, 2012) but this method remains the norm for identifying TBI in many highly regarded studies. Also, because survey items were limited to experiences of the last deployment, we do not know our respondents' full lifetime history of TBI, which may have taken place either in previous deployment or in non-combat situations (Corrigan, Bogner, & Holloman, 2012). The presence of prior TBIs, particularly in childhood may increase the complications experienced from the last TBI (McKinlay, Grace, Horwood, Fergusson, & MacFarlane, 2009). We do not know what proportion of respondents suffered multiple TBIs during the past year deployment; the possibility of not having healed from a TBI and experiencing a new one may also increase the risk of consequences from even a mild TBI (McCrory et al., 2009). In the absence of specific demand characteristics (e.g., secondary gain or avoidance of consequences), the accuracy of self-reported TBI, as elicited in the HRB Survey, is enhanced by the relative recency of events (i.e., the past year's deployment) and that TBI-level based on severity of LOC was used rather than number of TBIs experienced or symptoms attributed (Bogner & Corrigan, 2009; Corrigan & Bogner, 2007; Hoge, et al., 2008). The accuracy of the self-report will be diminished by the survey being self-administered and not via structured interview in which the respondent's recall could be enhanced through systematic probes (Corrigan & Bogner,

2007; Vanderploeg, et al., 2012). We did not measure additional potential confounders related to risk-taking propensity, resources, and environment.

It is also possible that data inaccuracy may arise due to affected respondents' self-report of negative consequences of drinking behavior. Despite the survey being anonymous, distrust, and social desirability may have encouraged under-reporting by some respondents. On the other hand, over-reporting is plausible in a culture where excessive drinking is promoted or admired. It is also likely that specific negative consequences (i.e., receiving detoxification treatment) have greater social and financial costs associated with them for both military personnel and the MHS compared to others (i.e., receiving a lower job performance rating). These considerations were not taken into account with these analyses. Further study of concurrent and predictive validity for self-reported negative drinking-related consequences may allow greater understanding of the limitations of this variable when employed in future studies.

As discussed previously, one response category on the instrument was an "LOC of 20 minutes or greater," and it did not allow us to isolate moderate or severe TBIs from mild TBIs, routinely defined as up to 30 minutes (Kay, et al., 1993). The 34 respondents in the TBI-LOC>20 group are heterogeneous. We think it is likely, however, that some of this heterogeneity is limited by the study design; personnel with more severe TBI and other injuries who returned from deployment in the past year, possibly by medical evacuation, may have been in rehabilitation because of their wounds and less likely to be eligible for the HRB survey at the time it was administered.

The HRB may represent a biased sample of personnel returning from deployment, depending on the number of personnel who have separated from the armed services after a deployment for reasons that may be associated with either drinking (e.g., administrative discharge) or injury (e.g., very severe injury). We do not know of any estimates of the number of personnel separating annually for these reasons after deployment.

While we controlled for frequent binge drinking in our multivariate analyses, the instrument did not ask detailed questions about drinking behaviors prior to deployment, therefore we could not ascertain if drinking patterns had changed for certain personnel. These limitations, as well as those described above related to TBI, contribute to measurement error in our models.

Implications and Conclusions

A loss of consciousness of greater than 20 minutes in combat is a significant medical event and suggests that the personnel in the TBI-LOC>20 group were likely to have required immediate medical attention after their injury. This early medical attention could serve as an access point for follow-up care. The initial injury is a potential opportunity for risk reduction education; messages about avoiding excessive alcohol use could be delivered immediately and at subsequent medical visits for persons who experienced a TBI.

In June 2010, the DOD issued a Directive-Type Memorandum (09-033) "Policy Guidance for Management of Concussion/Mild TBI in the Deployed Setting" to improve the identification and clinical treatment of TBI in theater mandating that all personnel who were exposed to a blast or vehicle accident have 24 hours of downtime and receive medical clearance before returning to duty (Deployment Health Clinical Center, 2011). This policy reflected a significant shift to incident-based screening for anyone involved in a potentially concussive event, removing the burden to seek help from military personnel themselves (Helmick, Baugh, Lattimore, & Goldman, 2012). In September, 2012, Directive-Type Memorandum 09-033 was replaced by DoD Instruction (6490.11), which established

policies, procedures, and responsibilities for management of mild TBI in deployed settings (Department of Defense, 2012). These initiatives provide an initial opportunity for a targeted prevention effort. Specifically, those personnel who experienced a TBI with longer than a momentary LOC, or those with a history of alcohol use-related problems, should be identified as a potential risk group who may be particularly vulnerable to high-risk drinking with greater negative consequences. Increased alcohol screening, medical counseling and advice, and brief treatment, as well as other non-medical support could be targeted to this potentially high-risk group as part of the re-integration interventions provided during the most risky post-deployment months.

To our knowledge, this study is the first to use a population-based assessment of the active duty component of the armed forces to examine the relationship between combat-acquired TBI and negative drinking-related consequences in those returning from a combat deployment in the past year. This study is strengthened by the HRB Survey's complex survey design and is comprehensive because of its inclusion of active duty military personnel from all branches. Results suggest that military personnel with a combat-acquired TBI, particularly those with a LOC of greater than 20 minutes, may be at greater risk for a wide array of negative social, medical and military-related consequences of drinking. While greater unhealthy drinking episodes do not explain these differences, dangerous drinking is inherently related to these drinking-related consequences. Thus, the DOD may help to prevent a vast array of negative consequences of drinking by implementing evidence-based screening and brief interventions for unhealthy drinking to those personnel who experienced a TBI.

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Glossary

Military Health System (MHS) or TRICARE	the health care organized and paid for by the Department of Defense (DOD) for military personnel, their dependents, and other beneficiaries entitled to DOD health care
Traumatic Brain Injury (TBI)	According to the standard case definition from the Centers for Disease Control and Prevention (CDC), a TBI is a blow or jolt to the head that results in a decreased level or loss of consciousness (LOC), a loss of memory, an intracranial lesion, a skull fracture, or a neurological or neuropsychological abnormality (Thurman, Sniezek, Johnson, Greenspan, & Smith, 1995). Mild TBIs are defined by the CDC, DOD, and Veterans Administration (VA) as one with an altered consciousness or LOC of up to 30 minutes (Centers for Disease Control and Prevention National Center for Injury Prevention and Control, 2003 Defense and Veterans Brain Injury Center, 2010 Kay et al, 1993). As described in detail in the Methods section, this study defines TBI as experiencing both an injury event (i.e., blast or explosion) and reporting either an alteration in consciousness (AC) or an LOC. We do not limit TBIs in this study to only those with mild TBI

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Selection of Study Sample

Figure 1.
Selection of the study sample.

Table 1

Characteristics of Active Duty Military Personnel who Reported Drinking Alcohol, Returning from a Past Year Combat Deployment, by Average Number of Negative Drinking-Related Consequences (0–22), (N=3,350) ^{I,II}

	Study Sample Unweighted Ns	Percentages Weighted	Mean Number of Negative Drinking-Related Consequences (0–22), 95% CI
	3,350	100%	0.78 (0.57 – 1.00)
Sex			
Male	2,697	87.8%	0.82 (0.59 – 1.05) ^a
Female (a)	653	12.2%	0.53 (0.35 – 0.72)
Age			
17 – 20	132	6.0%	1.43 (0.66 – 2.21) ^{b,c}
21 – 25 (a)	1,070	35.7%	1.18 (0.88 – 1.47) ^{b,c}
26 – 34 (b)	1,213	34.5%	0.65 (0.43 – 0.86) ^c
35 or older (c)	935	23.8%	0.23 (0.15 – 0.32)
Service Branch			
Army	497	27.0%	1.33 (0.79 – 1.87) ^{a,c}
Navy (a)	1,052	32.2%	0.71 (0.47 – 0.95) ^c
Marine Corps (b)	510	9.4%	0.95 (0.59 – 1.30) ^c
Air Force (c)	1,165	30.6%	0.32 (0.23 – 0.41) ^d
Coast Guard (d)	126	0.8%	1.06 (0.54 – 1.59)
Race/Ethnicity			
White, non-Hispanic	2,133	66.7%	0.66 (0.48 – 0.84) ^b
Black, non-Hispanic (a)	482	15.0%	0.99 (0.51 – 1.47)
Hispanic (b)	442	9.8%	1.26 (0.69 – 1.82)
Other, non-Hispanic (c)	293	8.4%	0.84 (0.43 – 1.26)
Marital Status ^{III}			
Married/living as married	2,148	63.9%	0.62 (0.42 – 0.82) ^b
Divorced/separated (a)	343	9.0%	0.88 (0.37 – 1.38)
Single (b)	840	27.2%	1.07 (0.71 – 1.43)
Education			
High School or Less	887	29.7%	1.27 (0.65 – 1.89) ^b
Some College (a)	1,631	48.1%	0.67 (0.53 – 0.82) ^b
College Graduate (b)	832	22.2%	0.38 (0.24 – 0.51)
Pay Grade			
E1–E6	2,248	71.8%	0.94 (0.67 – 1.21) ^{a,c}
E7–E9 (a)	416	10.8%	0.36 (0.07 – 0.66)
W1–W5 (b)	79	1.2%	0.86 (–0.31 – 2.04)

	Study Sample Unweighted Ns	Percentages Weighted	Mean Number of Negative Drinking-Related Consequences (0–22), 95% CI
O1–O10 (c)	607	16.2%	0.36 (0.24 – 0.48)
Combat Deployments Since 9/11/01			
1	1,366	42.7%	0.68 (0.49–0.87)
2 (a)	881	26.4%	0.92 (0.53–1.30)
3 or more (b)	1,035	30.9%	0.66 (0.41–0.91)
Lifetime Combat Exposure			
None	1,174	35.4%	0.46 (0.35 – 0.57) ^b
Moderate (a)	1,223	35.5%	0.43 (0.34 – 0.52) ^b
High (b)	802	29.1%	1.52 (1.04 – 2.00)
Traumatic Brain Injury			
None	3,094	90.3%	0.61 (0.45 – 0.77) ^{b,c}
TBI-AC (a)	150	5.4%	1.12 (0.42 – 1.81) ^c
TBI-LOC 20 (b)	72	3.0%	2.48 (1.05 – 3.91) ^c
TBI-LOC>20 (c)	34	1.3%	7.68 (4.73 – 10.63)
Drinking-Related Behaviors			
Frequent binge drinker, YES	760	25.3%	2.00 (1.40 – 2.56) ^a
Frequent binge drinker, NO (a)	2,590	74.7%	0.37 (0.28 – 0.47)
Possible Alcohol Dependence (20+)			
Possible Alcohol Dependence, YES	151	5.7%	4.61 (3.30 – 5.91) ^a
Possible Alcohol Dependence, NO (a)	2,903	94.3%	0.52 (0.38 – 0.66)
Positive PTSD screen, past month			
YES	322	11.4%	2.74 (1.88 – 3.59) ^a
NO (a)	2,976	88.6%	0.52 (0.37 – 0.68)
Positive depression screen, past year			
YES	657	20.6%	1.69 (1.05 – 2.32) ^a
NO (a)	2,610	79.4%	0.48 (0.38 – 0.59)
Suicidal ideation, past year			
YES	159	5.3%	2.56 (1.56 – 3.55) ^a
NO (a)	3,162	94.7%	0.67 (0.46 – 0.87)

Abbreviations: CI, confidence interval; E, enlisted; W, Warrant Officer; O, Officer; TBI, traumatic brain injury; LOC, loss of consciousness; AC, altered consciousness; PTSD, posttraumatic stress disorder

^I Weighted percentages are displayed for policy relevant findings; Unweighted N's; total weighted N for the study sample is 175,277. Some participants did not answer all relevant questions.

^{II} Bivariate associations are represented by superscripts and show that means are significantly different at the p .05 level or less. For example, Whites have significantly lower average negative drinking-related consequences compared to Hispanics at the p .05 level.

^{III} Single includes those never married and 9 widows.

Table 2

Negative Drinking-Related Consequences of Active Duty Military Personnel who Drink, Returning from a Past Year Combat Deployment, by TBI Level (N=3,350) *I,II*

	Total Study Sample N = 3,350	TBI Level <i>III</i>			
		No TBI N = 3,094 (90.3%)	Altered Consciousness N = 150 (5.4%)	LOC 20 Minutes N = 72 (3.0%)	LOC > 20 Minutes N = 34 (1.3%)
Social Consequences (0–10), Percentages					
Any Social Consequences (Y/N) <i>IV</i>	21.2%	19.5%	29.8%	43.3%	58.8%
Mean (CI) # of Social Consequences (range 0–10)	0.51 (0.39–0.63)	0.43 (0.33–0.52)	0.71 (0.30–1.13)	1.42 (0.82–2.01)	3.68 (2.25–5.11)
Drove car/vehicle when had too much to drink	12.6%	11.5%	14.8%	29.3%	39.8%
Rode in car/vehicle when driver had too much to drink	11.8%	11.0%	14.0%	18.3%	41.5%
Hit someone in a fight other than family member	6.1%	4.8%	10.9%	21.2%	40.7%
Drove/rode in water vehicle when had too much to drink	4.0%	3.3%	4.4%	12.8%	35.8%
Operated power tools/machinery when had too much to drink	4.3%	3.4%	10.3%	14.4%	20.3%
Found it harder to handle problems	3.2%	2.3%	5.0%	13.1%	36.2%
Arrested for driving under the influence	2.5%	1.8%	3.7%	5.9%	39.5%
Spouse/boyfriend/girlfriend threatened to leave or left	2.3%	1.5%	3.1%	9.9%	35.2%
Spouse/boyfriend/girlfriend asked to leave or left	2.4%	1.6%	2.3%	8.2%	40.3%
Arrested for drinking incident not related to driving	2.1%	1.3%	2.9%	8.7%	38.7%
Medical Consequences (0–5), Percentages					
Any Medical Consequences (Y/N) <i>V</i>	3.5%	2.5%	6.7%	10.7%	40.8%
Mean (CI) # of Medical Consequences (range 0–5)	0.10 (0.05–0.15)	0.06 (0.03–0.10)	0.18 (0.05–0.32)	0.37 (0.18–0.73)	1.60 (0.91–2.30)
Drinking caused accident where someone was hurt or property damaged	2.2%	1.5%	5.7%	8.8%	23.4%
Hurt in accident	2.0%	1.4%	3.4%	5.9%	32.2%
Received emergency medical help	2.0%	1.2%	3.7%	7.1%	34.7%
Hospitalized	1.9%	1.1%	3.1%	9.2%	34.4%
Received detoxification treatment	1.9%	1.2%	2.5%	6.3%	35.6%
Military/Discipline-Related Consequences (0–7) Percentages					
Any Military Consequences (Y/N) <i>VI</i>	5.6%	4.6%	6.8%	16.7%	45.5%

	Total Study Sample N = 3,350	TBI Level III			
		No TBI N = 3,094 (90.3%)	Altered Consciousness N = 150 (5.4%)	LOC 20 Minutes N = 72 (3.0%)	LOC > 20 Minutes N = 34 (1.3%)
Mean (CI) # of Military Consequences (range 0–7)	0.17 (0.12–0.23)	0.12 (0.08–0.16)	0.22 (0.05–0.39)	0.69 (0.12–1.25)	2.40 (1.50–3.29)
Received UCMJ punishment	2.7%	2.2%	3.2%	7.3%	23.4%
Trouble with police (civilian or military)	2.7%	1.9%	4.8%	11.8%	27.4%
Trouble on job	2.9%	2.1%	3.9%	11.8%	35.4%
Received lower score on efficiency report or performance rating	2.8%	1.9%	4.1%	11.3%	37.5%
Didn't get promoted	2.4%	1.6%	2.5%	10.0%	44.0%
Spent time in jail, stockade, or brig	2.0%	1.4%	1.3%	8.3%	31.1%
Kept from duty at least a week due to drinking-related illness	1.8%	1.0%	2.2%	8.1%	40.8%

Abbreviations: CI, confidence interval; LOC, loss of consciousness; UCMJ, Uniform Code of Military Justice.

All 22 items were asked about things that “happen to people while or after drinking, or because of using alcohol” which occurred within the past 12 months. Respondents reported 0, 1, 2, or 3+ times in the past 12 months, which were recoded as either 0 or 1+.

I The table shows weighted percentages. Sums may not add to 100% due to rounding.

II Results were significant at the $p .01$ level. The p -value was calculated with the use of a design-based F test.

III Traumatic brain injury was defined with 3 subgroups; TBI-AC – those reporting altered consciousness but no actual LOC; TBI-LOC 20 – those reporting LOC of up to 20 minutes, and; TBI-LOC > 20 – those reporting LOC of greater than 20 minutes. Those with no TBI consist of those with and without injury event exposure.

Table 3
Incidence Rate Ratios for Negative Binomial Regression Models of 22 Negative Drinking-Related Consequences (N= 3,350)^{a/}

	Models of Number of Negative Drinking-Related Consequences				
	Model 1: Adjusted for TBI Level only	Model 2: Adjusted for Demographics & Combat Exposure	Model 3A: Adjusted for Demographics, Combat Exposure, and PTSD	Model 3B: Adjusted for Demographics, Combat Exposure, Depression, and Suicidal Ideation	Model 4A: Adjusted for Demographics, Combat Exposure, PTSD, and Frequent Binge Drinking
					Model 4B: Adjusted for Demographics, Combat Exposure, Depression, Suicidal Ideation, and Frequent Binge Drinking
IRR (95% CI)					
TBI Level					
None (ref.)	1.0	1.0	1.0	1.0	1.0
Altered Consciousness	1.69 (1.13–2.52) *	1.34 (0.90–2.00)	1.14 (0.69–1.91)	1.32 (0.88–2.00)	1.03 (0.62–1.74)
LOC 20 minutes	3.65 (1.92–6.93) ***	1.47 (0.70–3.08)	1.13 (0.52–2.48)	1.04 (0.55–1.94)	0.97 (0.51–1.87)
LOC >20 minutes	11.24 (6.84–18.46) ***	8.32 (3.23–21.44) ***	4.10 (1.74–9.65) **	6.45 (2.14–19.46) ***	3.91 (1.98–7.73) ***
Gender					
Female (ref.)		1.0	1.0	1.0	1.0
Male		1.27 (0.94–1.72)	1.25 (0.93–1.67)	1.35 (0.96–1.91)	1.17 (0.94–1.47)
Service Branch					
Army (ref.)		1.0	1.0	1.0	1.0
Navy		1.22 (0.70–2.12)	1.15 (0.65–2.04)	1.15 (0.62–2.14)	1.10 (0.66–1.85)
Marine Corps		0.93 (0.59–1.46)	0.94 (0.58–1.51)	1.06 (0.63–1.79)	1.05 (0.65–1.69)
Air Force		0.54 (0.33–0.87) *	0.58 (0.34–0.98) *	0.62 (0.36–1.05)	0.56 (0.34–0.91) *
Coast Guard		1.13 (0.67–1.91)	1.16 (0.65–2.08)	1.25 (0.70–2.25)	0.98 (0.59–1.64)
Race/Ethnicity					
White, non-Hispanic (ref.)		1.0	1.0	1.0	1.0
Black, non-Hispanic		1.01 (0.78–1.32)	0.98 (0.74–1.29)	0.92 (0.68–1.24)	0.99 (0.73–1.34)
Hispanic		1.68 (1.14–2.47) **	1.70 (1.17–2.45) **	1.44 (0.92–2.26)	1.55 (1.16–2.07) **
Other		0.85 (0.65–1.10)	0.84 (0.59–1.19)	0.70 (0.54–0.92) **	0.85 (0.66–1.09)
Marital Status ^{II}					
Single (ref.)		1.0	1.0	1.0	1.0

	Models of Number of Negative Drinking-Related Consequences					
	Model 1: Adjusted for TBI Level only	Model 2: Adjusted for Demographics & Combat Exposure	Model 3A: Adjusted for Demographics, Combat Exposure, and PTSD	Model 3B: Adjusted for Demographics, Combat Exposure, Depression, and Suicidal Ideation	Model 4A: Adjusted for Demographics, Combat Exposure, PTSD, and Frequent Binge Drinking	Model 4B: Adjusted for Demographics, Combat Exposure, Depression, and Suicidal Ideation, and Frequent Binge Drinking
Married/living as married		0.61 (0.47–0.79) ***	0.52 (0.40–0.68) ***	0.63 (0.47–0.83) **	0.57 (0.45–0.73) ***	0.64 (0.49–0.83) ***
Divorced/separated		1.13 (0.72–1.79)	1.16 (0.67–2.00)	1.31 (0.81–2.14)	1.30 (0.70–2.40)	1.41 (0.80–2.50)
Pay Grade		1.0	1.0	1.0	1.0	1.0
E1–E6 (ref.)						
E7–E9		0.27 (0.18–0.41) ***	0.35 (0.23–0.53) ***	0.29 (0.21–0.40) ***	0.38 (0.26–0.56) ***	0.33 (0.24–0.46) ***
W1–W5		0.19 (0.07–0.54) **	0.25 (0.08–0.76) *	0.22 (0.06–0.72) *	0.23 (0.09–0.59) **	0.20 (0.07–0.55) **
O1–O10		0.52 (0.36–0.74) ***	0.62 (0.43–0.89) *	0.59 (0.41–0.84) **	0.76 (0.54–1.09)	0.73 (0.51–1.05)
Lifetime Combat Exposure						
None (ref.)		1.0	1.0	1.0	1.0	1.0
Moderate		1.11 (0.83–1.47)	1.08 (0.80–1.46)	0.99 (0.73–1.34)	1.10 (0.81–1.49)	1.04 (0.77–1.41)
High		2.49 (1.70–3.65) ***	2.04 (1.42–2.93) ***	1.99 (1.30–3.05) **	1.95 (1.36–2.81) ***	1.91 (1.25–2.91) **
PTSD positive screen, past month			2.92 (2.42–3.52) ***		2.14 (1.69–2.71) ***	
Positive depression screen, past year				2.12 (1.76–2.55) ***		1.69 (1.30–2.18) ***
Suicidal ideation, past Year				1.79 (1.04–3.08) *		1.50 (0.93–2.41)
Frequent binge drinking, past month					3.27 (2.75–3.90) ***	3.23 (2.72–3.85) ***

Abbreviations: IRR, incidence rate ratio; CI, confidence interval; LOC, loss of consciousness; ref., reference group; E, enlisted; W, Warrant Officer, O, Officer.

I All models were adjusted for the number of months home within the past year. Some participants did not complete all relevant questions.

II Single includes those never married and 9 widows.

*** Results were significant at the p .001 level

** Results were significant at the p .01 level

* Results were significant at the p .05 level P-values were calculated with the use of a design-based *F* test.