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The Prevalence, Characteristics, and Psychiatric Correlates of Traumatic Brain Injury in Incarcerated Individuals: An Examination in Two Independent Samples

Brett S. Schneider, M.S.^{1,2}, David B. Arciniegas, M.D.^{3,4}, Carla Harenski, Ph.D.⁵, Gerard Janez Brett Clarke, M.S.⁵, Kent A. Kiehl, Ph.D.^{5,6}, Michael Koenigs, Ph.D.^{1,*}

¹Department of Psychiatry, University of Wisconsin-Madison, 53719

²Department of Psychology, University of Wisconsin-Madison 53706

³Marcus Institute for Brain Health, University of Colorado-Anschutz Medical Campus, Aurora, Colorado 80045

⁴Department of Psychiatry and Behavioral Sciences, University of New Mexico School of Medicine, Albuquerque, New Mexico 87106

⁵The MIND Research Network, Albuquerque, New Mexico 87106

⁶Departments of Psychology, Neuroscience and Law, University of New Mexico, Albuquerque, New Mexico 87106

Abstract

Primary Objective: Identify the prevalence, characteristics, and psychological correlates of traumatic brain injury (TBI) among incarcerated individuals.

Research Design: Three aims: (1) Determine the prevalence and characteristics of TBI in 1469 adults incarcerated in Wisconsin state prisons (1064 men, 405 women); (2) Characterize the relationship between mild TBI and mental illness in a sub-sample of men and women; (3) Reproduce the findings from Aim 1 and Aim 2 in an independent sample of 1015 adults incarcerated in New Mexico state prisons (600 men, 415 women).

Methods and Procedures: Standardized TBI assessment with structured clinical interviews and self-report questionnaires.

Main Outcomes and Results: Rates of TBI were approximately five times greater than the general population, with a substantially higher rate of TBI caused by assault. In the Wisconsin sample, mild TBI was associated with greater levels of post-traumatic stress disorder (PTSD) among women (but not among men). In the New Mexico sample, TBI of any severity was associated with greater levels of major depressive disorder (MDD) among women (but not among men).

*Corresponding Author mrkoenigs@wisc.edu, Michael Koenigs, 6001 Research Park Boulevard, Madison, WI 53719.

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Conclusions: This study thus provides novel data on TBI and its correlates among individuals incarcerated in state prisons, and highlights a specific treatment need within the prison population.

Keywords

traumatic brain injury; TBI; forensic; head injury; prison

Introduction

Traumatic brain injury (TBI) is highly prevalent among incarcerated individuals and, for a non-trivial portion of this population, a chronic health condition ¹. Meta-analyses estimate the prevalence of TBI in male prisons from 40–60% ^{2,3}, compared to the general population estimates of 8–15% ^{4,5}. Furthermore, prison populations tend to include more cases of moderate or severe TBI and repeated injuries ⁶. The causes of these injuries differ from the general population as well, with increased rates of assaults and car accidents leading to TBI among the prison population ⁶. The natural history of TBI, across the injury severity continuum, tends towards recovery—albeit often incomplete recovery, particularly among individuals with more severe injuries and a higher number of comorbid conditions and psychosocial complexities ⁷. For a subset of persons with TBI in the general population, the medical and psychosocial complications of and comorbidities to TBI combine to create a chronic health condition that may engender progressive neurodegenerative processes, exacerbate current and incite additional comorbid conditions, and adversely affect aging, neurobehavioral and physical health, and functional outcomes ¹.

However, the currently available data on TBI and its long-term consequences in the prison population are limited in several ways. Many of the previous studies have focused on populations outside of the United States ^{8,9}. The prison population in the United States differs in several respects from other countries and for a variety of socioeconomic and policy reasons. For example, the U.S. incarceration rate began significantly outpacing those of other democratic nations beginning in the 1980s, around the time of the so-called “War on Drugs” and more punitive sentencing practices for repeated crimes ¹⁰. These policy changes have disproportionately impacted Black Americans ¹¹. Additionally, many of these studies have not used standardized TBI screening assessments or structured interviews of study participants, relying instead on review of general medical records for notation of TBI diagnoses or unvalidated screening measures. Prevalence estimates from individual studies range widely, between 25–88% in male prisons ^{12,13}. Furthermore, few studies have examined the prevalence of TBI in women using standardized screening measures, with only four previous studies using samples greater than fifteen individuals ^{6,14–16}. These studies of incarcerated females also report wide variation in prevalence, with estimates between 45–72% ^{6,14}. Notably, these studies find the prevalence of TBI among incarcerated females to be greater than or equal to incarcerated males ^{14,15}. In the general population, men present with greater rates of TBI than women ⁵, highlighting another unique TBI characteristic in prison populations.

The link between TBI and mental illness appears relevant to understanding a wide range of conditions and behavioral challenges in prison populations. Studies of non-incarcerated

samples have shown that individuals with a history of TBI are at greater risk for depression^{17–19}, externalizing behavior²⁰, substance use^{21,22}, antisocial behavior²¹, sexually inappropriate and/or disinhibited behaviors²³, and aggression^{24,25}. These psychological and behavioral sequelae of TBI may persist despite full cognitive recovery²¹. Moreover, the psychological correlates of TBI can vary significantly between men and women, with women showing increased levels of depression, anxiety, and PTSD while men present with increased externalizing behavior^{26–28}, though a recent study did not find significant differences in PTSD²⁸. These differences have been attributed to varying injury mechanisms, (e.g. more intimate partner violence in women than men), differences in the brain's response to injury dependent upon sex, and less aggressive treatments pursued in women than men^{28,29}. The injury mechanism and treatment related causes for differences in treatment outcome are particularly relevant in prison populations, where women suffer rates of inter-personal violence between 75–90%^{30,31}.

Though prison populations exhibit greater prevalence of mental illness and TBI, few studies have examined how TBI relates to symptoms of mental illness in incarcerated samples. A review of these studies suggests that incarcerated samples with a history of TBI have increased levels of depression, anxiety, neurocognitive deficits, substance use, and aggression³². These studies have also demonstrated preliminary evidence that a history of TBI is associated with more disciplinary infractions^{33,34}. Additionally, TBI has been associated with increased risk for recidivism³⁴. These studies, however, were relatively small with respect to sample size, lacking female subjects, and varied with respect to TBI assessment methods^{12,32}. A more detailed understanding of the link between TBI and mental illness is crucial to guide treatments and policies within the criminal justice system to improve outcomes during and following incarceration^{9,22}.

The current study aims to address the aforementioned gaps in understanding the impact of TBI in prisons in the United States. In Aim 1, we examine the prevalence and characteristics of TBI in a relatively large sample of both male and female adults incarcerated in Wisconsin state prisons. We predict the rate of TBI in both men and women will exceed estimates of TBI prevalence in the general population. Additionally, we predict a high proportion of both men and women with a history of moderate and severe TBI, repeated TBI, and TBI in the context of assault. In Aim 2, we examine how a history of mild TBI (mTBI) relates to diagnoses and symptoms of mental illness in a subset of the sample from Aim 1. We predict a gender-specific relationship between mTBI and psychiatric symptoms; men with a history of TBI will have increased externalizing behavior (substance use, antisocial behavior), whereas women with a history of TBI will have increased internalizing symptoms (depression, post-traumatic stress disorder). In Aim 3, we attempt to replicate the findings from Aim 1 and Aim 2 in an independent sample of men and women incarcerated in New Mexico state prisons.

Aim 1: TBI Prevalence and Characteristics

Methods

Participants—Participants were recruited from three adult prisons in Wisconsin (two medium-security male prisons and one mixed-security female prison). A total of 1469

incarcerated individuals (1064 men, 405 women) participated. All participants were adults who provided informed consent. This project was approved by the Institutional Review Board and the State of Wisconsin Department of Corrections Research Review Committee.

TBI Screening—All participants completed an interview screening measure for TBI. The screening measure was adapted from the Ohio State University TBI Identification method (OSU-TBI-ID)³⁵ and supplemented with the Rivermead Post Concussion Symptoms Questionnaire³⁶(see Supplemental Material for a copy of the measure). Participants report the age and circumstances of the injury, the presence and duration of loss of consciousness (LOC), presence and duration of post-traumatic amnesia (PTA) surrounding the injury, feeling dazed or disoriented at the time of injury, whether they were using alcohol or drugs at the time of injury, and any residual physical symptoms. We determined the presence and classified the severity of TBI based on the criteria outlined in the Diagnostic Statistical Manual of Mental Disorders-5 (DSM-5), which are presented in Table 1³⁷.

From the injury description, the mechanism of TBI was assigned to one of five categories: 1) motor vehicle accident, 2) fall, 3) assault, 4) blast-related, and 5) other, which included all injuries that did not fall within the previous four categories.

Results

Men—Of the 1064 men included in our analysis, 587 (55.2%) had at least one TBI (Fig. 1), 210 (19.7%) had two or more TBI, and 63 (5.9%) had three or more TBI (Table 2). One hundred and thirteen (10.6%) men in the sample suffered a moderate TBI, while 27 (2.5%) suffered a severe TBI. The mechanisms of TBI were motor vehicle accidents (302; 34.6%), assaults (242; 27.8%), other (173; 20.3%), falls (151; 17.3%), and blast-related (2; 0.2%). For 244 of the 872 TBI (27.9%), the individual reported consuming alcohol and/or illicit drugs preceding the injury. The average age of the first injury was 16.57 (8.8).

Women—Of the 405 women included in our analysis, 272 (67.2%) had at least one TBI (Fig. 1), 124 (30.6%) had two or more TBI, and 55 (13.6%) had three or more TBI (Table 2). 65 (16.0%) women in the sample suffered a moderate TBI, while 18 (4.4%) suffered a severe TBI. The mechanisms of TBI were motor vehicle accidents (144; 30.6%), assaults (136; 28.9%), other (120; 25.5%), falls (71; 15.1%), and blast-related accounted for none of the injuries. For 205 of the 471 TBI (43.5%), the individual reported consuming alcohol or drugs preceding the injury. The average age of the first injury was 18.05 (9.32).

Aim 2: Diagnoses and Symptoms of Mental Illness

Method

Participants—A subset of participants from Aim 1 completed a battery of clinical interviews and questionnaires. Data for this subset of participants were drawn from a larger ongoing program of prison research focused on examining psychological and neurobiological characteristics of individuals with psychopathy. Inclusion criteria for this larger study were age 18–55, no history of moderate or severe TBI, no current psychotropic medication use, and no lifetime diagnosis of a bipolar disorder or thought disorder.

These inclusion criteria were implemented to minimize the likelihood that experimental findings related to psychopathy could be attributable to factors like moderate/severe TBI or psychosis. These criteria therefore resulted in groups of individuals with either no TBI or mild TBI (mTBI); individuals with moderate or severe TBI were excluded prior to completing the clinical interviews and questionnaires. These assessments (described below) were administered at different timepoints in the larger ongoing project. Therefore, participants may have completed all or some of the assessments. Data analysis for each assessment was conducted using the maximum number of participants who completed each measure.

Psychiatric Assessments—The *Beck-Depression Inventory II (BDI-II)* is a self-report depression questionnaire consisting of 21 symptoms rated on severity from 0 (absent) to 3 (most severe)³⁸. The *Addiction Severity Index (ASI)* is a clinician-administered instrument that asks about recent substance use, lifetime substance use, and how substance use has impacted the individual³⁹. Prior to use in analyses, we applied a square root transformation of the raw score divided by age, to account for the influence of age and fit the data to a normal distribution³⁹. The *Post-Traumatic Stress Disorder Checklist-Civilian Version-IV (PCL-C)* is a self-report measure of common symptoms experienced following a traumatic experience⁴⁰. The *Structured Clinical Interview for DSM-V (SCID-V)* and *DSM-IV (SCID-V)* were administered to determine current and past psychiatric disorders^{37,41,42}. IQ scores were obtained using the *Wechsler Abbreviated Scale of Intelligence Full-Scale IQ-II (WASI-II)* generated from the four subtests.

Data Analyses—For the assessments with continuous scores (BDI-II, PCL-C, ASI, IQ), we conducted independent samples *t*-tests to compare the No TBI and mTBI groups within each sex, with effect size reported as *partial* η^2 . Type I error was controlled using the Holm-Bonferroni method⁴³. We also used a general liner model to test the interaction of sex and TBI status on these measures. A lifetime diagnosis of post-traumatic stress disorder (PTSD), major depressive disorder (MDD), antisocial personality disorder (APD), alcohol use disorder (AUD), or another (non-alcohol) substance use disorder (SUD) on the DSM-IV or DSM-5 was coded for a diagnosis using either interview. Note, the diagnostic criteria of DSM-5 were changed from DSM-IV, and thus diagnosis of the same diagnosis can vary between instruments (e.g., substance use disorder and PTSD), although the underlying conception of the disorders remains the same^{44,45}. For example, Lifetime diagnosis of a DMS-IV or DSM-5 disorder (yes vs. no, coded as 1 and 0 respectively) was included in a generalized linear model with group (No TBI or mTBI) as a dichotomous predictor using the logit link function, with No TBI coded as -0.5 and TBI 0.5 in our model.

Results

No significant results emerged within the male sample comparing No TBI vs mTBI history in continuous symptom measures or diagnosis, though a trend level association did emerge for greater rates of AUD diagnosis in the mTBI vs. No TBI group ($\chi^2(1) = 3.75$, $p = 0.053$; Fig. 3C). Within the female sample, women in the mTBI group showed greater symptoms of PTSD as measured by the PCL-C than those in the No TBI group ($\beta = 11.24$, $F(1,58) = 8.37$, $p = 0.048$, *partial* $\eta^2 = 0.13$ (Fig. 2A). No relationships emerged following

strict multiple comparisons correction across the other continuous measures and history of psychological diagnosis.

In the combined sample of men and women, there was a significant interaction between group (mTBI and No TBI) and sex ($\beta = -10.94$, $F(1,307) = 8.13$, $p = 0.042$, $\text{partial } \eta^2 = 0.026$; Fig. 2A). Among women, the mTBI group had significantly greater PCL-C scores than the No TBI group, whereas there was no such group difference among men. There were also significant main effects of both group ($\beta = 5.77$, $F(1,307) = 9.034$, $p = 0.029$, $\text{partial } \eta^2 = 0.029$) and sex ($\beta = -14.32$, $F(1,307) = 55.68$, $p < 0.000001$, $\text{partial } \eta^2 = 0.15$). This was not significant for the BDI-II, but the main effects of sex ($\beta = -7.62$, $F(1,475) = 42.28$, $p < 0.00001$, $\text{partial } \eta^2 = 0.082$) and group ($\beta = 3.30$, $F(1,475) = 7.92$, $p = 0.0051$, $\text{partial } \eta^2 = 0.016$; Fig. 2B) were significant. There was no significant interaction between group and sex for ASI, but the main effect of group did emerge significant ($\beta = 0.11$, $F(1,450) = 9.70$, $p = 0.0059$, $\text{partial } \eta^2 = 0.021$; Fig. 2C). Similarly, there was no significant interaction between group and sex related to WASI-II ($\beta = 6.30$, but the main effect of group was significant ($\beta = -3.012$, $F(1,450) = 4.14$, $p = 0.043$, $\text{partial } \eta^2 = 0.009$; Fig. 2D).

There were no significant interactions between sex and TBI group in relationship with any psychological disorder. However, the main effect of sex (higher among women) was significant for PTSD ($\chi^2(1) = 15.55$, $p < 0.0001$; Fig. 3A) and MDD ($\chi^2(1) = 4.58$, $p = 0.032$; Fig. 3B). For AUD, there was a significant main effect of group (higher among mTBI) ($\chi^2(1) = 9.71$, $p = 0.0018$), but the interaction between group and sex was not significant ($\chi^2(1) = 2.07$, $p = 0.15$; Fig. 3C). No significant associations were found for diagnoses of APD or other SUD.

Aim 3: Replication Study in Independent Sample

Method

Participants—Participants were recruited from five adult prisons in New Mexico (four mixed-security, medium to supermax, male prisons and one mixed-security female prison). A total of 1015 incarcerated individuals (600 men, 415 women) participated. All participants were adults who provided informed consent. This study was approved by an Ethical and Independent Review Services (E&I) and the State of New Mexico Corrections Department. A subset of 873 (520 men, 353 women) participants from the prevalence portion of Aim 3 completed a SCID-IV with information on a diagnosis of PTSD or MDD. Note that participants were not excluded for TBI severity greater than mild, and thus unlike Aim 2, individuals with injuries ranging from mild to severe were included in the TBI group. We performed a separate analysis in 750 participants containing only those with mTBI and No TBI (439 men, 311 women) to match the analyses completed in Aim 2 as well. Additionally, unlike Aim 2, individuals were not excluded for psychosis or psychotropic medications.

TBI Screening—All participants completed the same interview screening measure for TBI described in Aim 1. However, we do not currently have information on whether the person was consuming substances preceding the injury. Therefore, these results were not included in the replication study.

Data Analyses—In this replication study, we tested the sex-specific relationships between history of TBI and diagnoses of MDD and PTSD, as measured by the DSM-IV. We followed the same data analysis plan as Aim 2; we entered lifetime diagnosis of a psychiatric disorder (yes or no) in a generalized linear model that included group (TBI or No TBI) as a dichotomous predictor within the male and female prison samples, and then used the same statistical approach to test the interaction of sex and TBI status on PTSD and MDD diagnoses. Results are corrected for multiple comparisons using the Holm-Bonferroni method used in Aim 2.

Results

TBI Prevalence and Characteristics—In the New Mexico sample, 301 of the 600 men (50.2%) and 197 of the 421 women (46.8%) had at least one TBI (Table 6). Within the male sample, 118 (19.7%) had two or more TBI, and 56 (9.3%) had three or more TBI. Within the female sample, 69 (16.6%) had two or more TBI while 19 (4.6%) had three or more TBI (Table 5). The average age of the first TBI was significantly older ($p < 0.001$) for women (19.76 (9.26)) compared to men (16.84 (8.01)). 984 of the total sample (578 men, 406 women) had complete information to determine TBI severity according to the DSM-5 criteria used in Aim 1. 209 of the men (34.8%) had a history of mTBI while 70 (11.7%) had moderate or severe TBI. 136 of the women (32.8%) had history of mTBI and 46 (11.1%) had moderate or severe TBI. Finally, the mechanism of TBI in a total of 310 TBI in men consisted of 20.3% motor vehicle accidents, 13.9% falls, 48.7% assaults, 0% blast-related, and 17.1% other mechanism. Within the female sample, the mechanism of injury in a total of 240 TBI consisted of 18.3% motor vehicle accidents, 8.8% falls, 58.3% assaults, 0.4% blast-related, and 14.2% other.

Diagnoses and Symptoms of Mental Illness—Men with a history of a TBI did not have significantly different rates of PTSD ($\chi^2(1) = 0.32, p = 0.57$; Fig. 5A) or MDD ($\chi^2(1) = 0.61, p = 0.43$, Fig. 5B) than men with no history of TBI. When restricted to mTBI only, the relationships remained insignificant for PTSD ($\chi^2(1) = 0.47, p = 0.49$) and MDD ($\chi^2(1) = 0.52, p = 0.47$). Women with a history of a TBI had significantly greater rates of MDD ($\chi^2(1) = 16.81, p < 0.0001$; Fig. 5B) than those with no history of TBI. This relationship remained constant when restricted to women with a history of only mTBI ($\chi^2(1) = 13.55, p < 0.001$). The association between history of TBI emerged at the trend level for PTSD diagnosis ($\chi^2(1) = 3.32, p = 0.068$; Fig. 5A) and was not significant for mTBI compared to No TBI ($\chi^2(1) = 1.42, p = 0.23$).

Sex by TBI Interactions—In the total sample of 873 participants, logistic regressions examining the interaction of a history of TBI with gender predicting a diagnosis of PTSD, there was no significant main effect of group ($\chi^2(1) = 3.18, p = 0.074$), but a significant main effect of sex ($\chi^2(1) = 14.55, p = 0.00014$), with higher rates among women. The interaction term was not significant ($\chi^2(1) = 0.45, p = 0.50$; Fig. 5A). Comparing rates of only mTBI vs. No TBI, we find the relationship is unchanged (no main effect of group ($\chi^2(1) = 1.84, p = 0.18$), a significant main effect of sex ($\chi^2(1) = 14.55, p = 0.0033$). For MDD diagnosis, the main effects of both group ($\chi^2(1) = 10.19, p = 0.0014$) and sex ($\chi^2(1) = 69.11, p < 0.000001$), with women and the TBI group showing increased rates of

MDD diagnoses. The interaction emerged at a trend level ($\chi^2(1) = 3.86, p = 0.098$; Fig. 5B). Again, these results remained constant when using only mTBI and No TBI (significant main effects of group ($\chi^2(1) = 8.16, p = 0.0043$) and sex ($\chi^2(1) = 57.9, p < 0.000001$), and a trend-level interaction between mTBI and sex ($\chi^2(1) = 3.09, p = 0.079$).

Discussion

The overarching aim of this study was to characterize the prevalence, causes, and psychopathological correlates of TBI in two large, independent samples of incarcerated men and women, totaling over 2,500 participants. The data across samples yield two main findings: (1) TBI is highly prevalent in U.S. state prisons (52–55% in men and 47–67% in women), with a substantial proportion of TBI caused by motor vehicle accidents (20–35% in men and 18–31% in women) and assaults (28–49% in men and 29–58% in women), and participants who reported consuming illicit drugs and/or alcohol prior to the injury (28% in men and 44% in women). (2) There are significant sex differences in the psychiatric correlates of TBI within the prison population; specifically, TBI is associated with symptoms of PTSD and MDD in women, but not in men. We discuss each of these main findings in turn.

In Aim 1 and Aim 3, the TBI prevalence data highlight the unique characteristics which distinguish TBI in incarcerated samples from previously reported data in the general population. TBI history was highly prevalent in both studies, ranging from 52–55% in men and 47–67% in women. These results are consistent with previous estimates from meta-analyses and reviews of TBI in prison (40–60%)^{3,32}. In non-incarcerated samples, men typically present with TBI at least twice the rate of women^{4,5}. By contrast, in this study of incarcerated individuals, both men and women had similarly high prevalence of TBI history of all severities. Furthermore, incarcerated men and women had similar causes of injury, with assault (28–49% and 29–58%, respectively) and motor vehicle accidents (20–35% and 18–31%, respectively) being the most highly prevalent across both sexes. In contrast, among the general population, the proportions of TBI resulting from assault and motor vehicle accidents are 8.3% and 18.4%, respectively⁴⁶. The instances of repeated injuries and severe injuries was also highly present across incarcerated men and women in our study. A review of repeated TBI in non-athlete populations showed 5.5% of patients report a second TBI⁴⁷, while in our study 20–22% of men and 17–31% of women had two or more TBI. Taken together, the evidence suggests that among individuals incarcerated in state prisons, TBI is highly common, recurrent, and results from unique injury circumstances compared to the general population.

These characteristics place the prison population at risk for a number of adverse outcomes. Both higher severity TBI and repeated injuries in the general population lead to worse outcomes cognitively and psychologically^{47,48}. TBI is also a risk factor for a number of other health conditions, including neurodegenerative disease and dementia^{49–52}. This likely places prison populations at greater risk for developing Alzheimer's disease and related dementias, though more research is needed to determine the prevalence of these conditions in prison^{53,54}. Additionally, prison populations present with accelerated aging relative to the general population, and TBI has been hypothesized to significantly contribute to this

process along with poor nutrition, lack of exercise, and other environmental factors^{53,54}. Furthermore, a relatively high percentage of persons who are incarcerated suffered TBI while intoxicated with alcohol and/or illicit drugs, which previous evidence suggests is associated with a higher risk of poor long-term outcomes from TBI^{55,56}. Continued alcohol abuse after injury also limits recovery and often co-occurs with PTSD^{57,58}. Within our sample, both men and women with TBI had greater number of substance use symptoms and alcohol use disorder diagnoses. This combination of co-morbid conditions increases the likelihood for ongoing psychological difficulties following TBI.

The unique proportion of injuries due to assaults and motor vehicle accidents has an additional influence on recovery. Previous evidence comparing TBI from assault to sport-related concussions or motor vehicle accidents shows that those who suffered a TBI from assault have lower psychosocial functioning^{59–61} and a greater amount of PTSD symptoms⁶². Additionally, TBI due to motor vehicle accident and assault correlates with increased psychological symptoms compared to TBI due to falls, suggesting that the two most frequent mechanisms of TBI in the incarcerated population relate to worse psychological outcomes⁶². These unique injury mechanisms could have different neuropathophysiological correlates and may contribute importantly to variance in outcomes following TBI^{63–65}.

Our study also examined the impact of TBI on psychopathology. Our hypothesis predicted that women with TBI would present with increased internalizing symptoms compared to those without TBI, while men would have greater externalizing symptoms. In Aim 2, women with a history of TBI did indeed present with greater PTSD symptoms than those without TBI. This corresponds to findings in the general population^{26,66}. Additionally, this difference emerged at the trend level for PTSD diagnosis after a strict multiple-comparisons correction. This may also relate to assault accounting for a relatively large proportion of TBI within the women sample found in Aim 1, with some previous evidence suggesting an assault is associated with worse PTSD symptomology compared to non-assault TBI. Contrary to our hypothesis, we did not find evidence for increased externalizing behavior in the TBI group compared to the No TBI group, as did a previous study²¹. In Aim 3, women in the TBI group had significantly greater number of diagnoses for MDD compared to the No TBI group. The interaction between sex and TBI history emerged at the trend level predicting MDD diagnosis. No associations emerged indicating a relationship between TBI and MDD diagnosis in men. Overall, these results provide preliminary evidence for sex differences in psychiatric symptoms associated with TBI in the prison population.

The high comorbidity between TBI and PTSD among women is an important variable when considering treatment and identifying shared underlying pathophysiological mechanisms. Evidence suggests the biomechanics of a TBI can enhance the responsivity of the fear system, increasing the likelihood of developing PTSD⁶⁷. When these conditions co-occur, veterans and the general population are more likely to report continuing physical and sensory difficulties after a TBI^{68–70}. Additionally, persistent symptoms following a TBI and the symptoms of PTSD and MDD often overlap and obfuscate diagnosis⁷¹. TBI also has a direct and negative impact on executive function^{48,72,73}. Impaired executive functioning following a TBI predicts the dropout rate of individuals and predicts poorer treatment response in trauma-focused therapy⁷⁴. To address this issue, a combination of

both cognitive rehabilitation and psychotherapy (Cognitive Processing Therapy, Cognitive Behavioral Therapy, Prolonged Exposure) have been proposed to treat comorbid TBI with PTSD and substance use^{55,74–77}. Computerized cognitive rehabilitation may be a suitable accessible alternative for the prison population⁷⁸. In particular, women in prison might benefit from this combination of treatment given the high comorbidity of TBI and PTSD.

We found a significant main effect of group on AUD diagnoses, with men and women with a TBI having greater proportions of AUD diagnoses. About 69% of men and 77% of women with a TBI in the Wisconsin sample met criteria for AUD. Continuing alcohol abuse after TBI can worsen the effects of TBI and reduce the treatment effects of rehabilitation⁵⁷ and also increases the risk of future injuries⁷⁹. Additionally, the cognitive symptoms accompanied by TBI can negatively impact a person's ability to follow traditional treatments (e.g., twelve-step programs)⁵⁵. While previous studies have shown mixed evidence for the influence of alcohol on recovery from a TBI⁸⁰, neurobiological mechanistic accounts suggest the increased neuroinflammation of alcohol and TBI negatively impacts recovery^{57,81}.

We did not find evidence for a relationship between TBI and other externalizing behaviors like antisocial personality disorder. However, several factors must be considered. First, we did not measure specific constructs like disinhibition, aggression, or impulsivity which are often associated with TBI in prison^{20–22,24,25}. We also did not examine specific crime data (e.g., substance-related offenses, assault) or recidivism, though this will be an area of focus for future research. Second, our examination of externalizing behavior only included those with mTBI. While previous studies have shown increased externalizing behavior following a mTBI, more severe externalizing symptoms are often reported for more severe injuries^{21,22,82}. Our current analysis therefore likely underestimates the impact of TBI on externalizing behavior in prison.

Future directions

The current studies pave the way for future studies. First, future work should focus on how repeated injuries and more severe injuries correlate with both psychological and cognitive outcomes⁴⁸. This approach might help elucidate relationships between TBI and externalizing behavior in men with a history of TBI. Of special interest in this population will be the association between TBI and prison-related outcomes, including disciplinary infractions while incarcerated and recidivism upon release—with such associations likely reflecting, at least in part, TBI-related externalizing behaviors and executive dysfunction³³.

To understand these relationships more fully, research is needed examining the neural correlates of TBI in prison. One prior qualitative study found evidence of structural damage in incarcerated individuals compared to healthy controls⁸³, but this study is limited by not using advanced quantitative techniques like diffusor tensor imaging or fMRI sensitive to detecting a TBI^{64,84–86}. The difference in mechanisms of TBI in prison populations compared to the general population and veteran population could lead to specific and unique neural markers of TBI in prison. This sample also presents with a number of characteristics that increase vulnerability to poor recovery following TBI, including lower education, pre-morbid psychiatric difficulties, and other chronic health conditions^{87,88}. Understanding the

complex interactions of different variables in predicting outcome in the prison population would highlight those individuals most in need of services.

Limitations

Our analysis is limited to retrospective self-report of TBI and is not corroborated with day-of-injury medical records. Nevertheless, measures similar to our modified form such as the OSU-TBI-ID have been used in prison samples with strong validity and reliability¹⁵. Although we did not find evidence for increased externalizing in men with a history of mTBI, other domains such as aggression and psychopathy were unexplored in the current dataset. Furthermore, Aim 2 only examines the impact of mild TBI on psychiatric symptoms. In addition to these concerns, we cannot make any determinations on directionality or causality between measures of psychopathology and TBI history. Finally, many participants were either excluded from the larger prison project focused on psychopathy or were collected at different timepoints. Therefore, we were unable to complete analyses assessing the connection between TBI and mental health symptoms or diagnoses for the entire Wisconsin sample in Aim 2, particularly women, which limited the sample size compared to both Aim 1 and Aim 3.

In summary, the present study demonstrates that TBI among U.S. prison populations is a significant public health concern, with unique features regarding prevalence, causes, and psychiatric correlates.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Biographical Notes

Brett Schneider: Brett Schneider is a clinical psychology doctoral candidate at the University of Wisconsin-Madison. His research focuses on issues related to the unique characteristics and sequelae associated with traumatic brain injuries in individuals who are incarcerated.

David Arciniegas: David B. Arciniegas, MD is a Professor of Psychiatry & Behavioral Sciences at the University of New Mexico School of Medicine. He concurrently serves as Director of Research for the Marcus Institute for Brain Health and Clinical Professor of Neurology and Psychiatry at the University of Colorado-Anschutz Medical Campus. As a subspecialist in Behavioral Neurology & Neuropsychiatry, his clinical, research, and scholarly endeavors have focused principally on the cognitive and non-cognitive neuropsychiatric sequelae of traumatic brain injury and other neurological conditions. He

is a member of the editorial board of Brain Injury and serves as Chairman and CEO of the International Brain Injury Association.

Carla Harenski: Dr. Harenski studies the neuroscience of mental health conditions that are related to criminal behavior. She has led several federally-funded research projects that use magnetic resonance imaging (MRI) to investigate social and emotional processing in criminal offenders characterized by psychopathic personality and other externalizing conditions and behaviors. This research is conducted in incarcerated populations, which is made possible with the Mind Research Network's mobile MRI system and partnerships with correctional facilities across New Mexico and other states.

Gerard Janez Brett Clarke: Gerard Clarke is a research analyst and data manager at the Mind Research Network in Albuquerque, New Mexico. His research interests relate to the broader implications of psychopathy. He also has research experience on mild TBI in general populations.

Kent A. Kiehl: Dr. Kiehl is the Executive Science Officer and Director, Mobile Imaging Core and Clinical Cognitive Neuroscience Professor of Translational Neuroscience at the Mind Research Network and Professor of Psychology, Neuroscience and Law at the University of New Mexico. He is a neuroscientist who specializes in the use of clinical brain imaging techniques to understand major mental illnesses, with special focus on criminal psychopathy, psychotic disorders (i.e., schizophrenia, bipolar disorder, affective disorders), traumatic brain injury, substance abuse and paraphilias.

Michael Koenigs: Dr. Koenigs is a Professor of Psychiatry at the University of Wisconsin-Madison. He is a cognitive neuroscientist with training and experience in neuropsychological assessment, lesion analysis, forensic psychology, and neuroimaging. Dr. Koenigs has been conducting research at prisons in collaboration with the State of Wisconsin Department of Corrections for the past nine years.

Data Availability Statement:

The data that support the findings of this study are available from the corresponding author, BS, upon reasonable request.

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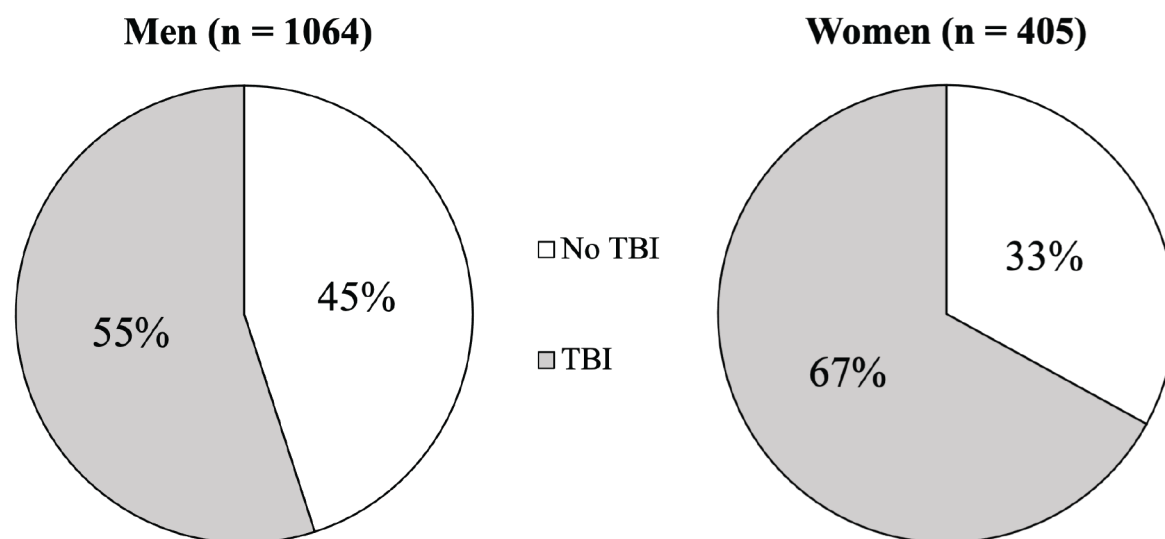


Figure 1.
Prevalence of TBI in WI prison sample

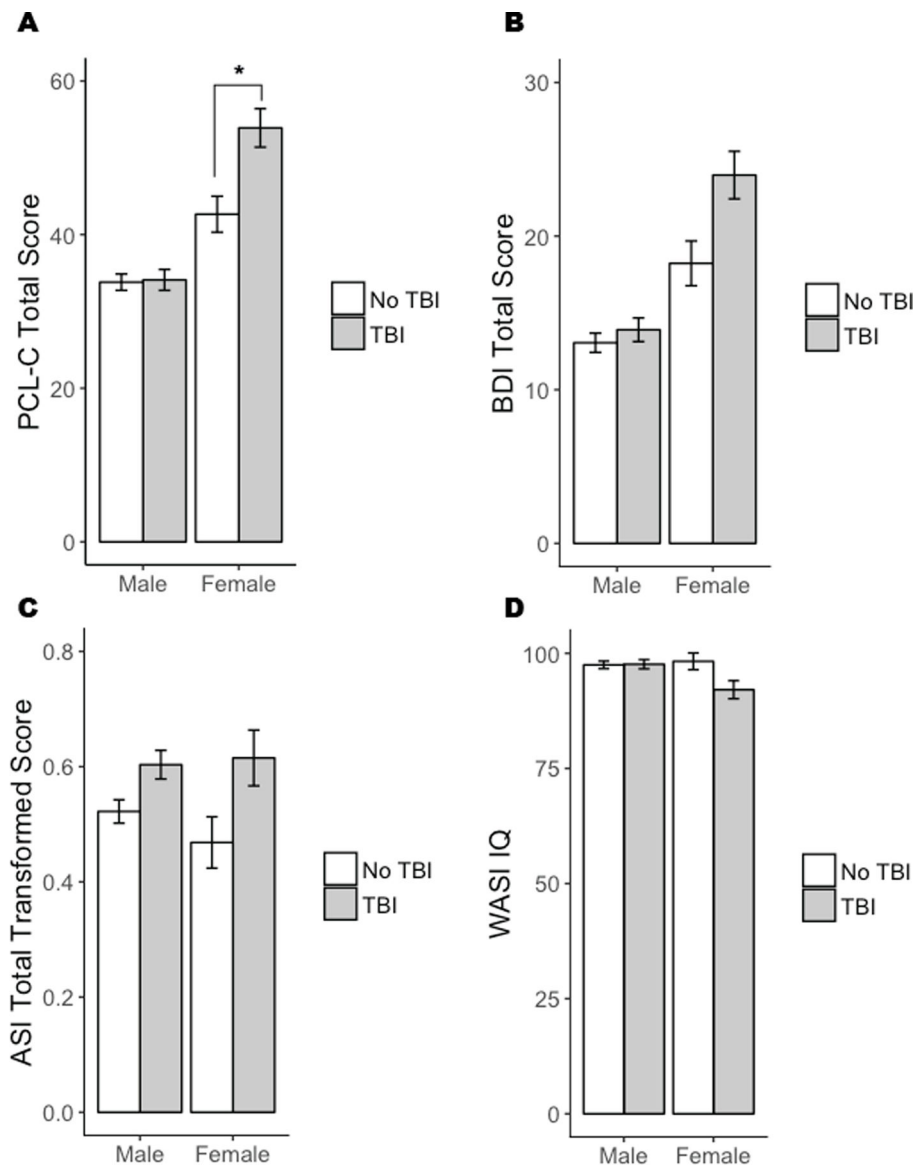


Figure 2.
Psychological correlates of TBI in WI sample

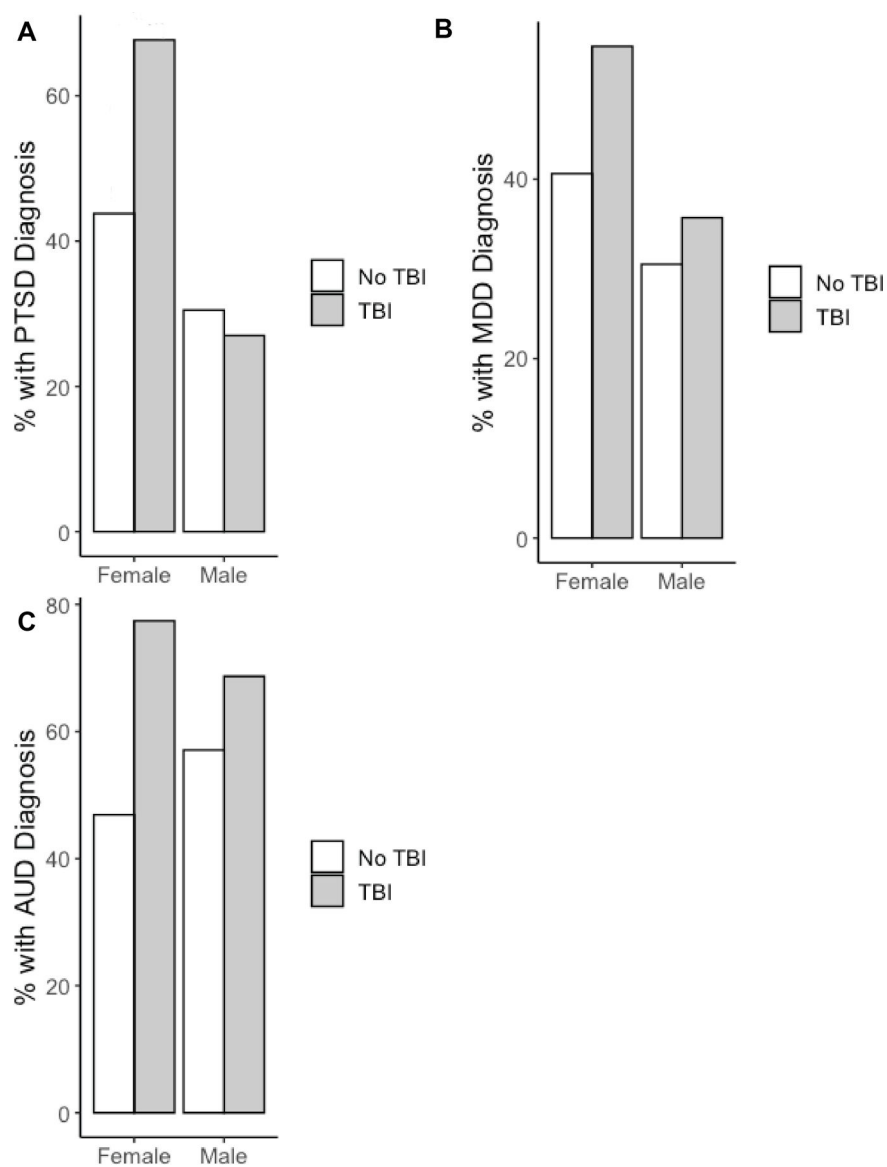


Figure 3.
TBI and lifetime psychiatric diagnosis in WI sample

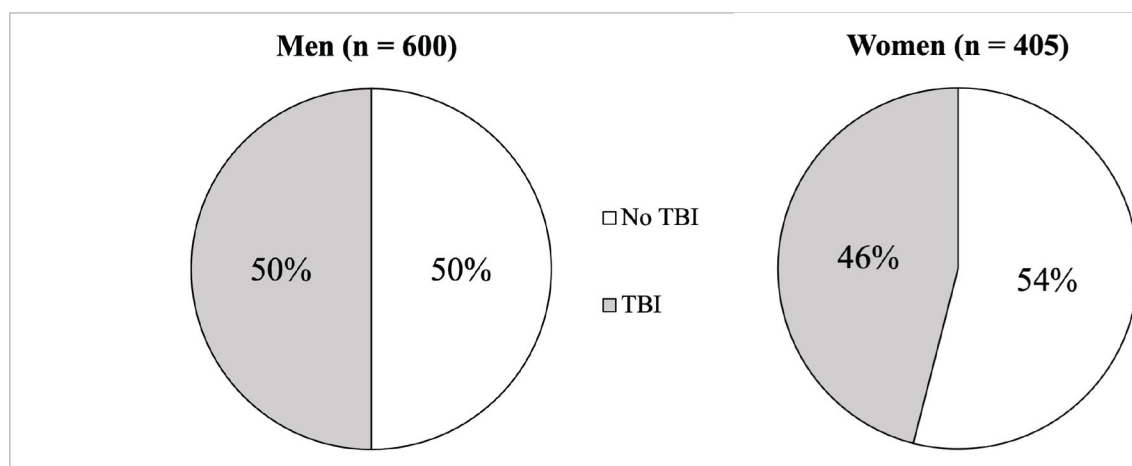


Figure 4.
Prevalence of TBI in NM sample

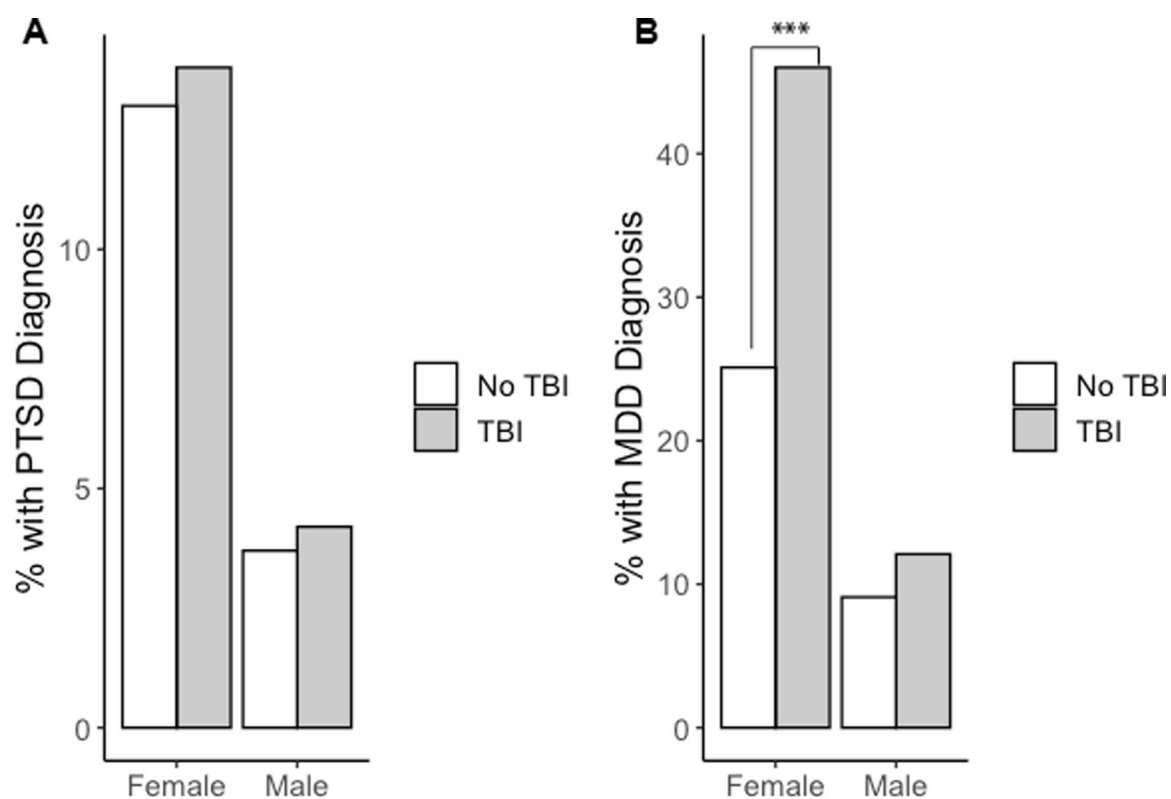


Figure 5.
TBI and lifetime psychiatric diagnosis in NM sample

Table 1.

Criteria for TBI Severity Classification

Mild TBI
<i>At least 1 of the following</i>
1. Any LOC < 30 minutes
2. Any loss of memory for events surrounding the injury
3. Any alterations in altered status (dazed, disoriented)
Moderate TBI
LOC > 30 minutes but < 24 hours
Severe
LOC > 24 hours

Table 2.

Number of TBI

# of TBI	Men <i>n</i> = 1064 <i>n</i> (%)	Women <i>n</i> = 405 <i>n</i> (%)
0	477 (44.8)	133 (32.8)
1	377 (35.4)	148 (35.7)
2	147 (13.8)	69 (17.0)
≥3	63 (5.9)	55 (13.6)
1 or more	587 (55.2)	272 (67.2)

Table 3.

TBI Severity

TBI Severity	Men <i>n</i> = 872 TBI <i>n</i> (%)	Women <i>n</i> = 471 TBI <i>n</i> (%)
Mild	708 (81.2)	368 (78.1)
Moderate	136 (15.6)	83 (17.6)
Severe	28 (3.2)	20 (4.3)

Table 4.

Male and Female Sample Characteristics

	Men			Women		
	mTBI n = 126 Mean (SD)	No TBI n = 195 Mean (SD)	p-value	mTBI n = 36 Mean (SD)	No TBI n = 42 Mean (SD)	p-value
Age	33.90 (7.95)	35.64 (8.92)	0.077	33.75 (7.52)	31.57 (8.16)	0.11
WASI-II	98.47 (12.35)	98.04 (12.48)	0.92	91.17 (10.86)	99.21 (10.46)	0.081
PCL-C	32.56 (11.86)	33.81 (13.41)	0.86	54.62 (16.73)	42.71 (14.00)	0.048
BDI-II	13.92 (8.37)	12.95 (9.38)	0.36	24.61 (13.63)	18.55 (11.39)	0.18
ASI	0.6 (.31)	0.51 (0.3)	0.092	0.64 (0.26)	0.46 (0.32)	0.19
MDD Diagnosis	41/115 (35.7%)	50/164 (30.5%)	0.37	17/31 (54.8%)	13/32 (40.6%)	0.26
PTSD Diagnosis	31/115 (27.0%)	50/164 (30.5%)	0.52	21/31 (67.7%)	14/32 (43.8%)	0.054
AUD Diagnosis	79/115 (68.7%)	94/164 (57.1%)	0.053	24/31 (77.4%)	15/32 (46.9%)	0.084
SUD Diagnosis	91/115 (79.1%)	127/164 (77.4%)	0.74	26/31 (83.8%)	22/32 (68.8%)	0.5
ASPD Diagnosis	53/115 (46.1%)	73/164 (44.5%)	0.79	13/31 (41.9%)	9/32 (28.1%)	0.5
Race						
Non-Hispanic White	65.87%	47.18%	0.0015	61.11%	57.14%	0.46
Black	22.22%	37.44%	0.0061	25%	16.67%	0.75
Hispanic	2.38%	8.21%	0.055	8.33%	4.76%	0.85
Other	9.52%	7.18%	0.59	5.56%	21.43%	0.032

Bold text indicates significant differences of corrected $p < 0.05$. Wechsler Abbreviated Scale of Intelligence Full-Scale IQ-II (WASI-II); Post-Traumatic Stress Disorder Checklist-Civilian Version-IV (PCL-C); Beck-Depression Inventory II (BDI-II); Addiction Severity Index (ASI). To see the demographics of each sample used across measures, see Table 1 in the Supplementary Materials.

Table 5.

Diagnoses and Symptoms of Mental Illness.

<i>Men</i>				
Dependent Variable	β	F	p	η_p^2
PCL-C (n=251)	0.011	0.032	0.86	0.0001
BDI-II (n=396)	0.046	0.84	0.36	0.0021
ASI (n=369)	0.081	6.45	0.092	0.017
WASI-II (n=373)	0.14	0.011	0.92	0
<i>Women</i>				
PCL-C (n=60)	11.24	8.37	0.049	0.13
BDI-II (n=83)	5.75	4.51	0.19	0.053
ASI (n=85)	0.15	4.82	0.19	0.055
WASI-II (n=84)	-6.16	6.68	0.096	0.075
<i>Total Sample Sex x TBI Interaction</i>				
PCL-C (n=311)	-10.94	8.13	0.042	0.026
BDI-II (n=479)	-4.9	4.37	0.22	0.0091
ASI (n=454)	-0.066	0.8	0.37	0.0018
WASI-II (n=457)	6.3	4.53	0.24	0.0099
SCID Analyses				
<i>Men (n=279)</i>	<i>b</i>	$\chi^2(1)$	<i>p</i>	OR
MDD	0.23	0.82	0.37	1.26
AUD	0.49	3.75	0.053	1.63
PTSD	-0.17	0.041	0.52	0.84
ASPD	0.064	0.068	0.79	1.07
SUD	0.1	0.11	0.74	1.1
<i>Women (n=63)</i>				
MDD	0.57	1.28	0.26	1.77
AUD	1.36	6.38	0.084	3.89
PTSD	0.99	3.71	0.22	2.7
ASPD	0.61	1.33	0.5	1.85
SUD	0.86	2.02	0.5	2.36

<i>Total Sample Sex x TBI Interaction (n=342)</i>				
MDD	-0.34	0.36	0.55	0.71
AUD	-0.87	2.07	0.15	0.42
PTSD	-1.17	4.01	0.27	0.311
ASPD	-0.55	0.88	0.35	0.58
SUD	-0.76	1.26	0.26	0.47

Bold text indicates significance. β = standardized coefficient; b = unstandardized coefficient (included for logistic regression); OR = odds ratio of TBI vs. No TBI. All results have been corrected for multiple-comparisons using Holm-Bonferroni corrections.

Table 6.

Number of TBI

# of TBI	Men <i>n</i> = 600 <i>n</i> (%)	Women <i>n</i> = 415 <i>n</i> (%)
0	299 (49.8)	224 (54.0)
1	188 (30.5)	122 (29.4)
2	62 (10.3)	50 (12.0)
≥3	56 (9.3)	19 (4.6)
1 or more	301 (50.2)	191 (46.0)

Table 7.

Male and Female Sample Characteristics

	Men			Women		
	TBI <i>n</i> = 266 Mean (SD)	No TBI <i>n</i> = 254 Mean (SD)	<i>p</i> -value	TBI <i>n</i> = 160 Mean (SD)	No TBI <i>n</i> = 193 Mean (SD)	<i>p</i> -value
Age	43.29 (8.96)	44.06 (9.19)	0.33	42.26 (8.55)	41 (8.23)	0.16
PTSD Diagnosis	4.50%	3.50%	0.57	13.75%	6.81%	0.068
MDD Diagnosis	12.41%	10.24%	0.43	46.25%	25.13%	<0.0001
Race						
Non-Hispanic White	28.95%	32.28%	0.47	30%	35.23%	0.29
Black	6.69%	11.02%	0.085	5.63%	7.77%	0.73
Hispanic	56.77%	48.43%	0.069	56.25%	49.22%	0.23
Other	7.89%	8.27%	1.00	8.13%	7.77%	1.00

Bold text indicates significant differences of Holm-Bonferroni corrected $p < 0.05$.