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Mental Health Problems, Traumatic Brain Injury, and Offending Behavior Among Persons Incarcerated in a County Jail

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by

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ABSTRACT

Previous work has found that although mental illness is positively related to offending behavior, it is a fairly poor predictor of aggression, violence, offending, and recidivism after controlling for sociodemographic and historical risk factors (i.e., criminal history, age, race, gender). This refutes the model that mental illness is a direct cause of crime. Instead, risk for recidivism or crime related to mental health problems may be higher when combined with other risk factors. The current study evaluated traumatic brain injury (TBI) and associated symptoms of post-concussion syndrome (PCS) as potential moderators of the relationship between mental health problems and concurrently assessed aggression, violence, and criminal history, as well as prospective 1-year recidivism. Results indicated that mental health problems and number of TBIs were related cross-sectionally to aggression and to a more violent and extensive criminal history, respectively, even after adjusting for each other and sociodemographic factors. In terms of future risk of re-arrest, PCS but not number of TBIs was related to an increased rate of rearrests over 1 year. There was little evidence that TBI or PCS moderated relationships between mental health problems and aggression, violence, or arrest. Instead, results suggested independent and somewhat modest relationships of mental health problems and TBI with offending behavior and recidivism, and that these influences exist amidst a number of other contextual risk factors. Results also suggested that ongoing PCS following injury may be more important in predicting future offending behavior than number of injuries, as it may be more reflective of an individual's current functioning.

INTRODUCTION

There is a belief among the general public that incarceration should be rehabilitative and lead to prevention of future crime (Cullen et al., 2000). There are few data to support reformative effects of imprisonment, however, with previous work instead indicating consistently high rates of recidivism (new arrests following release) in the United States. For example, results of one study indicated that as high as 64% of individuals released from jail were rearrested in the year following their release (Hastings et al., 2011). Recidivism is particularly problematic post-release from jails, in comparison to prisons. Individuals housed in jails are held in pre-trial detention, sometimes because they cannot bond out, or carry sentences of less than one year. This leads to increased frequency of releases and re-arrests, and has led some to assert that jails have a "revolving door" (Baillargeon et al., 2009). Jails are also routinely overcrowded, exacerbating conditions for persons who are incarcerated, correctional officers, and staff, which further strains resources (Shaw, 2015; Tafoya, 2015; Walsh, 2013).

Recidivism is, of course, a complex problem, but a logical first step in attempting to reduce rates of reoffending is examining factors that may increase risk. It is established that an individual's history of offending and aggression is a key risk factor for future crime and recidivism (Bonta et al., 1998; Swogger et al., 2015). As such, identifying variables associated with more extensive, violent, or aggressive criminal histories may aid in efforts to understand the avenues through which some individuals may repeatedly return to custody, and do so in a violent and aggressive manner. The current study focused on identifying mental health and

neurodisability correlates of aggression, violence, and criminal history, and on predicting recidivism in a large sample of individuals held in a non-urban jail.

Mental Health and Criminal Justice Involvement

Previous studies have investigated a range of psychological variables such as personality, substance use, traumatic experiences, and mental illness (e.g., Bonta et al., 2014; Bonta et al., 1998; Edens et al., 2001; O'Riordan & McConnell, 2014; Steiner et al., 2011; Widom, 1989), in addition to sociodemographic and historical variables (e.g., age, race, gender, and prior criminal history; Cunningham et al., 2005; Gendreau et al., 1996; Piquero et al., 2015), in predicting offending behavior. Diagnoses of mental illnesses (i.e., schizophrenia, bipolar disorder, personality disorders) and mental health problems (symptoms and behaviors associated with psychological distress[1]) have received particular attention in the search for recidivism predictors and offending correlates (Lovell et al., 2002; Skeem et al., 2014; Steiner et al., 2011; Wilson et al., 2011). The focus on mental health problems as predictors of behavior and recidivism is likely driven by the increased rates of mental health problems among incarcerated populations. Indeed, mental health problems are highly prevalent among individuals in jail, with as high as 77% of men and 74% of women in jail reporting mental health problems that are more severe than 96% of the general population (Drapalski et al., 2009). Mental health problems have also been associated with increased rates of aggression, violence, and recidivism (Becker et al., 2012; Ostermann & Matejowski, 2014; Rosenblatt et al., 2000; Silver et al., 2008; Sullivan et al., 2007). Incarcerated persons with serious mental illness (major depressive disorder, bipolar disorder, psychotic disorders) are more likely to experience multiple incarcerations, and substantially decreased time between periods of incarceration (Baillargeon et al., 2009; Cloyes et

[1] The broader term of mental health problems, instead of mental illness or specific diagnostic categories, is used in this paper to refer to a wide spectrum of general psychological functioning.

al., 2010; Skeem et al., 2011). Rates of re-arrest for individuals with mental health problems are also typically higher than those for individuals without these (Feder, 1991; Silver et al., 1989). Importantly, increased arrest and recidivism rates among individuals with mental health problems may partially stem from increased contact with law enforcement officers, who are often called for service in mental health crisis situations (Godfredson et al., 2011; Markowitz, 2011; Wood & Watson, 2017), and are also more likely to view individuals with mental health problems as more threatening and dangerous (Markowitz, 2011; Watson et al., 2004).

In seeming contradiction with established relationships between mental health problems and criminal justice contact, mental health problems have been found to add little to criminal risk assessments, when compared with the predictive utility of sociodemographic and behavioral risk factors, such as prior history of criminal/juvenile delinquency, younger age, and lower employment/education level (Bonta et al., 2014; Bonta et al., 1998; Cunningham et al., 2005; Gendreau et al., 1996; Skeem et al., 2014). These findings refute the model that mental health problems are a direct cause of offending behavior. This contradiction (mental health problems are associated with higher re-arrest but weak predictors of criminality) can be reconciled when considering prior work suggesting that mental health problems may interact with a confluence of other, compounding variables to exacerbate risk of offending (Douglas et al., 2009; Link et al., 2016; Skeem et al., 2014; Swanson et al., 2002; Witt et al., 2013). That is, individuals with mental health problems have a greater number of general risk factors (i.e., substance use, homelessness, witnessing violence, lower education/employment) for aggression, violence, and offending, and these other risk factors serve to compound risk and contribute to more extensive involvement in the criminal justice system (Bonta et al., 1998; Monahan et al., 2001; Peterson et al., 2014; Skeem et al., 2014; Steadman et al., 1998; Swanson et al., 2002; Walters et al., 2014).

One such compounding factor may be traumatic brain injury (TBI), which has been linked to both offending behavior and mental health problems fairly consistently (Kuukkainen et al., 2012; Corrigan & Deutschle, 2008; Hibbard et al., 1998; Slaughter et al., 2003; Williams et al., 2010; Williams et., 2018). Despite these links between TBI and crime, there has been a very limited focus on TBI as a predictor of recidivism, and no prior examinations of TBI as a compounding factor in the relationship between mental health problems and offending behavior. The current study sought to examine the relationships between mental health problems, TBI, and offending behavior (criminal history, aggression, violence), and specifically, the extent to which TBI would interact with mental health problems to increase risk for approximate 1-year recidivism, after controlling for other established risk factors (i.e., substance use, sociodemographic characteristics).

Traumatic Brain Injury and Crime

Much of the literature has defined TBI as any alteration in brain functioning, including (but not limited to) memory loss, aphasia, and confusion, that is caused by an external force (Menon et al., 2010). External forces can include the head being struck by an object, penetration of the brain by a foreign object, acceleration/deceleration-related brain movement without direct external trauma (i.e., severe whiplash, coup contrecoup injury), or blast/explosion-generated forces (as are common in military-related TBIs; Menon et al., 2010). TBI is diagnosed based on the presence of post-injury amnesia, loss of consciousness, or other neurological deficits following an injury to the head (Menon et al., 2010). Evidence of brain pathology (i.e., imaging evidence of damage) is not required to diagnose TBI and may not be sensitive enough to capture damage resulting from mild TBI (Menon et al., 2010). Though head injuries may include TBIs, it

is generally agreed that use of the term "head injury" is imprecise, as it could include damage to the scalp or skull rather than the brain. For this reason, the current study adopts the term TBI.

TBIs can range from mild to severe, depending on post-injury length of loss of consciousness (from less than 30 minutes to more than 24 hours) and of amnesia (from less than 24 hours to 7 days or greater; Carlson et al., 2011; Escorpizo et al., 2016; Peterson,et al., 2019; Vakil, 2005). TBIs usually result in a combination of physiological, cognitive, and behavioral symptoms, such as headaches, memory loss, and fatigue (Escorpizo et al., 2016; Lundin et al., 2006). The experience of one or more symptoms from these domains (physiological, cognitive, and behavioral) following TBI is commonly referred to as post-concussion syndrome (PCS; Silver & McAllister, 1997). Though the term concussion generally refers to mild TBI, PCS has been found to occur following TBIs of any severity (Arciniegas & Silver, 2001; Davies et al., 2012; Gordon et al., 2000; Mittenberg & Strauman, 2000; Sigurdardottir et al., 2009; Silver & McAllister, 1997). PCS can persist for months or, in more severe cases, years following injury as well, making TBI a leading cause of long-term disability (Fleminger & Ponsford, 2005; Zaloshnja et al., 2008) stemming from psychosocial, cognitive, and/or physical impairment (e.g., Andelic et al., 2010; Hillier et al., 1997; Perkes et al., 2011). PCS can significantly impact individuals' lives financially, socially, and psychologically (Colantonio et al., 2004; McMillan et al., 2012).

Rates of TBI are disproportionately high among incarcerated samples, with prevalence of upwards of 51% among incarcerated adults, compared to 8-12% among the general population (Farrer & Hedges, 2011; Fox et al., 2019; see Williams et al., 2018 for a review). Individuals involved in the criminal justice system are also more likely to suffer from multiple TBIs, and to report significantly more persistent PCS (i.e., ongoing headaches, memory loss, confusion;

Williams et al., 2010). Available research indicates that a greater number of TBIs are associated with more violent convictions (Brewer-Smyth et al., 2004; Fazel et al., 2009; Pitman et al., 2015; Williams et al., 2010), and in a large study of adolescents in Finland, the prevalence of violent crime was 43% among individuals with TBI compared to 9% in individuals without TBI, or an almost six-fold increased likelihood (Luukkainen et al., 2012). A similar study of Swedish adults indicated a little over a three-fold increased risk for violent offending associated with TBI (Fazel et al., 2011). Further, untreated head trauma during youth was found to differentiate violent and non-violent adults in prison (León-Carrión & Ramos, 2003). TBI has also been associated with increased risk for interpersonal violence (physical fights), even after controlling for alcohol and marijuana use, delinquency, and witnessing violence (Stoddard & Zimmerman, 2011). Therefore, prior work indicates that TBI has a positive relationship with crime and especially violent crime.

Although TBI has been associated with a history of committing multiple offenses (Williams et al., 2010), to our knowledge, few studies have examined this prospectively, including the predictive utility of TBI in terms of future crime or recidivism. In one study, Ray and Richardson (2017) found that individuals with TBI released from a U.S. prison were 1.57 times more likely to recidivate after one year than individuals without TBI (Ray & Richardson, 2017). Another prospective study found that head injuries sustained during the study period (7 years post-release) were associated with a 68% increase in general recidivism (2.12 times more likely than cases with no head injuries) and 65% increase in self-reported violent recidivism (1.85 times more likely; Schwartz, 2019). However, prior work on TBI and criminal recidivism has yet to examine potential effects of ongoing PCS (e.g., continuing to experience headaches, memory loss, etc., after the initial injury). Because these symptoms are likely more indicative of

the long-term impact of TBI (King & Kirwilliam, 2011, 2013), there is reason to believe that severity of PCS is more predictive of re-offending than just having a history of TBI. The current study is one of the first to examine TBI, especially PCS, as a predictor of recidivism. TBI also has yet to be incorporated into models predicting criminal risk associated with mental health problems, above the influence of established risk factors like sociodemographic factors and prior behavior, among individuals in jail.

Relevance of TBI for Mental Health and Crime Outcomes

Although various psychological or sociodemographic factors may exacerbate risk for re-offending among persons with mental health problems, the focus on TBI in this paper is deliberate. TBI may be a particularly important risk factor for offending behavior because of the constellation of difficulties that can follow injury. TBI has links to cognitive deficits (e.g., impaired problem solving, self-monitoring, and impulse control), emotion dysregulation, and personality change (e.g., unpredictable response patterns, increased irritability and anger; see McAllister, 2008 for review), all of which can be associated with increased difficulty controlling one's behavior (Banich et al., 2009; Scott et al., 2014; Shields & Cicchetti, 1998; Wilkowski & Robinson, 2008). It is common for TBI to be associated with several different difficulties; 95% of individuals report experiencing more than one PCS symptom, and 74% report more than three symptoms (Dikmen et al., 2010). The combination of difficulties associated with TBI may predispose an individual to greater risk for engaging in offending behavior than the presence of one of these features alone. For example, an individual with a TBI may experience an increase in risk related to a combination of increased impulsivity, emotion dysregulation, and irritability. In this way, the presence of several different TBI-related difficulties may heighten risk beyond the risk associated with just one of these features (e.g., impulsivity).

Further, a combination of cognitive, emotional, or behavioral difficulties following TBI may magnify risk for offending behavior associated with mental health problems. That is, it may be that emotion dysregulation or deficits in impulse control associated with mental health problems constitute some risk for offending (Nestor, 2002), but when combined with PCS, the difficulties associated with mental health problems may be more strongly related to aggression, violence, offending behavior, and recidivism. More colloquially, an individual with combined TBI/PCS and mental health problems may have greater difficulty applying the "brakes" on their emotional and behavioral responses than an individual with mental health problems alone.

It is also important to investigate TBI and PCS in relation to offending behavior because of the potential for intervention. Treatment of TBI symptoms or PCS within prisons and jails in the U.S. is rare, as the United States does not routinely assess, manage, or support persons with TBI who are incarcerated (Allely, 2016). Some countries outside of the U.S. have employed programs targeting TBI within correctional facilities. Although more research is needed to determine the impact of these interventions, early results are promising, showing better integration into the community post-release and a lack of disciplinary infractions during incarceration (Ramos et al., 2018). Should TBI be predictive of recidivism, as we hypothesize and as previous literature suggests (Ray & Richardson, 2017; Schwartz, 2019), rehabilitation or treatment services within correctional facilities or upon release may be important in reducing recidivism. Further, the potential relationship between TBI and mental health problems may better inform rehabilitation and treatment services for a unique but potentially large portion of incarcerated persons, as individuals with mental health problems *and* TBI/PCS likely have different needs from those who have experienced mental health problems or a TBI alone.

Current Study

Historically, previous research, interventions, and public opinion regarding offending behavior and recidivism have focused on a model of mental health problems causing aggression, violence, and/or offending (Batastini et al., 2017; Cuellar et al., 2006; Knoll & Annas, 2016; Link et al., 1999; Peterson et al., 2014; Torrey, 2011). However, other research has suggested that the assumption that mental illness directly causes offending behavior is oversimplified, and that this relationship is more complex (Metzl & MacLeish, 2015; Skeem et al., 2013; Swanson et al., 2002). Focusing on mental health problems as a cause of violence, aggression, and offending reinforces stigma around mental illness (Corrigan et al., 2004; Corrigan & Watson, 2005), and also acts as a barrier to developing and implementing more useful interventions.

TBI is rarely included in models predicting risk for recidivism. In fact, the current study is one of the first investigations of TBI as a predictor of prospective recidivism (Ray & Richardson, 2017; Schwartz, 2019), and the first examining lingering PCS in this capacity. Even further, this study is the first to examine the interaction between TBI and mental health problems in relation to aggression, violence, and offending behaviors, and as predictors of recidivism. Finally, this study is unique in its utilization of a large sample of individuals in jail and multimethod assessments of offending behavior, including official court records of criminal arrest history, cross-sectional self-report and interview ratings of aggression and violence, and official court records of prospective general and violent re-arrests.

Aims and Hypotheses

In light of the aforementioned gaps in the literature, the current study aimed to 1) analyze interrelationships between mental health problems, TBI and lasting PCS, measures of aggression and violence (i.e., trait aggression, history of violence, official records of criminal arrests), and

prediction of approximate 1-year general and violent recidivism; and 2) investigate to what extent TBI moderates the relationship between mental health problems and approximate 1-year recidivism. Most of these analyses used a large sample of participants screened at booking, except that analyses on history of aggression and violence were conducted using a smaller subset of participants who were administered a more thorough clinical assessment protocol (see Method section).

Aim 1

The first aim furthered our understanding of the unique roles of mental health problems and TBI in relation to aggression and violence, offending behavior, and recidivism. Hypotheses were as follows:

Hypothesis 1.1. In accordance with prior literature, we expected that mental health problems—the symptoms and behaviors associated with psychological distress—would be positively related to aggression, violence, and criminal history.

Hypothesis 1.2. However, we predicted that when a model was run accounting for sociodemographic and historical risk factors (substance use problems, age, gender, and education/employment history), mental health problems would offer little utility in predicting approximate 1-year violent and general recidivism.

Hypothesis 1.3. Given prior research indicating increases in impulsive and violent behavior post-TBI (e.g., Farrer, Frost, & Hedges, 2013; Fazel et al., 2011; Williams et al., 2010), we predicted that TBI (operationalized as number of injuries and severity of lasting PCS) would be positively related to aggression, violence, and criminal history.

Hypothesis 1.4. We further expected that TBI would predict prospective general and violent recidivism, even after controlling for several established risk factors: substance use problems, mental health problems, age, race, gender, and education/employment history.

Aim 2

For the second aim of the current study, we investigated TBI as a compounding risk factor in the relationship between mental health problems and violence, aggression, and criminal history, as well as general and violent recidivism. Hypotheses were as follows:

Hypothesis 2.1. We hypothesized that TBI would interact with mental health problems in the statistical prediction of violence, aggression and criminal history. We expected that the combination of TBI and mental health problems would relate to offending behavior, even after accounting for established risk factors.

Hypothesis 2.2. We expected that the combination of TBI and mental health problems would predict approximate 1-year general and violent recidivism, even after accounting for established risk factors.

Hypothesis 2.3. Finally, we predicted that lasting PCS would especially moderate relationships between mental health problems and offending behavior and approximate 1-year violent and general recidivism.

Exploratory Analyses

Additional analyses for Hypotheses 1.1 and 1.2 were conducted separately using different subscales of mental health problems as predictors (i.e., depressed-anxious, somatic complaints, suicidal ideation, thought disturbances, and traumatic experiences; see Method section).

In an attempt to capture some potential additional variance in TBI severity, we conducted supplemental exploratory analyses under Hypotheses 1.3 and 1.4 and all Aim 2 Hypotheses

using several additional operationalizations of TBI severity. These additional variables included age of self-reported most severe injury, duration of loss of consciousness, and hospitalization from injury. Further, previous work suggests that the severity of PCS typically declines as time post-injury increases, with more recent injury being associated with greater PCS symptoms (Røe et al., 2009; Sigurdardottir et al., 2009). As such, the current study included years elapsed between self-reported most severe injury and assessment date as an additional covariate in exploratory analyses involving PCS.

METHOD

Data for the present study were collected as part of a larger, ongoing two-phase study conducted at a county jail (see Fox et al., 2019 for more in-depth description of the larger study). Data collection was conducted in collaboration with the county's sheriff's office, to help inform classification/housing decisions and better understand needs and risk among persons incarcerated in the jail. The focus of the broader study was to investigate criminogenic and psychological risk factors for recidivism using broad screening measures as well as in-depth clinical interviews.

Participants

The current study includes 759 participants (67.6% male, $n = 513$) from the broad risk assessment phase of the study, referred to here as Phase 1, and 113 participants (69.9% male, $n = 79$) from Phase 2, involving clinical interviews and surveys conducted on a subset of Phase 1 participants. Participation for this study occurred between November 19th, 2018 and December 10, 2019. Participants were excluded if they were not able to speak and understand English well or were below the age of 18. The study had no other exclusion criteria. Participants were primarily white and in early adulthood, and mostly employed in low/mid income manual labor jobs (see Table 1 for complete demographic information). Participants were either pre-trial detainees or were serving sentences of one year or less.

Procedures

Phase 1 Broad Risk Assessment

Participants completed the broad risk assessment phase of the study upon being booked into the jail. Participants were recruited for participation if the timing of their booking coincided

with the timing of a data collection shift. Data collection shifts occurred at various times per day (ranging from 7:00 AM to 10:00 PM) and across six days per week (Monday through Saturday). Trained undergraduate students administered a battery of questionnaires on either an electronic tablet or paper forms to participants. Questionnaires included self-report measures of sociodemographic characteristics, pro-criminal attitudes, personality traits, mental health and substance use problems, adverse childhood experiences, and TBI (see Appendix A for a complete list of measures). The questionnaire battery took a total of 20-40 minutes to complete. After completing the surveys, participants were asked whether they consented to use of the data (which was collected as part of the USF-Pasco Jail collaboration) for research purposes. They were provided informed consent information, assured that such permission was completely voluntary and not communicated to the jail or anyone else, and were given the option to refuse use of their data for research purposes. Of the 848 total assessments completed, 71 individuals did not consent for use of their data in this research, 6 completed the survey during two different time points (for which the first assessment was retained), 8 were assigned IDs that did not align with participant names and could not be determined to be duplicates or new entries and therefore were not retained, and 4 were excluded due to validity concerns (i.e., falling asleep during administration, spending less than 10 minutes on the surveys, admitting answers were not truthful), leaving the current study with 759 participants with usable Phase 1 data.

Phase 2 Clinical Assessment

A list of participants who had completed Phase 1 was compiled and updated after each Phase 1 shift. From this list, a subset of participants who were still in custody at the jail and were available for interview (i.e., not in a medical unit, solitary confinement, programming, etc.) were asked to participate. As with the broad risk assessment phase, research consent was obtained

following the interview, but participants were informed prior to the interview that it would take approximately three hours and would be a combination of interviews and questionnaires. Participants were free to refuse the interview, and a substantial portion did (n = 99) and were returned to their housing units[2]. The 113 participants who agreed were administered the assessments described below. See Figure 1 for graphic representation of the participant recruitment process across both study phases.

Measures employed in this phase consisted of an assessment of cognitive and intellectual functioning; interviews assessing psychopathic personality, history of violence, suicidality and diagnostic symptoms of major depression, bipolar disorder, and psychotic disorders; and questionnaires assessing personality disorders, worry, aggression, substance use, anxiety and depression, self-harm, and trauma symptoms (see Appendix B for a complete list of measures). All interviews took place in attorney visitation rooms. Secondary raters (trained undergraduate students, graduate students, or principal investigators) were present for 29.2% of clinical interviews to provide inter-rater reliability. All ratings were made either during the interview session (while participants completed self-report questionnaires) or following the interview session before leaving the jail facility.

Measures

The majority of measures below were completed at Phase 1 and thus were administered to the larger sample of participants.

[2] Individuals who refused Phase 2 interview did not differ in PCS scores, number of TBIs, or demographic variables. Those who refused had significantly lower scores on the MAYSI mental health problems (M = 9.92, SD = 6.25) and substance use (M = 2.89, SD = 2.65) than individuals who agreed to the Phase 2 interview (Ms = 12.01 and 3.84, SDs = 6.47 and 2.57,respectively).

Control and Predictor Variables (Phase 1: n = 759)

Demographic Information. Participants completed a brief questionnaire assessing demographic variables including zip code, age, race, ethnicity, gender, marital status, household income, level of education, and occupation. Only age, race, gender, and education level were included in analyses for the current study. Age was coded continuously in number of years. Race was categorically coded to reflect racial minority status (coded as 1) versus white (coded as 0). Gender was also coded categorically (1 = man, 2 = woman), and education level was coded ordinally (1 = dropped out before or in high school, 2 = high school diploma or GED, 3 = some college, 4 = Bachelor's degree or higher).

Substance Use and Mental Health Problems. The Massachusetts Youth Screening Instrument-2 (MAYSI; Grisso & Barnum, 2000) is a self-report risk assessment measure designed for use among individuals involved in the criminal justice system. The current study employed a version of the MAYSI that has been adapted for use among criminal-justice involved adults (see Grisso et al., 2003). It contains seven subscales: alcohol and drug use, angry-irritable, depressed-anxious, somatic complaints, suicidal ideation, thought disturbances, and traumatic experiences. All items are dichotomous questions, with a "Yes" scored as 1 and a "No" scored as 0. Sample items include "Have you heard voices other people can't hear?" (thought disturbances subscale) and "Have you felt lonely too much of the time?" (depressed-anxious subscale). Substance use was operationalized as scores on the alcohol and drug use subscale, which were included in analyses as a covariate. The angry-irritable subscale was not included in analyses due to overlap with aggression and with the increases in anger and irritability associated with PCS. Scores on the remaining subscales (depressed-anxious, somatic complaints, suicidal ideation, thought disturbances, and traumatic experiences) were summed to create a composite mental

health problems score. Reliability for composite mental health problems scores in our sample was excellent (α = .92), and reliability for the MAYSI subscales ranged from poor (α = .58; though disturbances subscale) to good (α = .83; suicidal ideation subscale).

TBI. Presence of TBI and lasting PCS was assessed using the TBI section of the neurodisability scale of the Comprehensive Health Assessment Tool (CHAT; Chitsabesan et al., 2015)[3]. The CHAT is a screening tool used to assess health needs among individuals involved in the criminal justice system. It contains four scales: physical health, mental health, substance misuse, and neurodisability. The TBI section asks participants whether they have ever had a head injury that caused them to be knocked out and/or dazed/confused. Participants who answer "yes" to the first question were asked how many times total they've had head injuries resulting in a loss of consciousness or feeling dazed/confused. Participants were then asked how many times they've had TBIs resulting from each of the following categories: road accident, fall when sober, fall when under the influence of drugs/alcohol, sports injury, fight, or other (allowing participants to fill in injury cause type). For each category, participants were asked to think of the worst injury in that category, report their age at the time of that injury, and whether the injury resulted in hospitalization. If participants indicated a loss of consciousness, they were then asked how long the loss of consciousness lasted.

Finally, participants were asked to rate the extent to which they currently suffer from the following PCS symptoms: headaches, dizziness, nausea and/or vomiting, forgetfulness, poor concentration, confusion, brain fog, and difficulty recalling everyday events. The degree to which each symptom was problematic for the respondent at the time of assessment was rated on

[3] It is important to note that while our assessment of TBI is in agreement with the accepted definition, our measurement does not include interview by clinicians and therefore should not be considered diagnostic. Instead, our measurement of TBI assesses whether a head injury occurred that resulted in symptoms typical of TBI.

a 5-point Likert scale, from 1 (not at all) to 5 (a severe problem). Scores for each symptom were summed to create an overall lasting PCS score. Reliability for this overall PCS score was good (α = .89). For use in exploratory analyses, the amount of time between each participant's most recent self-reported worst injury and their assessment date was calculated.

Criminogenic Risk Factors. Antisocial peer association and low self-control have been well-established in the criminology literature as predictors of offending behavior (Burgess & Akers, 1966; DeLisi & Vaughn, 2008; Gottfredson & Hirschi, 1990; Moffitt et al., 2011; Monahan et al., 2009). To control for these established criminogenic risk factors, two items assessing criminal peer association and three items assessing self-control were administered to participants. For each of these items, participants rated their agreement with statements on a Likert scale from 1 (strongly disagree) to 4 (strongly agree). Criminal peer association items were drawn from Burgess & Akers (1966) and asked participants to rate their agreement with the following two statements: 1) At least one of my close friends has done something I know to be illegal in the past 6 months, and 2) At least one of my close friends has suggested that I do something that I know to be illegal in the past 6 months. Scores on criminal peer association items were summed and included as a covariate in exploratory analyses. Reliability of the criminal peer association scale was acceptable (α = .72). Scores on three items measuring self-control were drawn from Grasmick and colleagues' (1993) Low Self-Control Scale. Items used to assess self-control include 1) I act on the spur of the moment without stopping to think, 2) I do things that bring me pleasure here and now, even at the cost of some future goal, and 3) I'm more concerned with what happens to me in the short run than in the long run. Scores on these items measuring self-control were summed and entered as a covariate in exploratory analyses. Reliability for the self-control scale was also acceptable (α = .70).

Offending Behavior [4]

Criminal History (*n* = 759). Trained undergraduate and graduate students coded criminal history for each participant using official public records. Public records were checked for a series of counties neighboring the county in which participants were originally arrested (see Appendix C for a complete list of counties searched), in addition to counties in which participants reported being arrested, as reported in Phase 1 sociodemographic questionnaire. Only counties within the state of Florida were searched due to the ease of access of Florida public records. The total number of arrest incidents and the total number of arrest incidents involving violent offenses were summed to reflect how extensive and violent each individual's criminal history was. As with the coding of index offenses, assault, battery, murder, attempted murder, manslaughter, sexual battery, rape, and robbery were coded as violent. All other offenses were coded as non-violent.

The current study operationalized both criminal history and recidivism as number of arrests because convictions can take several months following an arrest, and therefore would have limited the data available for coding during the recidivism period. Further, conviction can often be the result of a long and discretionary process involving plea bargaining and sentencing, which may alter the appearance of a charge on one's criminal record, and may be subject to biases (i.e., racial, socioeconomic; Besemer et al., 2013; Rehavi & Starr, 2014). Prior work has also suggested that defining criminal history and recidivism as convictions and reconvictions likely results in underestimated crime and recidivism rates (see Fortune & Lambie, 2006 for review). Finally, and perhaps most importantly, the aims of the current study centered on the

[4] Data from each participant's index offense (offense for which they were arrested for at the time of assessment) were also collected and coded as violent or non-violent. These data were still being analyzed and are not included in results. Criminal history and recidivism data are likely better indices of offending behavior and, as count variables, allow greater variance in data than index offense, a binary variable.

relationships between mental health problems, TBI, and offending *behavior*, rather than conviction or sentencing. Arrests provide the best proxy for behavior, without the influence of processes involved in conviction and sentencing processes. However, it is important to acknowledge that arrests are subject to over-policing and biases as well, particularly racial bias (Kamalu, 2016; Lum & Isaac, 2016).

Recidivism (*n* = 627). Recidivism was measured across a period of at least 1 year following each participant's release from the jail facility following their Phase 1 assessment. Trained undergraduate research assistants queried county public records for incidents of re-arrest in the same manner used for criminal history coding. Again, only counties within the state of Florida were searched. Recidivism has been defined in several different ways across previous studies, with the most common definitions including post-release arrests, convictions, and violations of conditional release (Cottle et al., 2001; Hemphill et al., 1998; Skeem & Lowenkamp, 2016). General recidivism was coded as the number of arrests (all charges under the same date was considered 1 arrest) that occurred within the recidivism time period, including arrests for violent offenses. Violent recidivism was coded as the number of arrests that included an assault, battery, murder, attempted murder, manslaughter, sexual battery, rape, or robbery charge that occurred during the recidivism time period. Although some studies have operationalized recidivism as number of post-release charges rather than post-release arrests, the aim of assessing recidivism in the current study was determining the frequency of behavior that may lead to a person returning to jail or prison custody. Arrests measure how many separate occasions a person may be rearrested on, while charges may assess the scope of a particular incident. For example, an individual may be charged with several crimes during one particularly severe incident, resulting in several different charges. This incident, however, would likely result

in one return to custody (one rearrest). Measuring recidivism using number of charges could lead to the appearance that one is engaging in offending behavior more often, even though all charges could stem from one incident.

Not all participants screened in Phase 1 were be released by December 10th, 2019 to allow for at least a 1-year long recidivism period. Participants who were never released following their Phase 1 assessment by December 10th, 2019 (n = 128), including the 28 participants who went from jail straight to prison following their Phase 1 arrest, were excluded from recidivism analyses due to lack of opportunity to recidivate (i.e., still incarcerated). Additionally, for several participants (n = 4), the arrest related to the Phase 1 assessment could not be found in public records. These participants were excluded due to inability to determine the release date following the Phase 1 arrest and therefore the length of the recidivism period. This resulted in a final sample size of 627 for recidivism analyses.

Recidivism coding was completed through December 10th, 2020. Recidivism checks were conducted on a rolling basis based on participant release date following Phase 1 assessment (i.e., recidivism checks for participants with the earliest release dates were conducted first) and included the period between release and the date of coding. The recidivism period was always at least 1 year long, but because participants were released at different times, the length of additional time beyond the 1-year mark in this period varied. The length of the recidivism period (in weeks), which ranged from 52 weeks (0 additional weeks beyond one year) to 74 weeks (22 additional weeks beyond one year), was recorded. We also recorded dates of re-arrests and releases (either jail or state prison detentions, determined based on additional searches of the Department of Corrections public records) during the recidivism period. Any time spent incarcerated during the recidivism period (i.e., no opportunity to re-offend) was summed and subtracted from the total length of the

recidivism period to create a score reflecting the amount of time at risk for re-arrest. This time at-risk score (in weeks) was controlled for in analyses. In addition to number of general and violent re-arrests, time to recidivate (in weeks) was calculated by subtracting each participant's release date following Phase 1 assessment from the date of each participant's first re-arrest.

Aggression and Violence (Phase 2: n = 110)

History of Violence. The Lifetime History of Aggression interview (LHA; Coccaro et al., 1997) was conducted and rated during Phase 2 interviews. The 10-item interview was developed for the purposes of reliably assessing acts of violence since the age of 13. The LHA contains 3 subscales: aggression, self-directed, and consequences. The aggression subscale is comprised of items reflecting violence toward others and property; the self-directed subscale reflects aggression toward the self; and the consequences subscale assesses the extent to which the individual has experienced functional impairments (i.e., academic, occupational, legal problems) as a result of acting aggressively and antisocially. Items were rated on a scale from 0 to 5 according to how frequently the individual reported engaging in a given behavior since age 13 (from "Never" to "Too many times to count"). Total aggression scores were generated from summing the scores for each of the ten items. For the purposes of the current study, only the aggression subscale and the total aggression scores were used in analyses, as the self-directed and consequences subscales are not relevant to our aims. Reliability in our sample for LHA total aggression ($\alpha = .75$) was acceptable. Reliability for the aggression subscale ($\alpha = .60$) was questionable, though this may have been due to this subscale containing only five items.

Trait Aggression. The Aggression Questionnaire (AQ; Buss & Warren, 2000) is a 34-item self-report measure used to measure dispositions toward aggression and hostility, administered during Phase 2. In addition to a total score, the measure contains five subscales:

physical aggression, verbal aggression, indirect aggression, anger, and hostility. Participants were asked to indicate the extent to which they generally feel or act a certain way in their current, everyday life on a 5-point Likert scale ranging from "Not at all" to "Extremely." Sample questions from the first three subscales of the AQ include, respectively, "My friends say that I argue a lot" (verbal); "I may hit someone if he or she provokes me" (physical); and "When people are bossy, I take my time doing what they want, just to show them" (indirect). Reliability for AQ in our sample ranged from questionable ($\alpha = .66$; indirect subscale) to excellent ($\alpha = .94$; total score).

Data Analysis

Aim 1

Aim 1 hypotheses were investigated first using a zero-order correlation matrix to present relationships between mental health problems (MAYSI) and the following variables: aggression (AQ) and violence (LHA), criminal history (number of prior arrests), and general and violent recidivism (number of rearrests and time to rearrest). For Hypotheses 1.1 and 1.2, a series of regression models were conducted. In these models, age, race, gender, education level, number of prior arrests (only in models not involving criminal history dependent variables), and scores on the MAYSI alcohol and drug use subscale were included as covariates.

Multiple linear regression was used to examine relationships between MAYSI composite mental health problems scores and continuous scores on the aggression and violence dependent variables assessed in Phase 2 (LHA and AQ). For analyses of the count variables, including criminal history (number of arrests and number of violent arrests) and general and violent recidivism (number of re-arrests), we used negative binomial regression (or Poisson regression, if data did not exhibit overdispersion). In recidivism analyses with count data, time at-risk

(length of recidivism period minus time spent incarcerated during the recidivism period) was included as an offset variable. Poisson and negative binomial regression traditionally assume that observation occurs within time periods of the same length, an assumption violated by the variable recidivism periods in the current study. An offset variable can be used to adjust for violations to this assumption and for variations in opportunity of the event represented in the count data (Coxe et al., 2009). In keeping the offset variable on the same scale as the predictors used in negative binomial and Poisson regression (log link) models, the natural logarithm of number of weeks at risk for rearrest (plus a constant of one, because there were zero values for number of weeks at risk) was included as an offset in the model to control for variation in time spent incarcerated during the recidivism period. Finally, a survival analysis (Cox proportional hazards model) was conducted to evaluate the relationship between MAYSI composite scores and time to recidivate.

Aim 1 Hypotheses 1.3 and 1.4 were evaluated using the same dependent variables and models as those used for the above, but number of TBIs and lasting PCS scores on the CHAT replaced MAYSI composite mental health problems scores as the independent variables (in separate analyses), and mental health problems was added as covariate.

Aim 2

Aim 2 hypotheses were tested using multiple linear, Poisson, and/or negative binomial regression analyses in which MAYSI composite mental health problems, number of TBIs and lasting PCS (in separate models), and the interaction between mental health problems and each TBI variable were entered as independent variables. In these analyses, aggression and violence (LHA and AQ), criminal history (number of prior arrests and violent arrests), and recidivism (number of general re-arrests and number of violent re-arrests) served as the dependent variables.

For all analyses for this aim, age, race, gender, education level, number of prior arrests (only in models not involving criminal history dependent variables), and substance use were included as covariates. To evaluate the nature of moderator relationships, simple slope analysis using scores at the 16th, 50th and 84th percentile and the Johnson-Neyman technique, was applied to the data. Further, we conducted two Cox proportional hazards models in which the covariates (age, race, gender, education level, substance use scores, time at-risk), TBI (one model for count, one model for PCS), mental health problems, and an interaction between mental health problems and TBI (count or lasting PCS) were entered as predictors of time to recidivate.

Exploratory Analyses

The correlation matrix and regression models conducted under Hypotheses 1.1 and 1.2 were repeated with the scores from each subscale of the MAYSI (excluding the angry-irritable subscale). Subscale scores were evaluated as independent variables in separate regression models due to the potentially high degree of multicollinearity. Analyses conducted for Hypotheses 1.3 and 1.4 and all Aim 2 hypotheses were also repeated using other operationalizations of TBI from the CHAT, including earliest age of injury, duration of loss of consciousness, and hospitalization from injury. Further, analyses were repeated with time elapsed between most recent self-reported worst injury and assessment date included as an additional covariate in analyses involving PCS.

Finally, all Aim 1 and Aim 2 analyses were conducted again with the inclusion of scores on the two measures of criminogenic risk (antisocial peer association, self-control) as additional covariates. Because of potential overlap between self-control and mental health problems, substance use, and/or PCS (Kennedy et al., 2005; Tagney et al., 2004), and because the association between antisocial peers and offending behavior may decline into adulthood (Monahan et al., 2009), we included these covariates in exploratory analyses.

Measures of Effect Size

Effect sizes for individual predictors in linear regression models will be estimated using standardized beta coefficients, and the effect sizes of the overall models will be estimated using multiple R^2 and semi-partial correlations. Semi-partial correlations describe the variance in the dependent variable that is attributable to each independent variable. Multiple R^2 values correspond to the percentage of variance in the dependent variable accounted for by the predictor variables. For Poisson and negative binomial regression models, effect sizes will be estimated using incidence rate ratios (IRR). IRRs range in value from 0 to infinity, with an IRR of 1 indicating that the predictor does not influence the outcome. Values less than 1 indicate that the predictors are associated with decreased risk of the outcome, while values greater than 1 are associated with increased risk of the outcome. The IRR for each predictor reflects the percent change in the incident rate of the dependent variable given a one-unit increase in the predictor; an IRR of 1.15 would indicate a 15% increase in incident rate for a one-unit increase in the predictor, for example. Overall Poisson/negative binomial regression model effects will be estimated using deviance R^2, a pseudo-R^2 value that reflects the reduction in deviance accounted for by the inclusion of the predictor variables. Increases in deviance reflect poorer model fit relative to a model with less deviance, and thus a larger deviance R^2 indicates improvement in model fit (Coxe et al., 2009). For Cox proportional hazards models, effect sizes will be estimated using hazards ratios (HR). Like IRRs, an HR of 1 indicates a lack of association. An HR greater than 1 indicates increased probability of the outcome event, and an HR less than 1 indicates decreased probability of the outcome event given a one-unit increase in the predictor variable.

Power Analyses

Post hoc power analyses were conducted using G*Power (Faul et al., 2007). Results determined that given a sample size of 759 participants, multiple linear regression models with continuous dependent variables and an alpha of .05 would yield .97 power to detect a small effect (f^2 = .02), and 1.0 power to detect medium (f^2 = .15) and large (f^2 = .35) effects (Cohen, 1988). For our smaller sample of 110 participants, our study is adequately powered (.98) to detect medium but not small effect sizes in multiple regression models with continuous predictors.

In regard to recidivism, preliminary analyses indicated that 37.5% of participants in our sample (n = 235) were rearrested at least once during the recidivism period. Given our sample size and rate of recidivism, Poisson and negative binomial regression models for recidivism analyses involving count data (number of times re-arrested) would yield .93 power to detect a 1.15 response rate (a 15% increase over the estimated base rate). For criminal history analyses using the larger sample of 759, Poisson and negative binomial regression models would yield .99 power to detect a 1.15 response rate. Power for Cox regression models was evaluated using the powerSurvEpi package (v0.1.3; Qiu et al., 2021) in R, and indicated that our sample size of 627 would yield .90 power to detect a hazard ratio (HR) of 1.14 (a HR of 1.14 is estimated to indicate a small effect; Azuero, 2016). Therefore, we anticipated that analyses will be adequately powered to detect small to moderate effects.

Preliminary Analyses

Prior to hypothesis testing, all relevant scores for measures above were calculated. Data were screened for outliers and violations to normality assumptions by assessing dependent variables for skewness and kurtosis. One outlier that was greater than three standard deviations

above the mean was identified in the AQ scores and was subsequently removed from analyses. Two outliers greater than three standard deviations above the mean for self-reported number of TBIs on the CHAT were identified and also removed from analyses. None of the dependent variables for use in linear regression models (LHA and AQ) had skewness and kurtosis values above the recommended guideline values (+/- 1). The remaining dependent variables (criminal history and recidivism variables) were count variables for use in negative binomial or Poisson (criminal history and recidivism) and Cox proportional hazards (time to rearrest) regression models, which do not assume normality of dependent variables. Descriptive statistics for main study variables can be found in Table 2. See Appendix D for histograms of scores on main study variables. Because the number of individuals identifying as non-binary (n = 1) and transgender (n = 1) was very small, these data were not included in analyses involving gender as a covariate. For Aim 2, all predictors were grand mean centered prior to inclusion in models with interaction terms.

Prior to all analyses with count data, tests of overdispersion (Cameron & Trivedi, 1990) were conducted to assess violations to the assumption of equal mean and variance for Poisson regression. Results revealed significant overdispersion for all models except the model predicting number of violent rearrests from lasting PCS (z = 1.00, p = .16). Thus, negative binomial regression was used for analyses of criminal history (number of prior arrests and number of prior violent arrests) and recidivism (number of general rearrests and number of violent rearrests), except the models predicting number of violent rearrests from lasting PCS and the interaction between lasting PCS and mental health problems, for which Poisson regression was conducted.

Finally, all analyses for Aims 1 and 2 were conducted again with the exclusion of the MAYSI substance use scale, which was highly correlated with MAYSI mental health problems.

Results from these analyses did not significantly impact results, except where indicated (see footnotes).

Table 1

Sample Characteristics

	Phase 1			Phase 2		
	Total (*n*)	Prevalence (%)	Mean (*SD*)	Total (*n*)	Prevalence (%)	Mean (*SD*)
Age	754		36.6 (11.7)	110		36.5 (11.2)
Missing	5	0.7		3	2.7	
Gender Identity						
Man	511	67.6		79	69.9	
Woman	240	31.6		32	28.3	
Non-binary	1	0.1		0	0.0	
Transgender	1	0.1				
Missing	6	0.8		2	1.8	
Race						
White/Caucasian	546	71.9		76	67.3	
Black/African American	97	12.8		18	15.9	
Asian American	1	0.1		0	0	
Pacific Islander	1	0.1		0	0	
Native American	10	1.3		4	3.5	
Mixed Race	37	4.9		5	4.4	
Other	64	8.4		9	8.0	
Missing	3	0.4		1	0.9	
Ethnicity						
Hispanic	115	15.2		14	12.4	
Non-Hispanic	637	83.9		97	85.8	
Missing	7	0.9		2	1.8	
Annual Income						
Less than $15,000	273	36.0		43	38.1	
$15,000 - $30,000	177	23.3		29	25.7	
$30,001 - $45,000	133	17.5		17	15.0	
$45,001 - $60,000	80	10.5		11	9.7	
$60,001 - $75,000	37	4.9		2	1.8	
More than $75,000	48	6.3		6	5.3	
Missing	11	1.4		5	4.4	
Occupation						
Laborer/Service Worker	128	16.9		27	23.9	
Skilled Manual Worker	145	19.1		17	15.0	
Untrained Worker	62	8.2		10	8.8	
Machine Operator/Semi-Skilled Worker	56	7.4		9	8.0	
Clerical/Sales Worker	32	4.2		4	3.5	
Technician/Semi-Professional	24	3.2		2	1.8	
Manager/Other Professional	45	5.9		4	3.5	
Administrator/Technical Professional	21	2.8		1	0.9	
Executive/Major Professional	19	2.5		3	2.7	
Homemaker	27	3.6		4	3.5	
Other/Retired	195	25.7		30	26.5	
Missing	5	0.7		2	1.8	

Table 1 (Continued)

	Phase 1			Phase 2		
	Total (*n*)	Prevalence (%)	Mean (*SD*)	Total (*n*)	Prevalence (%)	Mean (*SD*)
Education						
9^{th}-12^{th} Grade	148	19.5		31	27.4	
High School Diploma/GED	284	37.4		38	33.6	
Some College	230	30.3		29	25.7	
Bachelor's Degree	50	6.6		5	4.4	
Graduate Education	10	1.3		3	2.7	
Missing	9	1.2		3	2.7	

Table 2

Descriptive Statistics for Main Study Variables

	n	*M*(*SD*)	Min	Max
MAYSI Substance Use	755	3.09(2.58)	0	8
MAYSI Mental Health Problems	747	10.23(6.44)	0	30
CHAT PCS	402	17.91(8.08)	8	40
CHAT Number of TBIs	732	1.55(2.66)	0	20
AQ Total	98	82.76(24.66)	33	152
LHA Aggression	110	11.40(5.00)	2	24
LHA Total	110	22.23(8.63)	6	41
Prior Arrests	759	5.68(6.10)	0	34
Prior Violent Arrests	759	1.80(1.86)	0	15
General Rearrests	627	0.57(0.95)	0	6
Violent Rearrests	627	0.10(0.34)	0	3
Time to First Rearrest (Weeks)	235	18.26(15.87)	0	63
Time Incarcerated During Recidivism Period (Weeks)	212	11.63(15.47)	0	70

Note. MAYSI = Massachusetts Youth Screening Instrument; CHAT = Comprehensive Health Assessment Tool; PCS = Post-Concussion Syndrome; TBI = Traumatic Brain Injury; LHA = Lifetime History of Aggression.

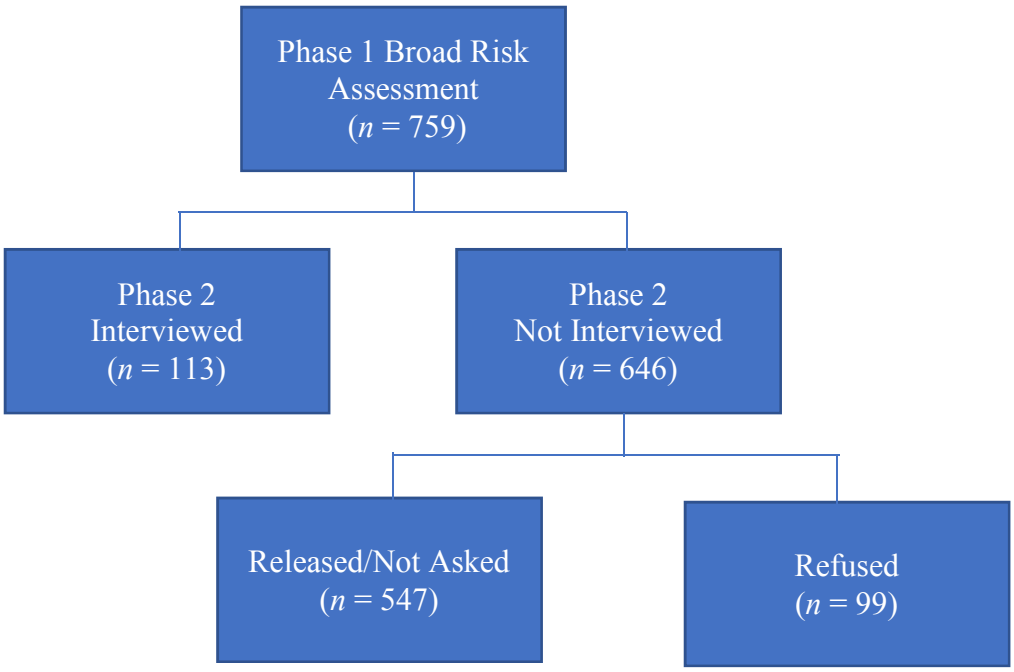

Figure 1

Recruitment Process for Participants across Study Phases.

RESULTS

Aim 1

The zero-order correlation matrix for all independent and dependent variables for Aim 1 is presented in Table 3.[5]

Hypotheses 1.1 & 1.2: Mental Health Problems, History of Offending, & Recidivism

Analyses for Hypotheses 1.1 and 1.2 assessed relationships between mental health problems and history of aggression, violence, and offending behavior.

Aggression and Violence. Multiple linear regression analyses conducted on measures of aggression and violence (AQ, LHA total, and LHA aggression in separate models) revealed a medium-sized, positive association between MAYSI mental health problems and scores on these measures (AQ, LHA total, and LHA Aggression). All variables together accounted for 20-23% of the variance across models.[6] Mental health problems uniquely accounted for small-moderate amounts of the variance in scores on aggression measures (sr^2 = .08-.17, *ps* < .01). See Table 4 for full model results.

Criminal History. Results of negative binomial regression models with mental health problems as the independent variable and number of general and violent prior arrests as the dependent variables revealed statistically significantly effects of all covariates (except race,

[5] For the sake of thoroughness, zero-order correlations between a measure of intellectual functioning, the Weschler Abbreviated Scale of Intelligence-II, and scores on MAYSI mental health problems (*r* = -.10), CHAT PCS (*r* = -.04), and CHAT number of TBIs (*r* = .17) were also conducted post-hoc. The small positive correlation between number of TBIs and IQ suggested that as number in injuries increased, IQ score increased. However, the sample size was relatively small (*n* = 103), so the meaningfulness of this relationships is unclear.

[6] Removal of MAYSI substance use scores from models did not meaningfully impact or alter the pattern of results.

which was marginally significant for number of general prior arrests; see Table 5). Surprisingly, MAYSI mental health problems were not related to prior arrests (IRRs = 1.00-1.01, *p*s = .33-.64)[7]. Deviance R^2 values indicated that the inclusion of all independent variables reduced model deviance by 7.6-8.9%.

Recidivism. In negative binomial regression models with covariates and mental health problems as the independent variable predicting number of general and violent rearrests, only number of prior arrests and gender (for violent rearrests only) emerged as significant predictors (see Table 5). That is, each prior rearrest was associated with a 6% increase in the incident rates of general and violent rearrests, and being a man was associated with a 62% increase in the incident rate of violent rearrests. MAYSI mental health problems did not significantly predict general or violent recidivism (IRRs = 1.00-1.04, *p*s = .14-.76). The addition of all independent variables accounted for reductions in model deviance between 3.0-7.7%.

The final analysis for Hypothesis 1.2 tested the relationship between mental health problems and time to first rearrest. None of the variables in the model predicted time to first rearrest (see Table 6), and the likelihood ratio test of the overall model was also not significant (LR = 8.00, $p = .33$).

Exploratory Analyses. The zero-order correlation matrix including all MAYSI subscales is presented in Appendix F. Results of multiple linear regression models including MAYSI subscales as independent variables revealed a pattern and size of effects similar to those involving the mental health composite score, though effect sizes for subscales were generally smaller (see Appendix F). None of the MAYSI subscales were significantly related to arrest and

[7] Results from models without MAYSI substance use scores resulted in a 3% increase in the rate of violent rearrests (IRR = 1.07, $p = .03$; see Appendix E) over the model with substance use scores (IRR = 1.04, $p = .16$). The remainder of the models did not change substantively.

rearrest outcomes, with the notable exception of Thought Disturbances. Every one-unit increase in Thought Disturbances was associated with a 53% in the incidence rate of violent rearrests (IRR = 1.53, p = .009; see Appendix F). This effect was substantially larger than that for the mental health problems composite score (IRRs = 1.04, ps = .14). The addition of criminogenic risk factors did not alter the pattern of results for any dependent variables. Results of these exploratory analyses suggest that thought disturbances may play a larger role in prediction of violent rearrest than mental health problems more broadly, and in comparison to other aspects of mental health problems (i.e., depression, suicidality, traumatic experiences).

Hypotheses 1.3 & 1.4: TBI, History of Offending, & Recidivism

Aggression and Violence. Multiple linear regression analyses conducted on measures of aggression and violence (AQ, LHA total, and LHA aggression in separate models) revealed a medium-sized, positive association between number of TBIs and scores on LHA total and LHA Aggression. All variables together accounted for 22-31% of the variance across models. Number of TBIs accounted for small, significant amounts of variance in LHA total and LHA Aggression scores (sr^2 = .05, ps < .05), but not AQ scores (sr^2 = .01, p = .28). PCS scores did not account for significant amounts of variance in dependent variables (sr^2 = .00-.01, ps > .05). See Table 7 for full model results.

Criminal History. Results of negative binomial regression models with number of TBIs and lasting PCS scores as independent variables and number of general and violent prior arrests as the dependent variables revealed statistically significantly relationships between number of TBIs and number of prior arrests and prior violent arrests, such that each TBI was associated with a 4% increase in the incidence rate of prior arrest (IRR = 1.04, p = .02) and 3% increase in the incidence rate of violent arrest (IRR = 1.03, p = .02). Lasting PCS scores were associated

with a 2% decrease in the incidence rate of prior violent arrest (IRR = .98, p = .02). Deviance R^2 values indicated that the inclusion of all the independent variables reduced model deviance by 5-9%.

Recidivism. In negative binomial regression models with number of TBIs and lasting PCS scores as the independent variables predicting number of general and violent rearrests, again number of prior arrests and gender (for the violent rearrests by number of TBIs model only) emerged as significant predictors (see Table 8). Number of TBIs and PCS scores were not related to general or violent recidivism (IRRs = .98-1.04, ps = .45-.94). The addition of all predictor variables accounted for reductions in model deviance of around 3% for general rearrest and 6-8% for violent rearrest.

Cox proportional hazards models were used to test the relationship between number of TBIs and lasting PCS scores and time to first rearrest. Only lasting PCS scores predicted time to first rearrest, with each unit increase in PCS scores associated with a 3% increase in the probability of sooner rearrest (HR = 1.03, p = .04; see Table 9). The likelihood ratio tests of the overall models were not significant for both number of TBIs (LR = 9.95, p = .19) and lasting PCS scores (LR = 4.71, p = .70).

Exploratory Analyses

Results of models including different operationalizations for TBI (earliest age of injury, duration of loss of consciousness, and hospitalization for injury) as independent variables were similar in pattern and size of effects to results using number of TBIs as the independent variable, except for results for hospitalization. There was a significant, medium-sized positive relationship between hospitalization and AQ scores (β = .26, p = .04) but not LHA scores (see Appendix F). These relationships differed from those of primary analyses, in which number of TBIs had a

small, non-significant association with AQ scores (β = .11, p = .28), and a medium-sized association with LHA scores (β = .23, p = .015). Hospitalization was also associated with a 21% increase in the incidence rate of general rearrest and (IRR = 1.21 p = .48) and a 14% increase in the incidence rate of violent rearrests (IRR = 1.14 p = .70). Although these relationships were not statistically significant, they were larger in size in comparison to relationships between number of TBIs and general (IRR = .98, p = .51) and violent rearrests (IRR = 1.04, p = .57). Time elapsed between most recent self-reported worst injury and the date of assessment added as an additional covariate did not change the pattern or size of effects but did relate to prior violent arrests (IRR = .99, p = .001), though this effect was small. This means that for each year elapsed since most recent TBI, the incident rate of violent arrest decreased by 1%. Over time, however, this effect may be more meaningful. A 1% decrease in the incidence rate for violent crime over twenty years post-injury would reduce the rate from 1.79 to 1.43, for example. The addition of criminogenic risk factors (i.e., peer delinquency and self-control) did not alter the pattern of results for any dependent variables. In all, results of these exploratory analyses suggest that hospitalization may be an important operationalization in assessing relationships between TBI and aggression and recidivism, and that the time elapsed following TBI may be associated with decreases in the rate of violent crime.

Aim 2

Hypotheses 2.1-2.4: Number of TBIs & PCS as Moderators

Aggression and Violence. Multiple linear regression analyses conducted on measures of aggression (AQ, LHA total, and LHA aggression in separate models) revealed no significant interactions between mental health problems and the two moderators (number of TBIs and PCS, in separate analyses). The exception was a moderate-sized interaction between number of TBIs

and mental health problems for LHA Total scores (β = -.20, p = .042), but not the other aggression variables. Simple slopes analyses revealed, contrary to hypotheses, that the positive relationship between mental health problems and LHA total scores was stronger when number of TBIs was one standard deviation *below* the mean (B = .60, p = .001) than at the mean (B = .40, p = .002), which was stronger than when number of TBI scores was one standard deviation above the mean (B = .19, p = .14; see Figure 2). All variables together accounted for 23-31% of the variance across models (see Table 10).

Lasting PCS did not moderate relationships between mental health problems and the aggression variables. All variables together accounted for 21-31% of the variance across models involving lasting PCS. See Table 10 for full model results.

Criminal History. Results of negative binomial regression models including the interactions between mental health problems and number of TBIs or lasting PCS in relation to number of general and violent prior arrests did not suggest the presence of moderator relationships (see Table 11). Deviance R^2 values indicated that the inclusion of all the independent variables reduced model deviance by 5-9%.

Recidivism. Negative binomial regression models with the interactions between mental health problems and number of TBIs or lasting PCS predicting number of general and violent rearrests did not indicate statistically significant moderation. The addition of predictor variables accounted for reductions in model deviance of around 3% for general rearrest and 8-11% for violent rearrest.

Cox proportional hazards models were used to test the relationship between the interactions between mental health problems and number of TBIs or lasting PCS and time to first rearrest. Results did not reveal evidence of moderation (see Table 12).

Exploratory Analyses

Results of multiple linear, negative binomial, and Poisson regression models assessing the interaction between mental health problems and TBI using alternate operationalizations for TBI (earliest age of injury, duration of loss of consciousness, and hospitalization for injury) did not suggest moderation in relation to the other dependent variables. Adding time elapsed between most recent self-reported worst injury and the date of assessment as an additional covariate did not change the pattern of results.

The addition of criminogenic risk factors as covariates produced results that did not meaningfully differ from those for only one of the primary analyses for Aim 2, except for one small interaction that was not present in primary analyses. Specifically, the introduction of these covariates produced a significant interaction between number of TBIs and mental health problems in predicting number of general rearrests (IRR = .99, p = .033), such that the relationship between mental health problems and rearrests was stronger when number of TBIs was one standard deviation *above* the mean (B = .03, p = .24) than at the mean (B = -.01, p = .76), which was stronger than when number of TBI scores was one standard deviation below the mean (B = -.04, p = .10; see Appendix F). However, the IRR for this interaction did not differ from the IRR in primary analyses (IRR = .99). Given the small size of this exploratory interaction effect, these results should be interpreted with caution.

Correction for Multiple Comparisons

Given the large number of analyses conducted in the present study, we adjusted the p-value significance criterion using False Discovery Rate correction (FDR; Benjamini & Hochberg, 1995). Primary aim analyses consisted of 318 comparisons. An FDR of 5% resulted in a new significance threshold of .003. For variables of interest, associations between MAYSI

mental health problems and aggression measures (*p*s = .000-.002) survived FDR correction, but associations between number of TBIs and aggression (*p*s = .015-.020) and criminal history (*p*s = .021) did not. Associations between PCS and past violent arrests (*p* = .033) and time to first rearrest (*p* = .043) also did not survive FDR correction, nor did the interaction between mental health problems and TBI for LHA scores (*p* = .042).

Table 3

Zero-Order Correlations between Main Study Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. MAYSI Mental Health Problems	–													
2. CHAT PCS	.61**	–												
3. CHAT Number of TBIs	.26**	.17**	–											
4. AQ Total	.37**	.30*	.15	–										
5. LHA Aggression	.31**	-.03	.24*	.53**	–									
6. LHA Total	.31**	-.03	.24*	.56**	.93**	–								
7. Prior Arrests	.06	-.06	.10**	.09	.21*	.26**	–							
8. Prior Violent Arrests	.07	-.07	.11**	.04	.13	.14	.63**	–						
9. General Rearrests	.07	.02	-.02	.05	-.05	-.03	.17**	.07	–					
10. Violent Rearrests	.09*	.02	.05	.07	.12	.06	.12**	.13**	.27**	–				
11. Age	-.04	.04	.05	-.04	-.04	-.13	.09*	.07*	-.05	-.04	–			
12. Gender	.09*	.19**	-.11**	-.11	-.05	-.13	-.16**	-.20**	-.04	-.08*	.01	–		
13. Race	-.07	-.11*	-.08	.17	.02	.06	-.02	.04	-.03	.01	-.18**	-.16**	–	
14. Education	-.01	-.04	.09*	-.02	-.04	-.09	-.14**	-.09*	-.07	-.02	-.22**	.13**	-.05	–
15. MAYSI Substance Use	.41**	.15**	.12**	.14	.29**	.33**	.21**	.16**	.06	.10*	-.14**	-.11**	-.02	-.10**

Note. MAYSI = Massachusetts Youth Screening Instrument; CHAT = Comprehensive Health Assessment Tool; PCS = Post-Concussion Syndrome; TBI = Traumatic Brain Injury; LHA = Lifetime History of Aggression. Sample sizes for correlations varied due to missing and not applicable data. For correlations with MAYSI subscales: n = 399 for PCS, n = 722 for number of TBIs, n = 97 for AQ, n = 109 for LHA, n = 746 for criminal history, and n = 619 for recidivism; for number of TBIs: n = 399 for PCS, n = 93 for AQ, n = 105 for LHA, n = 731 for criminal history, and n = 607 for recidivism; for PCS: n = 55 for AQ, n = 61 for LHA, n = 399 for criminal history, and n = 325 for recidivism.
*p<.05.
**p<.01.

Table 4

Regression Results for Aggression Scores as a Function of Mental Health Problems

AQ Total						
Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Intercept	65.65	15.87				R^2 = .233**
Age	-.06	.24	-.06	.81	.00	95% CI[.04,.32]
Gender	-9.02	5.58	-.16	.11	.02	
Race	10.31	5.50	.19	.06	.03	
Education	3.62	2.70	.13	.18	.02	
Number of Prior Arrests	.30	.35	.08	.39	.01	
MAYSI Substance Use	-0.50	1.12	-.05	.65	.00	
MAYSI Mental Health Problems	1.65	.38	.47	.000**	.17	

LHA Total						
Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Intercept	18.56	4.92				R^2 = .249**
Age	-.04	.08	-.05	.59	.00	95% CI[.07, .34]
Gender	-3.00	1.72	-.16	.08	.02	
Race	.65	1.72	.04	.71	.00	
Education	.05	.84	.01	.95	.00	
Number of Prior Arrests	.26	.10	.22	.016*	.05	
MAYSI Substance Use	.61	.35	.17	.09	.02	
MAYSI Mental Health Problems	.36	.12	.31	.002**	.08	

LHA Aggression						
Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Intercept	6.26	2.92				R^2 = .200**
Age	.02	.04	.05	.64	.00	95% CI[.03, .28]
Gender	-.91	1.02	-.08	.37	.01	
Race	.46	1.02	.04	.65	.00	
Education	.22	.50	.04	.66	.00	
Number of Prior Arrests	.11	.06	.16	.08	.03	
MAYSI Substance Use	.37	.21	.18	.08	.02	
MAYSI Mental Health Problems	.22	.07	.32	.002**	.08	

Note. For gender, 1 = man, 2 = woman; MAYSI = Massachusetts Youth Screening Instrument; AQ = Aggression Questionnaire.
*$p < .05$.
**$p < .01$.

Table 5

Negative Binomial Regression Results for Criminal History and Recidivism as a Function of Mental Health Problems

Prior Arrests							
Independent Variable	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	1.68	1.23, 2.13	.22				.076
Age	.01	.01, .02	.00	3.96	1.01	.000**	
Gender	-.36	-.54, -.18	.09	-3.96	.70	.000**	
Race	-.05	-.23, .14	.09	-.51	.95	.61	
Education	-.14	-.23, -.05	.05	-3.02	.87	.003**	
MAYSI Substance Use	.08	.05, .11	.02	4.54	1.08	.000**	
MAYSI Mental Health Problems	.00	-.01, .02	.01	.47	1.00	.64	

Prior Violent Arrests							
Independent Variable	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	.65	.28, 1.03	.19				.089
Age	.01	.00, .02	.00	3.37	1.01	.001**	
Gender	-.42	-.58, -.26	.08	-5.20	.66	.000**	
Race	.10	-.05, .25	.08	1.28	1.10	.20	
Education	-.08	-.16, -.01	.04	-2.12	.92	.03*	
MAYSI Substance Use	.05	.03, .08	.01	3.66	1.06	.000**	
MAYSI Mental Health Problems	.01	-.01, .02	.01	.97	1.01	.33	

General Rearrests							
Predictor	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	-3.37	-4.53, -2.19	.51				.030
Age	-.02	-.04, .00	.01	-1.79	.98	.07	
Gender	-.13	-.59, .34	.20	-.63	.88	.53	
Race	-.38	-.87, .11	.21	-1.78	.68	.08	
Education	.03	-.20, .27	.11	.31	1.03	.76	
Number of Prior Arrests	.06	.03, .10	.02	3.78	1.06	.000**	
MAYSI Substance Use	.01	-.09, .11	.04	.24	1.01	.81	
MAYSI Mental Health Problems	.00	-.03, .04	.02	.31	1.00	.76	

Violent Rearrests							
Predictor	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	-5.89	-8.06, -3.71	1.00				.077
Age	-.01	-.05, .03	.02	-.34	.99	.73	
Gender	-.97	-1.95, -.03	.42	-2.29	.38	.022*	
Race	-.22	-1.15, .72	.41	-.53	.80	.59	
Education	.24	-.24, .74	.20	1.20	1.27	.23	

Table 5 (Continued)

Predictor	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Number of Prior Arrests	.06	-.01, .13	.02	2.02	1.06	.043*	
MAYSI Substance Use	.11	-.06, .30	.08	1.47	1.12	.14	
MAYSI Mental Health Problems	.04	-.03, .11	.03	1.41	1.04	.16	

Note. For gender, 1 = man, 2 = woman; MAYSI = Massachusetts Youth Screening Instrument.
*$p < .05$.
**$p < .01$.

Table 6

Cox Proportional Hazards Model Results Predicting Time to First Rearrest from Mental Health Problems

Predictor	*ß*	HR	95% CI	SE	*z*	*p*
Age	.01	1.01	1.00, 1.02	.01	1.36	.17
Gender	-.11	.90	.67, 1.21	.15	-.71	.48
Race	-.08	.92	.66, 1.28	.17	-.50	.62
Education	.06	1.06	.90, 1.25	.08	.70	.48
Number of Prior Arrests	.01	1.01	.99, 1.04	.01	1.05	.29
MAYSI Substance Use	.02	1.02	.96, 1.08	.03	.55	.58
MAYSI Mental Health Problems	.01	1.01	.99, 1.03	.01	1.17	.24

Note. For gender, 1 = man, 2 = woman; MAYSI = Massachusetts Youth Screening Instrument.
*$p < .05$.
**$p < .01$.

Table 7

Regression Results for Aggression Scores as a Function of TBI and PCS

AQ Total						
Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Intercept	62.37	16.64				R^2 = .227**
Age	-.02	.25	-.01	.94	.00	95% CI[.03, .31]
Gender	-6.64	5.95	-.12	.27	.01	
Race	10.80	5.84	.20	.07	.03	
Education	2.67	2.86	.10	.35	.01	
Number of Prior Arrests	.31	.37	.09	.40	.01	
MAYSI Substance Use	-.48	1.14	-.05	.68	.00	
MAYSI Mental Health Problems	1.57	.40	.44	.000**	.15	
Number of TBIs	1.03	.94	.11	.28	.01	
Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Intercept	45.67	23.66				R^2 = .315*
Age	-.08	.34	-.04	.94	.00	95% CI[.00, .40]
Gender	-6.62	8.71	-.10	.27	.01	
Race	15.99	8.13	.27	.07	.06	
Education	6.22	3.91	.22	.35	.04	
Number of Prior Arrests	.57	.54	.15	.40	.02	
MAYSI Substance Use	-.62	1.83	-.05	.68	.00	
MAYSI Mental Health Problems	1.89	.70	.51	.000**	.11	
Lasting PCS	.35	.64	.10	.28	.00	

LHA Total						
Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Intercept	17.06	4.98				R^2 = .289**
Age	-.03	.08	-.04	.66	.00	95% CI[.09, .37]
Gender	-2.02	1.77	-.11	.26	.01	
Race	1.15	1.78	.06	.52	.00	
Education	-.36	.85	-.04	.67	.00	
Number of Prior Arrests	.25	.11	.21	.023*	.04	
MAYSI Substance Use	.62	.35	.18	.08	.02	
MAYSI Mental Health Problems	.33	.12	.27	.007**	.06	
Number of TBIs	.76	.31	.23	.015*	.05	

Table 7 (Continued)

Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Intercept	19.26	7.02				R^2 = .228
Age	-.01	.10	-.02	.91	.00	95% CI[.00, .31]
Gender	-3.79	2.68	-.19	.16	.03	
Race	3.99	2.51	.21	.12	.04	
Education	.45	1.23	.05	.72	.00	
Number of Prior Arrests	.24	.16	.22	.13	.04	
MAYSI Substance Use	.62	.55	.17	.27	.02	
MAYSI Mental Health Problems	.44	.23	.36	.06	.06	
Lasting PCS	-.12	.21	-.11	.56	.01	

LHA Aggression

Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Intercept	5.66	2.98				R^2 = .228**
Age	.02	.05	.06	.59	.00	95% CI[.04, .31]
Gender	-.39	1.06	-.04	.71	.00	
Race	.62	1.07	.06	.57	.00	
Education	.00	.51	.00	.99	.00	
Number of Prior Arrests	.09	.07	.14	.15	.02	
MAYSI Substance Use	.38	.21	.19	.07	.03	
MAYSI Mental Health Problems	.18	.07	.26	.011*	.06	
Number of TBIs	.43	.18	.23	.020*	.05	

Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Intercept	6.16	4.35				R^2 = .198
Age	.04	.06	.08	.57	.01	95% CI[.00, .28]
Gender	-1.80	1.66	-.15	.28	.02	
Race	1.71	1.56	.15	.28	.02	
Education	.52	.76	.09	.50	.01	
Number of Prior Arrests	.14	.10	.20	.17	.03	
MAYSI Substance Use	.57	.34	.26	.10	.05	
MAYSI Mental Health Problems	.24	.14	.32	.10	.05	
Lasting PCS	-.06	.13	-.09	.63	.00	

Note. For gender, 1 = man, 2 = woman; MAYSI = Massachusetts Youth Screening Instrument; AQ = Aggression Questionnaire; TBI = Traumatic Brain Injury; PCS = Post-Concussion Syndrome; *n* = 103 for TBI models; *n* = 59 for PCS models

*$p < .05$.

**$p < .01$.

Table 8

Negative Binomial and Poisson Regression Results for Criminal History and Recidivism as a Function of TBI and PCS

Prior Arrests							
Independent Variable	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	1.69	1.24, 2.15	.23				.079
Age	.01	.01, .02	.00	3.73	1.01	.000**	
Gender	-.35	-.53, -.16	.09	-3.66	.71	.000**	
Race	-.04	-.22, .14	.10	-.43	.96	.66	
Education	-.15	-.24, -.06	.05	-3.12	.86	.002**	
MAYSI Substance Use	.08	.04, .11	.02	4.35	1.08	.000**	
MAYSI Mental Health Problems	.00	-.02, .01	.01	-.40	1.00	.69	
Number of TBIs	.04	.00, .07	.02	2.31	1.04	.021*	
Independent Variable	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	1.77	1.14, 2.40	.32				.051
Age	.01	.00, .02	.00	2.73	1.01	.006**	
Gender	-.17	-.42, .09	.13	-1.26	.67	.21	
Race	.03	-.22, .29	.13	.25	1.12	.81	
Education	-.14	-.25, -.03	.06	-2.43	.92	.015*	
MAYSI Substance Use	.06	.01, .10	.02	2.50	1.05	.013*	
MAYSI Mental Health Problems	.01	-.01, .03	.01	.70	1.00	.48	
Lasting PCS	-.01	-.03, .00	.01	-1.41	1.03	.16	
Prior Violent Arrests							
Independent Variable	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	.61	.23, .99	.19				.092
Age	.01	.00, .02	.00	3.35	1.01	.001**	
Gender	-.40	-.56, -.23	.08	-4.77	.67	.000**	
Race	.12	-.04, .27	.08	1.50	1.12	.13	
Education	-.08	-.16, -.01	.04	-2.13	.92	.033*	
MAYSI Substance Use	.05	.02, .08	.02	3.40	1.05	.001**	
MAYSI Mental Health Problems	.00	-.01, .01	.01	.33	1.00	.74	
Number of TBIs	.03	.00, .05	.01	2.31	1.03	.021*	
Independent Variable	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	.67	.15, 1.18	.26				.088
Age	.01	.00, .02	.00	2.57	1.01	.010*	

Table 8 (Continued)

Independent Variable	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Gender	-.25	-.48, -.03	.11	-2.25	.78	.025*	
Race	.20	-.01, .40	.10	1.92	1.22	.06	
Education	-.10	-.19, .00	.05	-1.97	.91	.048*	
MAYSI Substance Use	.06	.02, .09	.02	3.01	1.06	.003**	
MAYSI Mental Health Problems	.01	-.01, .03	.01	1.43	1.01	.15	
Lasting PCS	-.02	-.03, .00	.01	-2.13	.98	.033*	

General Rearrests

Predictor	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	-3.36	-4.52, -2.19	.51				.031
Age	-.01	-.03, .01	.01	-1.62	.99	.11	
Gender	-.18	-.65, .30	.21	-.86	.84	.39	
Race	-.35	-.84, .15	.22	-1.61	.71	.11	
Education	.04	-.20, .28	.11	.36	1.04	.72	
Number of Prior Arrests	.06	.03, .10	.02	3.90	1.07	.000**	
MAYSI Substance Use	.01	-.09, .11	.04	.14	1.01	.89	
MAYSI Mental Health Problems	.01	-.03, .05	.02	.36	1.01	.72	
Number of TBIs	-.02	-.12, .08	.04	-.66	.98	.51	

Predictor	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	-2.63	-4.39, -.84	.74				.033
Age	-.02	-.05, .01	.01	-1.76	.98	.08	
Gender	.13	-.56, .84	.30	-.43	1.14	.67	
Race	-.23	-.94, .50	.31	-.74	.79	.46	
Education	-.13	-.45, .19	.14	-.95	.88	.34	
Number of Prior Arrests	.05	.01, .10	.02	2.53	1.05	.011*	
MAYSI Substance Use	-.03	-.17, .11	.06	-.51	.97	.61	
MAYSI Mental Health Problems	-.03	-.10, .04	.03	-1.10	.97	.27	
Lasting PCS	.02	-.03, .06	.02	.76	1.02	.45	

Violent Rearrests

Predictor	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	-5.87	-8.08, -3.66	1.02				.083
Age	.00	-.05, .04	.02	-.27	1.00	.79	
Gender	-1.02	-2.05, -.04	.44	-2.31	.36	.021*	

Table 8 (Continued)

Predictor	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Race	-.16	-1.11, .80	.42	-.39	.85	.70	
Education	.24	-.27, .80	.21	1.15	1.27	.25	
Number of Prior Arrests	.06	-.01, .14	.03	1.98	1.06	.048*	
MAYSI Substance Use	.12	-.07, .31	.08	1.48	1.13	.14	
MAYSI Mental Health Problems	.03	-.04, .11	.03	1.11	1.04	.27	
Number of TBIs	.03	-.13, .23	.06	.57	1.04	.57	
Predictor[a]	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	-6.05	-8.06, -4.12	1.00				.060
Age	-.01	-.05, .02	.02	-.75	.99	.33	
Gender	-.44	-1.37, .36	.43	-1.01	.65	.23	
Race	.07	-.73, .78	.38	.18	1.07	.28	
Education	.03	-.33, .38	.18	.15	1.03	.78	
Number of Prior Arrests	.06	.02, .10	.02	2.86	1.06	.003**	
MAYSI Substance Use	.09	-.05, .24	.07	1.27	1.10	.22	
MAYSI Mental Health Problems	.03	-.04, .10	.04	.78	1.03	.50	
Lasting PCS	.00	-.06, .05	.03	-.13	1.00	.94	

Note. For gender, 1 = man, 2 = woman; MAYSI = Massachusetts Youth Screening Instrument.
[a] Model is a Poisson regression.
*$p < .05$.
**$p < .01$.

Table 9

Cox Proportional Hazards Model Results Predicting Time to First Rearrest from TBI and PCS

Predictor	*ß*	HR	95% CI	SE	*z*	*p*
Age	.01	1.01	.99, 1.02	.01	1.21	.23
Gender	-.12	.89	.65, 1.20	.16	-.77	.44
Race	-.12	.88	.63, 1.24	.17	-.73	.47
Education	.10	1.11	.93, 1.31	.09	1.17	.24
Number of Prior Arrests	.02	1.02	1.00, 1.05	.01	1.62	.11
MAYSI Substance Use	.01	1.01	.95, 1.08	.03	.41	.68
MAYSI Mental Health Problems	.02	1.02	1.00, 1.04	.01	1.55	.12
Number of TBIs	-.04	.96	.90, 1.02	.03	-1.28	.20

Predictor	*ß*	HR	95% CI	SE	*z*	*p*
Age	.00	1.00	.99, 1.02	.01	.52	.60
Gender	-.22	.80	.53, 1.21	.21	-1.04	.30
Race	-.07	.93	.57, 1.52	.25	-.28	.78
Education	.02	1.03	.83, 1.26	.11	.23	.82
Number of Prior Arrests	.01	1.01	.98, 1.04	.02	.41	.68
MAYSI Substance Use	.02	1.02	.95, 1.10	.04	.62	.53
MAYSI Mental Health Problems	-.03	.97	.94, 1.01	.02	-1.36	.17
Lasting PCS	.03	1.03	1.00, 1.06	.02	2.02	.043*

Note. For gender, 1 = man, 2 = woman; MAYSI = Massachusetts Youth Screening Instrument; TBI = Traumatic Brain Injury; PCS = Post-Concussion Syndrome.
*$p < .05$.
**$p < .01$.

Table 10

Regression Results for Aggression Scores as a Function of Interactions between Mental Health Problems and TBI or PCS

AQ Total						
Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Intercept	79.84	2.66				R^2 = .238**
Age	-.01	.25	-.01	.95	.00	95% CI[.02, .31]
Gender	-7.27	5.98	-.13	.23	.01	
Race	10.75	5.84	.20	.07	.03	
Education	2.66	2.85	.10	.35	.01	
Number of Prior Arrests	.41	.38	.11	.28	.01	
MAYSI Substance Use	-.68	1.16	-.07	.56	.00	
MAYSI Mental Health Problems	1.72	.42	.49	.000**	.16	
Number of TBIs	.53	1.02	.07	.54	.00	
Mental Health Problems x TBIs	-.12	.12	-.12	.30	.01	
Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Intercept	79.42	4.90				R^2 = .315*
Age	-.09	.34	-.04	.80	.00	95% CI[.00, .39]
Gender	-6.48	8.80	-.10	.45	.01	
Race	16.06	8.22	.27	.06	.06	
Education	6.05	4.06	.22	.14	.04	
Number of Prior Arrests	.56	.54	.15	.31	.02	
MAYSI Substance Use	-.64	1.85	-.06	.73	.00	
MAYSI Mental Health Problems	1.92	.74	.52	.012*	.11	
Lasting PCS	.37	.66	.10	.58	.00	
Mental Health Problems x PCS	-.01	.07	-.03	.85	.00	
LHA Total						
Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Intercept	20.54	.81				R^2 = .318**
Age	-.03	.07	-.03	.72	.00	95% CI[.11, .40]
Gender	-2.31	1.74	-.12	.19	.01	
Race	.90	1.72	.05	.60	.00	
Education	-.38	.84	-.04	.65	.00	
Number of Prior Arrests	.29	.11	.25	.008**	.05	
MAYSI Substance Use	.51	.35	.15	.14	.02	

Table 10 (Continued)

Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
MAYSI Mental Health Problems	.40	.12	.33	.002**	.08	
Number of TBIs	.55	.32	.15	.12	.02	
Mental Health Problems x TBIs	-.08	.04	-.20	.042*	.03	

Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Intercept	21.88	1.49				R^2 = .222**
Age	-.01	.10	-.01	.95	.00	95% CI[.00, .29]
Gender	-3.47	2.67	-.17	.20	.03	
Race	3.55	2.44	.19	.15	,03	
Education	.36	1.26	.04	.78	.00	
Number of Prior Arrests	.20	.15	.18	.19	.03	
MAYSI Substance Use	.56	.55	.16	.30	.02	
MAYSI Mental Health Problems	.46	.23	.38	.05	.06	
Lasting PCS	-.14	.20	-.13	.49	.01	
Mental Health Problems x PCS	-.01	.02	-.05	.75	.00	

LHA Aggression

Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Intercept	10.49	.48				R^2 = .263**
Age	.03	.04	.06	.53	.00	95% CI[.06, .34]
Gender	-.55	1.04	-.05	.60	.00	
Race	.59	1.03	.05	.57	.00	
Education	-.03	.50	-.01	.95	.00	
Number of Prior Arrests	.12	.06	.18	.06	.03	
MAYSI Substance Use	.32	.21	.16	.13	.02	
MAYSI Mental Health Problems	.23	.07	.33	.002**	.08	
Number of TBIs	.30	.19	.16	.12	.02	
Mental Health Problems x TBIs	-.04	.02	-.19	.06	.03	

Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Intercept	10.98	.91				R^2 = .218*
Age	.04	.06	.09	.52	.01	95% CI[.00, .28]
Gender	-1.67	1.63	-.14	.31	.02	
Race	1.71	1.49	.15	.26	.02	
Education	.36	.77	.07	.65	.00	

Table 10 (Continued)

Independent Variable	*B*	*SE(B)*	*β*	*p*	sr^2	Fit
Number of Prior Arrests	.12	.09	.19	.18	.03	
MAYSI Substance Use	.57	.33	.26	.09	.05	
MAYSI Mental Health Problems	.26	.14	.36	.07	.05	
Lasting PCS	-.05	.12	-.07	.69	.00	
Mental Health Problems x PCS	-.01	.01	-.14	.35	.01	

Note. For gender, 1 = man, 2 = woman; MAYSI = Massachusetts Youth Screening Instrument; TBI = Traumatic Brain Injury; PCS = Post-Concussion Syndrome; $n = 103$ for TBI models; $n = 59$ for PCS models.
*$p < .05$.
**$p < .01$.

Table 11

Negative Binomial and Poisson Regression Results for Criminal History and Recidivism as a Function of Interactions Between Mental Health Problems and TBI or PCS

Prior Arrests							
Independent Variable	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	1.66	1.57, 1.74	.04				.081
Age	.01	.01, .02	.00	3.77	1.01	.000**	
Gender	-.34	-.53, -.15	.09	-3.61	.71	.000**	
Race	-.04	-.22, .15	.10	-.42	.96	.68	
Education	-.15	-.24, -.06	.05	-3.11	.86	.002**	
MAYSI Substance Use	.08	.05, .12	.02	4.46	1.08	.000**	
MAYSI Mental Health Problems	.00	-.02, .01	.01	-.47	1.00	.64	
Number of TBIs	.03	.00, .07	.02	1.79	1.03	.07	
Mental Health Problems x TBIs	.00	.00, .01	.00	1.32	1.00	.19	
Independent Variable	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	1.76	1.63, 1.90	.07				.051
Age	.01	.00, .02	.00	2.74	1.01	.006**	
Gender	-.17	-.41, .10	.13	-1.25	.85	.21	
Race	.03	-.22, .29	.13	.24	1.03	.81	
Education	-.14	-.25, -.03	.06	-2.42	.87	.015*	
MAYSI Substance Use	.06	.01, .10	.02	2.50	1.06	.012*	
MAYSI Mental Health Problems	.01	-.01, .03	.01	.69	1.01	.49	
Lasting PCS	-.01	-.03, .01	.01	-1.36	.99	.17	
Mental Health Problems x PCS	.00	.00, .00	.00	.16	1.00	.87	
Prior Violent Arrests							
Independent Variable	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	.52	.44, .59	.04				.096
Age	.01	.00, .02	.00	3.33	1.01	.001**	
Gender	-.40	-.56, -.23	.08	-4.77	.67	.000**	
Race	.12	-.04, .27	.08	1.48	1.12	.14	
Education	-.08	-.16, .00	.04	-2.07	.92	.039*	
MAYSI Substance Use	.05	.03, .08	.02	3.60	1.06	.000**	
MAYSI Mental Health Problems	.00	-.01, .01	.01	.11	1.00	.92	
Number of TBIs	.02	-.01, .05	.01	1.58	1.02	.12	
Mental Health Problems x TBIs	.00	.00, .01	.00	1.83	1.00	.07	

Table 11 (Continued)

Independent Variable	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	.59	.47, .70	.06				.088
Age	.01	.00, .02	.00	2.57	1.01	.010*	
Gender	-.25	-.48, -.03	.11	-2.22	.78	.026*	
Race	.20	-.01, .40	.10	1.91	1.22	.06	
Education	-.10	-.19, .00	.05	-1.97	.91	.049*	
MAYSI Substance Use	.06	.02, .09	.02	3.01	1.06	.003**	
MAYSI Mental Health Problems	.01	-.01, .03	.01	1.43	1.01	.15	
Lasting PCS	-.02	-.03, .00	.01	-1.97	.98	.049*	
Mental Health Problems x PCS	.00	.00, .00	.00	.12	1.00	.91	

General Rearrests

Predictor	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	-3.69	-3.91, -3.44	.10				.032
Age	-.01	-.03, .01	.01	-1.62	.99	.11	
Gender	-.17	-.64, .31	.21	-.82	.84	.41	
Race	-.34	-.83, .16	.22	-1.56	.72	.12	
Education	.04	-.20, .27	.11	.33	1.04	.74	
Number of Prior Arrests	.06	.03, .10	.02	3.82	1.06	.000**	
MAYSI Substance Use	.01	-.09, .11	.04	.13	1.01	.89	
MAYSI Mental Health Problems	.00	-.03, .04	.02	.26	1.00	.79	
Number of TBIs	-.01	-.11, .12	.04	-.14	.99	.89	
Mental Health Problems x TBIs	-.01	-.02, .01	.01	-1.06	.99	.29	

Predictor	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	-3.34	-3.71, -2.95	.17				.035
Age	-.02	-.05, .01	.01	-1.56	.98	.12	
Gender	.11	-.58, .82	.30	.36	1.11	.72	
Race	-.20	-.91, .55	.31	-.62	.82	.53	
Education	-.15	-.47, .17	.14	-1.07	.86	.28	
Number of Prior Arrests	.05	.00, .10	.02	2.43	1.05	.015*	
MAYSI Substance Use	-.04	-.18, .11	.06	-.67	.96	.50	
MAYSI Mental Health Problems	-.03	-.10, .04	.03	-.94	.97	.35	
Lasting PCS	.02	-.03, .08	.02	1.00	1.02	.31	
Mental Health Problems x PCS	.00	-.01, .00	.00	-.84	1.00	.40	

Table 11 (Continued)

Violent Rearrests							
Predictor	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	-5.76	-6.20, -5.31	.19				.083
Age	.00	-.05, .04	.02	-.29	1.00	.78	
Gender	-1.02	-2.05, -.03	.45	-2.29	.36	.022*	
Race	-.16	-1.12, .81	.42	-.37	.86	.71	
Education	.25	-.27, .77	.21	1.17	1.28	.24	
Number of Prior Arrests	.06	-.01, .14	.03	1.97	1.06	.049*	
MAYSI Substance Use	.12	-.07, .31	.08	1.47	1.13	.14	
MAYSI Mental Health Problems	.03	-.05, .11	.03	1.04	1.03	.30	
Number of TBIs	.05	-.14, .28	.06	.80	1.05	.42	
Mental Health Problems x TBIs	-.01	-.04, .03	.01	-.56	.99	.58	
Predictor[a]	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	-2.60	-2.92, -2.32	.15				.11
Age	-.03	-.06 .-01	.01	-3.01	.97	.003**	
Gender	-.29	-.81, .19	.25	-1.13	.75	.26	
Race	.26	-.19, .69	.22	-1.57	1.29	.25	
Education	.08	-.14, .29	.11	.70	1.08	.48	
Number of Prior Arrests	.07	.04, .09	.01	5.00	1.07	.000**	
MAYSI Substance Use	.10	.01, .19	.05	2.26	1.11	.024*	
MAYSI Mental Health Problems	.03	-.01, .07	.02	1.28	1.03	.20	
Lasting PCS	.00	-.04, .04	.02	-.06	1.00	.95	
Mental Health Problems x PCS	.00	-.01, .00	.00	-1.29	1.00	.20	

Note. For gender, 1 = man, 2 = woman; MAYSI = Massachusetts Youth Screening Instrument.
[a]Model is a Poisson regression.
*$p < .05$.
**$p < .01$.

Table 12

Cox Proportional Hazards Model Results Predicting Time to First Rearrest from Interactions Between Mental Health Problems and TBI or PCS

Predictor	*ß*	HR	95% CI	SE	*z*	*p*
Age	.01	1.01	.99, 1.02	.01	1.03	.30
Gender	-.10	.90	.66, 1.22	.16	-.67	.50
Race	-.12	.89	.63, 1.25	.18	-.68	.49
Education	.10	1.10	.93, 1.31	.09	1.13	.26
Number of Prior Arrests	.02	1.02	.99, 1.05	.01	1.50	.13
MAYSI Substance Use	.01	1.01	.95, 1.07	.03	.31	.76
MAYSI Mental Health Problems	.02	1.02	.99, 1.04	.01	1.47	.14
Number of TBIs	-.02	.98	.92, 1.05	.04	-.49	.63
Mental Health Problems x TBI	-.01	.99	.98, 1.00	.01	-1.13	.26

Predictor	*ß*	HR	95% CI	SE	*z*	*p*
Age	.01	1.01	.99, 1.02	.01	.68	.49
Gender	-.22	.80	.53, 1.21	.21	-1.07	.28
Race	-.08	.92	.57, 1.50	.25	-.33	.75
Education	.00	1.00	.81, 1.24	.11	.04	.97
Number of Prior Arrests	.00	1.00	.97, 1.03	.02	.21	.84
MAYSI Substance Use	.02	1.02	.95, 1.10	.04	.50	.62
MAYSI Mental Health Problems	-.02	.98	.94, 1.01	.02	-1.25	.21
Lasting PCS	.04	1.04	1.01, 1.07	.02	2.53	.011*
Mental Health Problems x PCS	.00	1.00	.99, 1.00	.00	-1.42	.15

Note. For gender, 1 = man, 2 = woman; MAYSI = Massachusetts Youth Screening Instrument; TBI = Traumatic Brain Injury; PCS = Post-Concussion Syndrome.
*$p < .05$.
**$p < .01$.

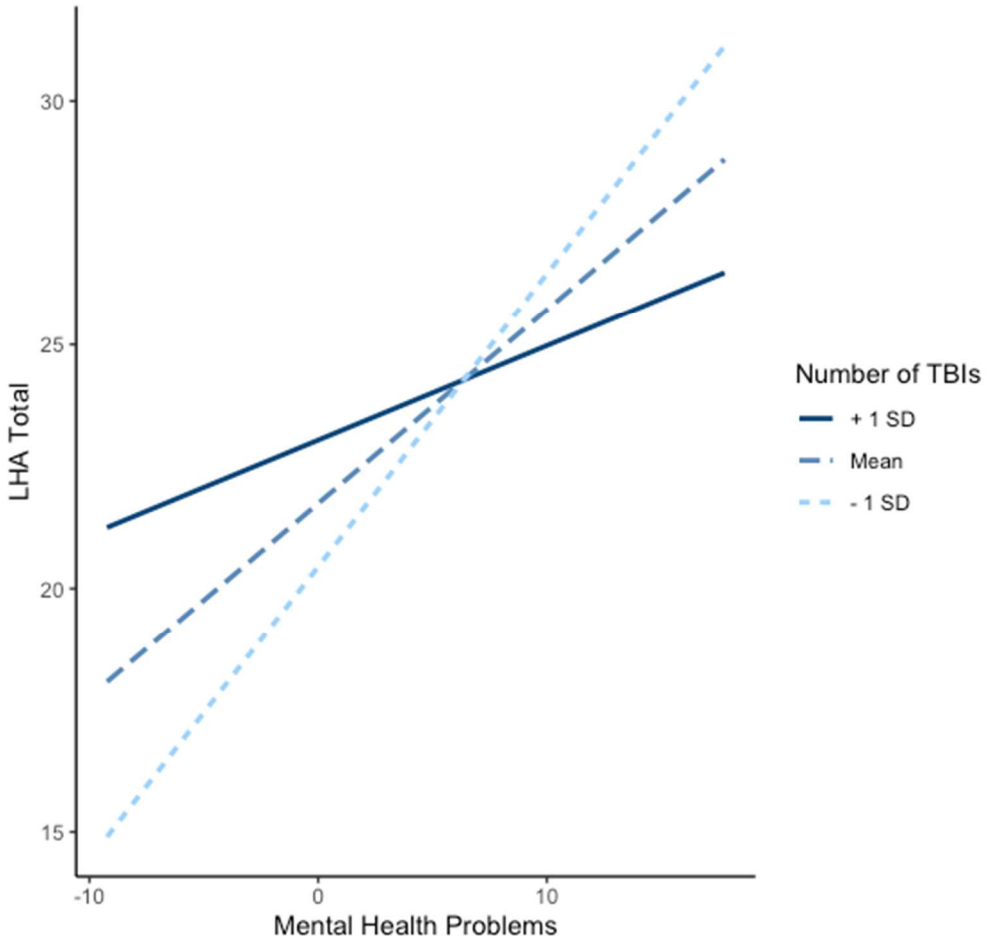

Figure 2

Results of Simple Slopes Analyses Involving Number of TBIs as a Moderator of the Relationship between Mental Health Problems and LHA Total Scores.

DISCUSSION

It is a common belief among the general public that mental health problems cause violent, aggressive, or offending behavior (Batastini et al., 2018; Corrigan & Shapiro, 2010; Markowitz, 2011). These beliefs may be partially due to the establishment of prisons and jails as de facto mental health treatment facilities in the United States, and to the remarkably high rate of mental health problems among individuals housed in correctional facilities (Becker et al., 2012; Ostermann & Matejowski, 2014; Rosenblatt et al., 2000; Silver et al., 2008; Sullivan et al., 2007). Despite the high prevalence of mental health problems in prisons and jails, it seems that there are other related, compounding variables that moderate risk for aggression, arrest, and rearrest, such as substance use and homelessness (Markowitz, 2011; Skeem et al., 2014; Swanson et al., 2002; Witt et al., 2013). The current study focused on TBI and ongoing PCS as moderators because many of the difficulties following TBI (e.g., impulsivity, emotion dysregulation, impaired problem solving) mirror those seen in persons with mental health problems. Thus, the presence of TBI and PCS have the potential to magnify the risk associated with mental health problems, as they compound difficulties that have been linked to impulse control problems (Banich et al., 2009; Scott et al., 2014; Wilkowski & Robinson, 2008). Additionally, given the existing literature showcasing relationships between TBI, aggression, and prior arrest, as well as more recent studies suggesting a relationship between TBI and recidivism (Ray & Richardson, 2017; Schwartz, 2019; Schwartz et al., 2021), this study assessed TBI and PCS as predictors of 1-year general and violent recidivism.

Results supported relationships between mental health problems and aggression proneness but were unrelated to criminal history or recidivism. Positive relationships between TBI and lifetime history of aggression and prior general and violent arrests replicated previous cross-sectional relationships (Markowitz, 2011; Perroud et al., 2011; Schwartz et al., 2021), although there was little evidence that TBI predicted recidivism. In contrast, PCS showed minimal associations with aggression and criminal variables, except for a small negative relationship with prior violent arrests, and exhibited modest utility in predicting recidivism. Finally, neither TBI nor PCS moderated relationships between mental health problems and trait aggression, violence, and offending behavior.

Overall, TBI and PCS seem to correlate with mental health problems among incarcerated persons, and TBI more than PCS showed unique variance separate from mental health problems in relationships with aggression and criminal justice correlates. However, PCS and mental health problems were highly correlated, likely due to symptom overlap across the two measures, which may have limited our ability to detect the true contributions of PCS and mental health problems in our analyses. More practically, the overlap between mental health problems and PCS is representative of the difficulties in disentangling the sequalae associated with a confluence of exacerbating factors faced by individuals involved in the criminal justice system (e.g., substance use, homelessness and housing difficulties, violence exposure, unemployment; Benda et al., 2001; Chauhan et al., 2009; Lutze et al., 2014; Nally et al., 2014). It is therefore difficult to identify the unique influence of TBI, as well as the feasibility of addressing TBI-related concerns when many other pressing issues exist. The results of the current study suggest that more work is needed to assess the practicality of prioritizing the treatment of TBI/PCS-related sequelae amidst a plethora of other practical concerns, where resources are already limited.

Aim 1a: Interrelationships between Mental Health Problems, Aggression, and Offending Behavior

Results generally supported hypotheses that mental health problems would be associated with aggression and violence, in line with prior work suggesting that they share common trait liabilities, including emotionally-relevant impulsivity, such as negative and positive urgency (Johnson & Carver, 2016; Velotti et al., 2017). However, mental health problems were not related to criminal history and did not predict recidivism, after accounting for established risk factors (age, gender, education level, substance use, and prior arrests). This is consistent with the literature suggesting that rather than being directly related to crime, mental health problems may actually be an indicator of other, co-occurring risk factors for arrest that are present in the environment (Skeem et al., 2014; Swanson et al., 2002; Witt et al., 2013).

Surprisingly, mental health problems in our sample were not related to prior arrests, even before controlling for other risk factors, inconsistent with previous work indicating cross-sectional relationships between mental health problems and crime (Becker et al., 2012; Markowitz, 2011; Silver et al., 2008). Much of this past work has assessed mental health at the diagnostic or categorical disorder (e.g., psychosis, bipolar disorder) level. In contrast, work investigating symptoms of mental health problems or broader psychological distress (e.g., worry, feelings of sadness, unusual thought content) has found that the relationship between symptoms of mental health problems and offending is actually quite inconsistent, and that offending behavior is rarely directly related to symptoms (Peterson et al., 2010, 2014; Skeem et al., 2016). The measure of mental health problems in our study assessed a range of severity and symptoms of mental health problems, rather than specific diagnostic categories that were severe enough to meet diagnostic criteria. It may be that specific mental health diagnoses are associated with

additional factors that in turn increase risk for offending or arrest, but that the aggregate symptom scores used in this study were too broad to capture this risk. Results of exploratory analyses in the current study somewhat support this idea, with each one-unit increase in thought disturbances (measuring symptoms of psychosis, which may reflect more severe mental health problems) being associated with a 53% increase in the rate of violent rearrest. This effect size was much larger than that of the aggregate mental health problems composite score (4% increase in rate for each one-unit increase), suggesting that more severe or potentially disabling mental health problems may be more strongly related to recidivism.

Alternatively, discrepancies in relationships between mental health problems and aggression versus arrest data may reflect common-method variance. Aggression and mental health problems were both measured via self-report questionnaires or interviews, while criminal history and recidivism were assessed using arrest records. Mental health problems scores were also higher among individuals who refused the interview phase of our study, which may have impacted the strength of relationships between mental health problems and measures of aggression. Finally, weak relationships between mental health problems and arrests may be also be due to the lower variability present in arrest and rearrest data, which are relatively infrequent events.

Aim 1b: Interrelationships between TBI/PCS, Aggression, and Offending Behavior

Results for number of TBIs were similar to what we found in regard to mental health problems, with medium-sized relationships between number of TBIs and history of violence (LHA) and more extensive and violent criminal histories (prior arrests). Results for TBI did not survive correction for false discovery rate, though results were consistent with the prior literature supporting associations between TBI, aggression, and arrest data (see Williams et all, 2018 for

review). In contrast, TBI did not predict recidivism. Given that we measured number of TBIs, aggression, and past arrests across one's lifetime, at least adult lifetime, our results may indicate that TBI and arrest are associated only indirectly and share environmental risk. That is, there are likely other factors that contribute to increased risk for both TBI and arrest. Recent work has found that arrests increase before TBI and continue to increase for at least 24-months post-injury (Schwartz et al., 2021), suggesting that these co-occur due to shared risk factors (e.g., impulsivity, drug use, violence exposure). Exposure to these different risk factors may change over time, leading to an association between lifetime arrests and lifetime TBIs that does not extend to recidivism prediction. Like the relationship between mental health problems and aggression and arrest, TBI and arrest may be linked through combinations of other, interrelated risk factors.

The exception to the above are results that PSC scores were associated with increased risk for sooner rearrest over one year, though this effect did not survive false discovery rate correction and therefore conclusions are tentative. The size of this effect was small (3% increased risk for one-unit increase in PCS score). These results may reflect increased difficulty navigating reentry following release among individuals with high PCS scores, which may be associated with sooner rearrest. PCS may also be reflective of other risk factors for rearrest, such as increased difficulty with employment due to injury-related difficulties, or other sociodemographic factors potentially indicative of shared risk for PCS and arrest, such as poorer access to medical care (Chiang et al., 2016; Kontos et al., 2020; Volger, 2020).

Aim 2: Number of TBIs and PCS as Moderators

The second aim of the current study tested hypotheses that TBI and PCS would moderate relationships between mental health problems and aggression, criminal history, and recidivism,

such that increased number of TBIs or PSC scores would relate increased strength of these relationships. Results did not support these hypotheses. There was no evidence of moderation by TBI or PCS for trait aggression, criminal history, or recidivism variables. There was, however, a small moderating effect of number of TBIs on history of violence, as measured by the LHA, although the direction was opposite to what was hypothesized. Decomposition of this effect indicated that the relationship between mental health problems and aggression was stronger at low incidence of TBI than high incidence of TBI. This effect was small, however, and did not survive correction for false discovery rate. The meaningfulness of this relationship is therefore unclear.

Conclusions and Implications

In summary, the study's results indicated that mental health problems and a history of TBI both had little utility, independently or interactively, in predicting recidivism in our sample of jail inmates. This was contrary to hypotheses, though not inconsistent with the broader literature suggesting the relationships between TBI, mental health problems, and arrest may exist indirectly in combination with other, general risk factors (Schwartz et al., 2021; Swanson et al., 2002). Though mental health problems were related to aggression, and TBI was related to aggression and official records of past general and violent arrests, the lack of association with recidivism substantiates the idea that involvement in the criminal justice system is multidetermined. The one exception in regard to recidivism included results that the extent to which a person continues to experience problematic symptoms after a TBI, as measured by lasting PCS, related to increased risk of being rearrested sooner (but not more often). The measurement of PCS as affecting individuals at the time of assessment (rather than across the lifespan) may have allowed us to capture this risk more closely to the outcome of rearrest.

A few implications come out of these findings. Many of the effect sizes were small, which should be considered when interpreting the results. At the same time, these small effect sizes should be interpreted with the scale of the measure in mind. For example, a one-unit increase in PCS score represents a relatively small change in self-reported functioning (for example, endorsing headaches as a moderate problem rather than a mild problem) in comparison with a large scale outcome like rearrest. Small subjective one-point changes in functioning may add up to increase risk for rearrest. A small effect size associated with arrest is quite meaningful on a broad scale, given the consequences arrest has from a public health standpoint. In our data, a 3% increase in the rate of rearrest would be associated with an additional 5.82 individuals rearrested per year for each unit increase in PCS. Arrests, even of an additional five people over a year, consume community resources that could have been allocated elsewhere, disrupt social networks, destabilize communities, and can lead to continued involvement in the criminal justice system, which in turn exposes individuals to exacerbating adverse contexts and outcomes (e.g., jail traumatic experiences, mental health problems, housing and employment difficulties; see Clear, 2007 for a review).

In any case, greater focus on PCS rather than TBI among researchers and correctional staff in prediction and prevention of recidivism may be warranted, given its closer proximity to an individual's current functioning. That is, whereas TBI reflected increased risk (whether direct or indirect) for arrests over one's lifespan, PCS seems to reflect the extent to which an individual remains impacted by TBI (and any associated risk factors) at the time of assessment, and therefore may have more utility for prediction. Although more work is needed in piloting interventions for PCS among individuals involved with the criminal justice system, our results lend justification to the implementation of screening procedures and rehabilitation or treatment

programs for individuals who continue to experience PCS while incarcerated. Upon release from jail or prison custody, connecting individuals experiencing PCS to services that may assist with potential associated difficulties (i.e., finding employment, medical care) may be necessary to substantially decrease the risk for rearrest. That is, addressing PCS likely will not be enough to make a substantive impact unless individual-level interventions occur in conjunction with reforms that address structural factors.

Limitations, Strengths, and Future Directions

The current study has several limitations. First there was limited variability in our main outcome variable, recidivism. Though it is common to use a one-year follow-up period for recidivism, a longer follow-up period may have given us more statistical power to detect the utility of mental health problems, TBI, and PCS in predicting long-term outcomes. Further, we were limited to coding only arrests that occurred within the state of Florida. Extending our search to other states would allow us to more fully capture the scope of our participants' criminal histories and likely increase variability in recidivism. Next, there was still considerable variation in TBI that was not captured in the current study, such as age at first and last injury (rather than age at worst injury), and severity at the time of injury (rather than at the time of assessment). Such information may have given us a better sense for when injuries occurred in relation to arrests. For example, increases in arrests before and after the timing of injuries would have further supported indirect relationships between TBI and arrest through other risk factors. Self-report is also unreliable in assessment of TBI, given that memory loss often surrounds the event (McKinlay et al., 2016). The current study could have been strengthened by utilizing a combination of self-report, interview, and official medical records to assess TBI. At the same time, the current study improved on previous work in this area to include assessments of the

number of TBIs accrued across one's lifespan as well as the extent to which one remained impacted by PCS. Assessing lasting PCS in the present analyses allowed for some indication of the relationships between TBI sequelae and severity and offending behavior. In particular, assessment of PCS granted some insight into the associations between ongoing effects of TBI and recidivism.

Despite limitations, the current study included several strengths, such as recruitment of a large sample of persons incarcerated in a county jail, many of whom reentered the community during the study follow-up period. This allowed for assessment of the relationship between study variables and returns to custody, an important consideration given the frequency of rearrest upon release from jails across the country, not just in our sample, and the strain returns to custody place on jail resources and returnees, including difficulties related to health, employment status, and quality of life (Conklin et al., 2000; Prost et al., 2020; Visher et al., 2011). Further, this study was able to assess aggression and offending behavior using several methods, including self-report questionnaires and interviews, as well as official court records of arrest. This allowed us to test the relationships between TBI, mental health problems, and several similar but distinct correlates and outcomes (i.e., criminal history versus recidivism). The utility of these different measures ultimately allowed us to observe the ways in which mental health problems and TBI may be related to aggression and criminal history, but yet be poor predictors of recidivism.

Further, this study highlights several different avenues for future research. Given the preliminary nature of our results regarding PCS and recidivism, future work should continue to evaluate the possibility that symptoms post-TBI and the potential distress related to them may be meaningful for offending behavior outcomes. Should this be the case, additional work evaluating the utility of rehabilitation or treatment programs for ongoing PCS among incarcerated persons

would be an important extension of the present research. It may also be that the association between PCS and recidivism is a byproduct of a more generalized risk; future work evaluating this possibility is warranted. Similarly, given the relationships between mental health problems, TBI, aggression, and criminal history, but the poor utility of these variables in predicting recidivism and moderating effects of mental health problems, the search for common risk factors among these relationships should continue. Such work may be useful guiding where interventions can be directed. One potential avenue for prevention and harm reduction, for example, may be improving education regarding the potential effects of TBI, guidelines to follow post-injury (i.e., preventing reinjury, avoiding bright lights), and best practices to avoid injury.

Finally, as mentioned above, it is possible that broad psychological distress or symptom counts may have different relationships to offending behavior and recidivism than psychiatric diagnoses. To better understand how mental health problems relate to offending behavior, future research should evaluate the relationships assessed in the current study using both broader symptom counts and more specific diagnostic criteria.

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APPENDICES

Appendix A: List of Phase 1 Measures

Table A1

Phase 1 Measures

Measure	Citation	Description
Massachusetts Youth Screening Instrument (MAYSI) – adapted for adult forensic populations	Grisso & Barnum, 2000	Self-report survey developed for assessment of mental health/substance use problems in forensic populations
Comprehensive Health Assessment Tool (CHAT)	Chitsabesan et al., 2015	Self-report survey assessing history of head injury and presence of lasting post-concussion symptoms
Adverse Childhood Experiences Questionnaire (ACE)	Felitti et al., 1998	Self-report survey measuring childhood trauma, abuse, neglect, and family dysfunction
Criminal Peer Association items	Burgess & Akers, 1966	Two self-report items measuring criminal peer association
Self-Control items	Grasmick et al., 1993	Three self-report items measuring self-control
Mini International Personality Item Pool (MINI-IPIP)	Donnellan et al., 2006	Self-report measure of the 5-factor model of personality traits

Note. Measures used in the current study are bolded.

Appendix B: List of Phase 2 Measures

Table A2

Phase 2 Measures

Measure	Citation	Description
Mini-International Neuropsychiatric Interview (MINI)	Sheehan et al., 1998	A structured clinical interview used to diagnose major depressive, bipolar, and psychotic disorders
Penn State Worry Questionnaire (PSWQ)	Meyer et al., 1990	Self-report measure assessing worry and anxiety
Mood and Anxiety Symptom Questionnaire- D30 (MASQ-D30)	Wardenaar et al., 2010	Self-report measure assessing symptoms of mood and anxiety disorders
Columbia Suicide Severity Rating Scale (CSSRS)	Posner et al., 2008	Interview measure evaluating risk of suicidality
Self-Injurious Thoughts & Behaviors Interview (SITBI)	Nock et al., 2007	Self-report measure evaluating self-harm thoughts and behaviors
Texas Christian University Drug Screen 5 (TCUDS)	Knight, 2017	Assesses past and current alcohol/drug use and symptoms of substance use disorders
Weschler Abbreviated Scale of Intelligence- II (WASI-II)	Weschler, 2011	Estimated IQ and cognitive capabilities
Psychopathy Checklist – Revised (PCL-R)	Hare, 2003	Clinical interview used to assess psychopathic traits and antisocial characteristics
Diagnostic and Statistical Manual-5 (DSM-V) for Antisocial Personality Disorder (ASPD)	American Psychiatric Association, 2013	Interviewer ratings on diagnostic criteria for ASPD and conduct disorder
Personality Assessment Inventory – Borderline Features Scale (PAI-BOR)	Morey, 1991	Self-report measure evaluating features of borderline personality disorder
Pathological Narcissism Inventory (PNI)	Pincus et al., 2009	Self-report survey evaluating features of narcissistic personality pathology
Multidimensional Personality Questionnaire	Patrick et al., 2013	Self-report measure assessing normative personality traits
PTSD Checklist-5 (PCL-5)	Weathers et al., 2013	Self-report checklist measuring exposure to trauma and assessing symptoms of post-traumatic stress disorder
Aggression Questionnaire (AQ)	Buss & Warren, 2000	Self-report measure evaluating aggression dispositions and risk of violence
Life History of Aggression (LHA)	Coccaro et al., 1997	Interviewer ratings of history of aggression and aggressive behaviors

Note. Measures used in the current study are bolded.

Appendix C: Florida Counties Searched During Recidivism Coding

- Broward County
- Hernando County
- Hillsborough County
- Miami-Dade County
- Pasco County
- Pinellas County
- Polk County

Appendix D: Histograms of Main Study Variables

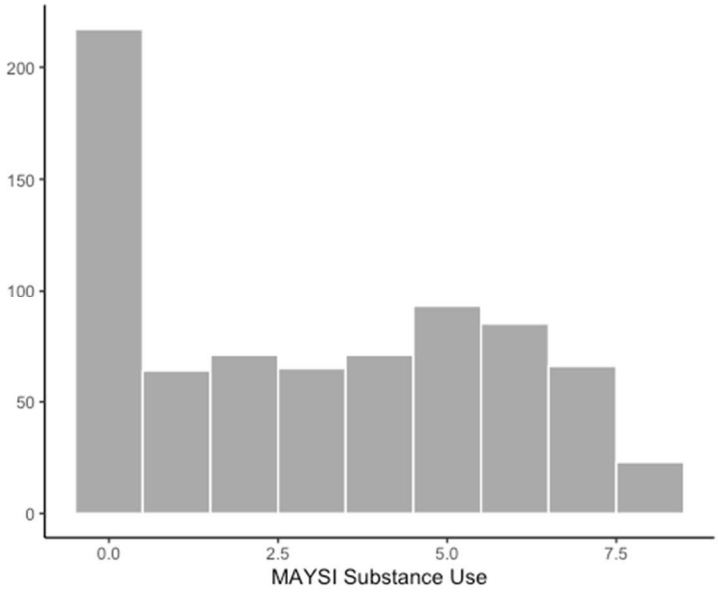

Figure A1

Sample Distribution of Substance Use Scores

Appendix D (Continued)

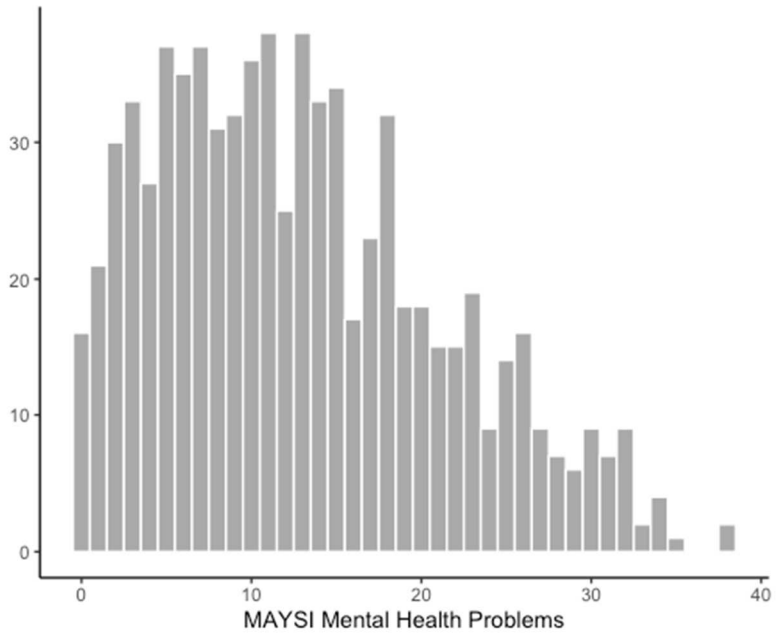

Figure A2

Sample Distribution of Mental Health Problems Scores

Appendix D (Continued)

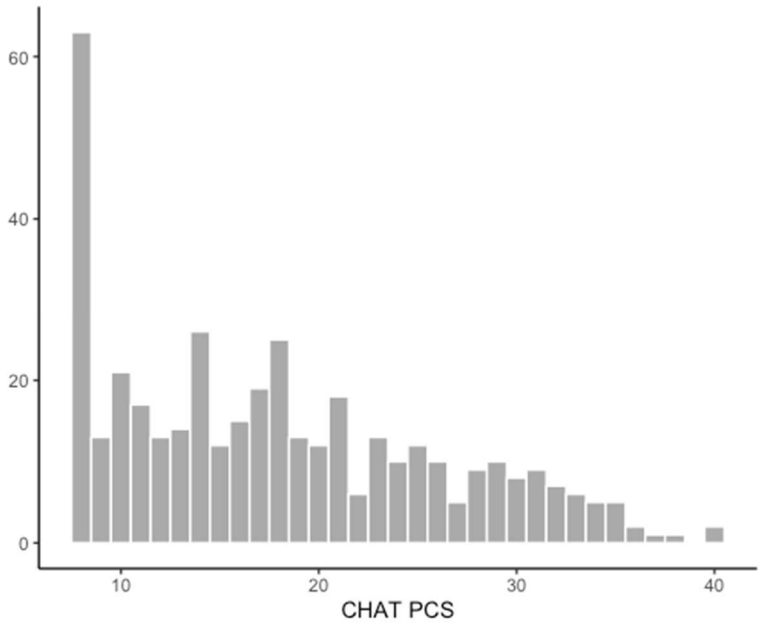

Figure A3

Sample Distribution of Post-Concussion Syndrome Scores

Appendix D (Continued)

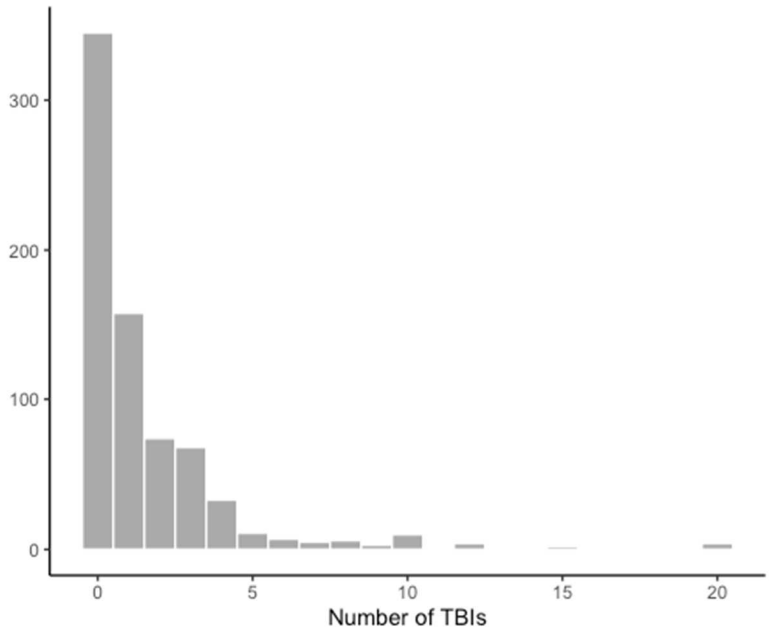

Figure A4

Sample Distribution of Number of Traumatic Brain Injuries

Appendix D (Continued)

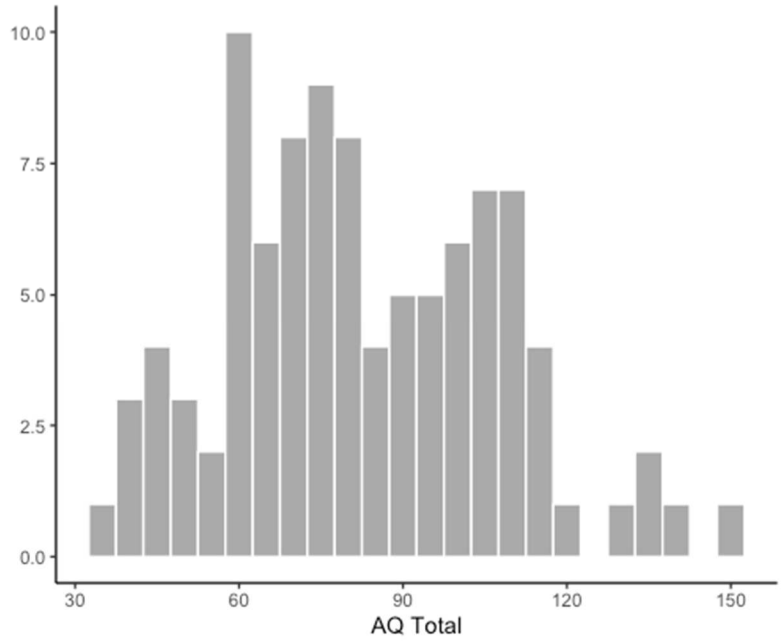

Figure A5

Sample Distribution of Trait Aggression Scores

Appendix D (Continued)

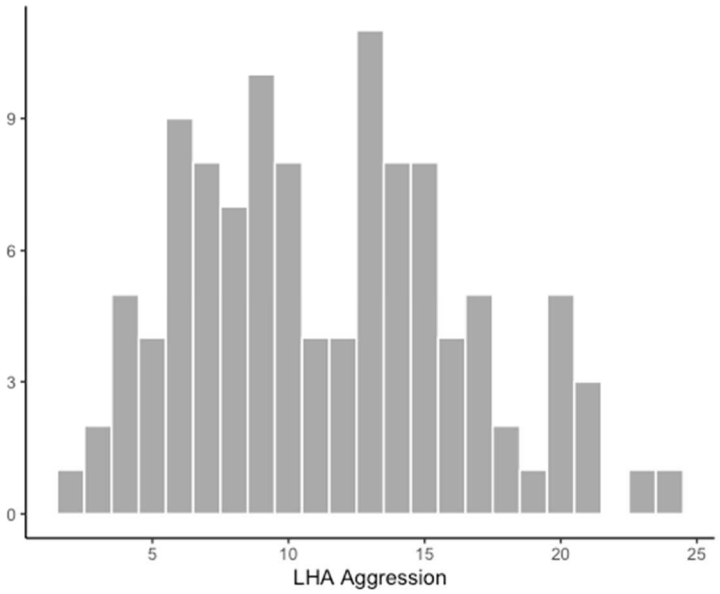

Figure A6

Sample Distribution of Lifetime History of Aggression Subscale Scores

Appendix D (Continued)

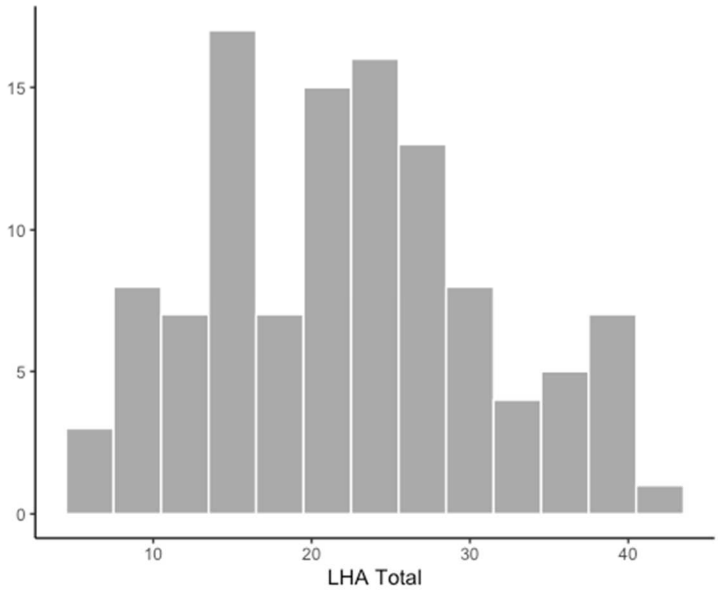

Figure A7

Sample Distribution of Lifetime History of Aggression Total Scores

Appendix D (Continued)

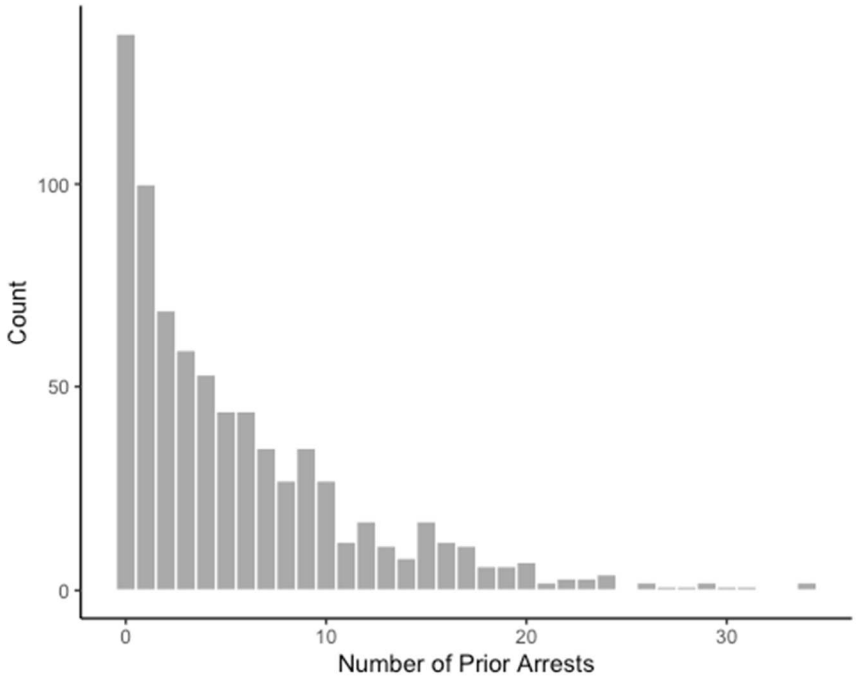

Figure A8

Sample Distribution of Number of Prior Arrests

Appendix D (Continued)

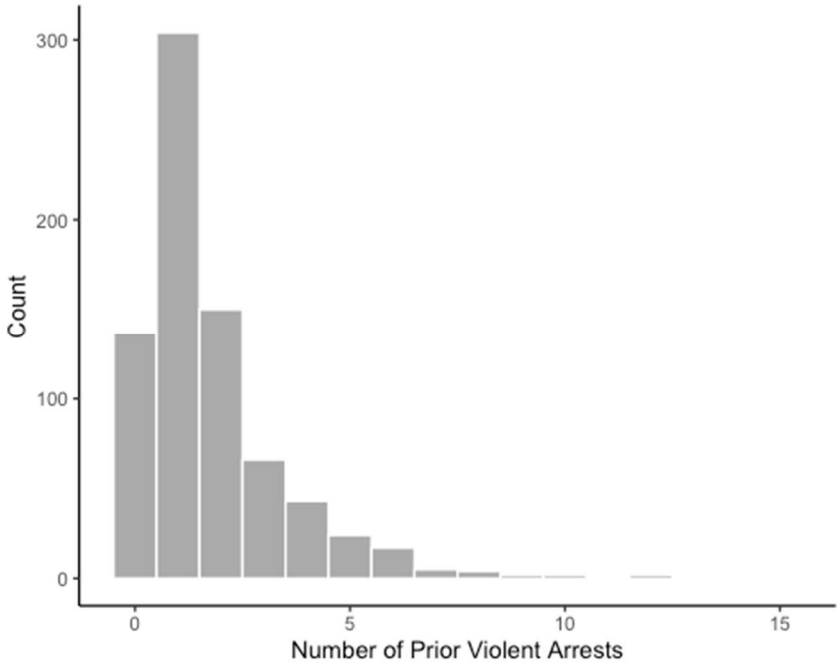

Figure A9

Sample Distribution of Number of Prior Violent Arrests

Appendix D (Continued)

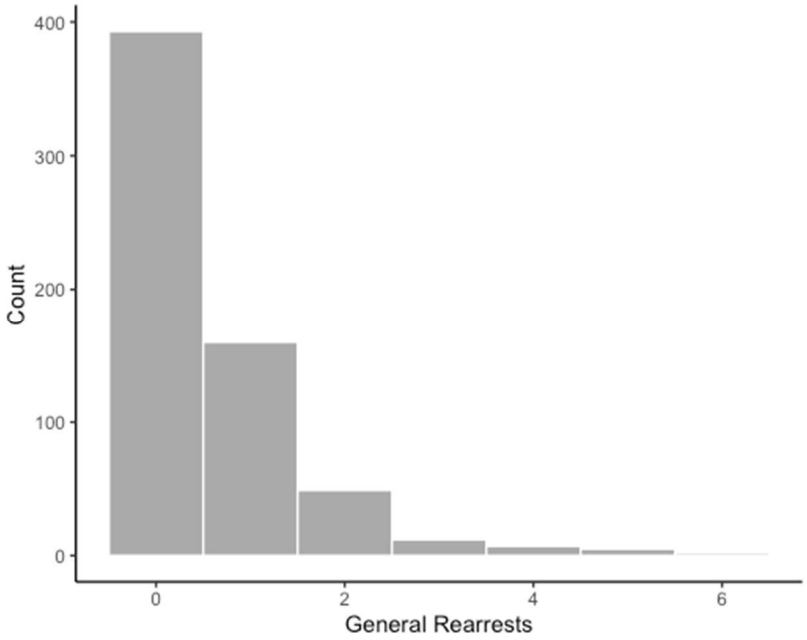

Figure A10

Sample Distribution of Number of General Rearrests

Appendix D (Continued)

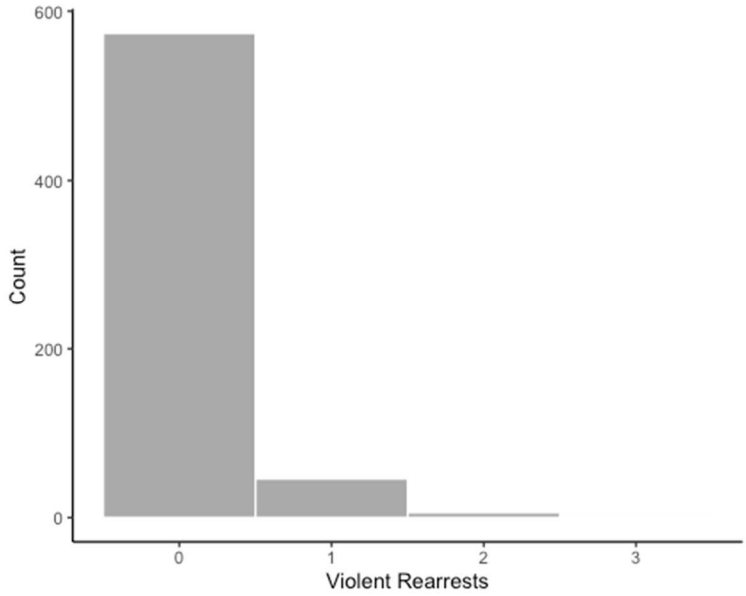

Figure A11

Sample Distribution of Number of Violent Rearrests

Appendix D (Continued)

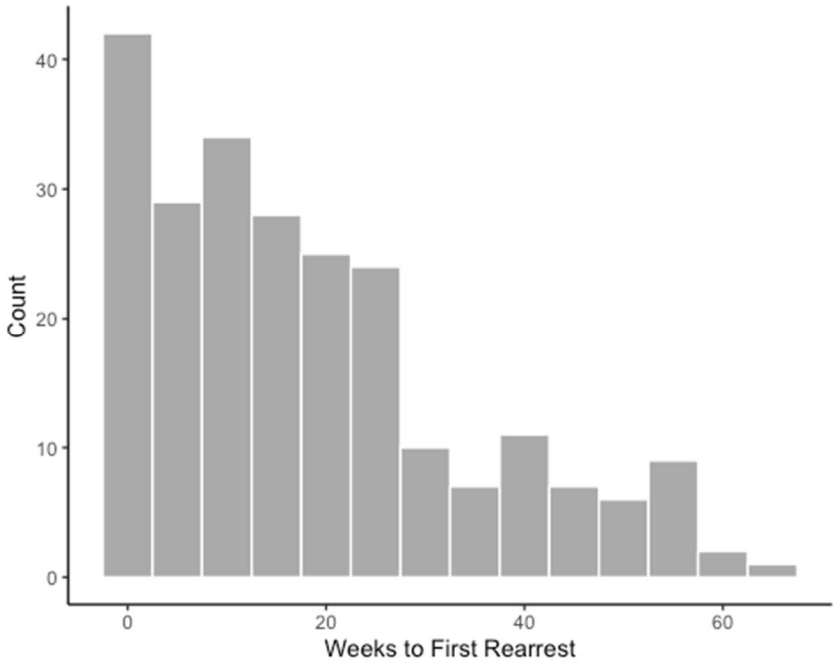

Figure A12

Sample Distribution of Weeks to First Rearrest

Appendix D (Continued)

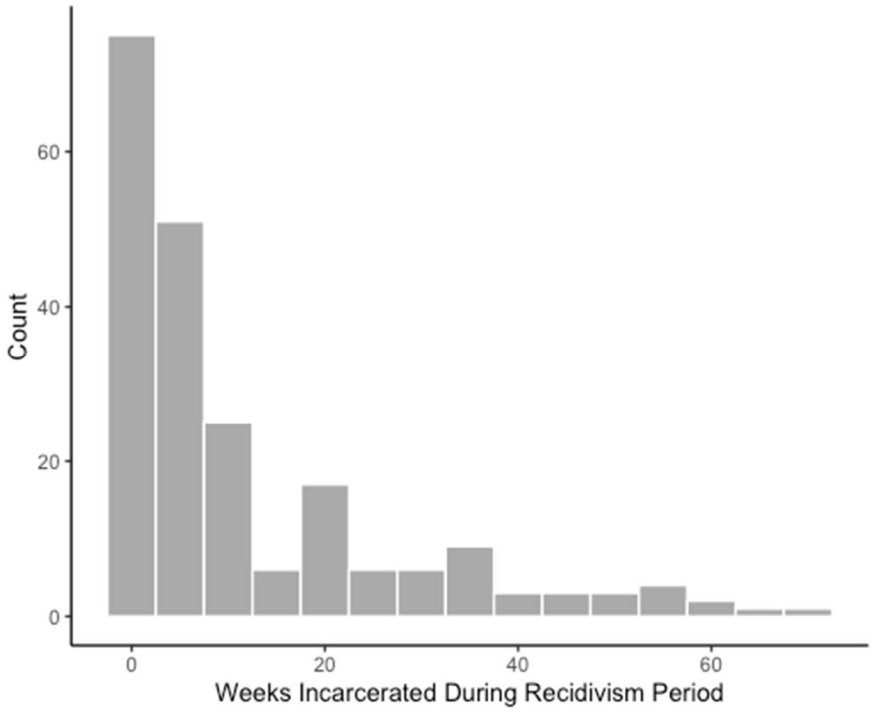

Figure A13

Sample Distribution of Weeks Spent Incarcerated During the Recidivism Period

Appendix E: Results of Models Without MAYSI Substance Use Scores Included as a Covariate

Table A3

Negative Binomial Regression Results for Criminal History and Recidivism as a Function of Mental Health Problems

Prior Arrests							
Independent Variable	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	1.96	1.52, 2.41	.21				.056
Age	.01	.00, .02	.00	3.56	1.01	.000**	
Gender	-.40	-.58, -.22	.09	-4.39	.67	.000**	
Race	-.08	-.26, .11	.10	-.80	.93	.43	
Education	-.16	-.25, -.07	.05	-3.30	.85	.001**	
MAYSI Mental Health Problems	.02	.00, .03	.01	2.52	1.02	.012*	

Prior Violent Arrests							
Independent Variable	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	.88	.53, 1.24	.18				.072
Age	.01	.00, .01	.00	2.86	1.01	.004**	
Gender	-.47	-.63, -.31	.08	-5.82	.63	.000**	
Race	.08	-.07, .23	.08	1.01	1.08	.31	
Education	-.09	-.17, -.01	.04	-2.30	.91	.022*	
MAYSI Mental Health Problems	.01	.00, .02	.01	2.75	1.01	.006**	

General Rearrests							
Predictor	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	-3.33	-4.42, -2.21	.49				.030
Age	-.02	-.04, .00	.01	-1.85	.98	.06	
Gender	-.13	-.59, .33	.20	-.67	.87	.51	
Race	-.39	-.87, .10	.21	-1.82	.68	.07	
Education	.03	-.21, .27	.11	.30	1.03	.76	
Number of Prior Arrests	.06	.03, .10	.02	3.84	1.06	.000**	
MAYSI Mental Health Problems	.01	-.03, .04	.01	.46	1.01	.65	

Violent Rearrests							
Predictor	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	-5.34	-7.33, -3.33	.94				.069
Age	-.01	-.05, .03	.02	-.77	.99	.37	
Gender	-1.01	-1.99, -.07	.42	-2.43	.36	.012*	
Race	-.35	-1.27, .56	.41	-.86	.70	.15	

Table A3 (Continued)

Predictor	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Education	.23	-.26, .73	.20	1.13	1.26	.16	
Number of Prior Arrests	.06	-.01, .12	.03	2.10	1.06	.023*	
MAYSI Mental Health Problems	.07	.00, .14	.03	2.32	1.07	.029*	

Note. For gender, 1 = man, 2 = woman; MAYSI = Massachusetts Youth Screening Instrument.
*$p < .05$.
**$p < .01$.

Appendix E (Continued)

Table A4

Regression Results for Aggression Scores as a Function of Mental Health Problems, TBI, and PCS

AQ Total						
Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Age	.00	.22	.00	.99	.00	R^2 = .214**
Gender	-7.66	5.81	-.14	.19	.02	95% CI[.04, .31]
Race	9.78	5.75	.18	.09	.03	
Education	3.26	2.80	.12	.25	.01	
Number of Prior Arrests	.32	.36	.09	.38	.01	
MAYSI Mental Health Problems	1.58	.36	.45	.000**	.18	
Intercept	59.58	15.15				R^2 = .226**
Age	.02	.22	.01	.93	.00	95% CI[.03, .32]
Gender	-6.44	5.90	-.11	.28	.01	
Race	10.68	5.80	.20	.07	.03	
Education	2.69	2.84	.10	.35	.01	
Number of Prior Arrests	.30	.36	.08	.40	.01	
MAYSI Mental Health Problems	1.51	.37	.43	.000**	.16	
Number of TBIs	1.03	.94	.11	.27*	.01	
Intercept	41.13	19.34				R^2 = .313*
Age	-.04	.31	-.02	.91	.00	95% CI[.02, .41]
Gender	-6.85	8.59	-.11	.43	.01	
Race	16.57	7.87	.28	.041*	.07	
Education	6.28	3.87	.22	.11	.04	
Number of Prior Arrests	.61	.52	.16	.24	.02	
MAYSI Mental Health Problems	1.78	.62	.48	.006*	.12	
Lasting PCS	.41	.61	.12	.50	.01	

LHA Total						
Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Age	-.09	.07	-.11	.21	.01	R^2 = .218**
Gender	-3.09	1.79	-.16	.09	.02	95% CI[.05, .31]
Race	.66	1.82	.09	.72	.00	
Education	-.06	.87	-.01	.94	.00	
Number of Prior Arrests	.28	.11	.24	.014*	.05	
MAYSI Mental Health Problems	.44	.12	.35	.000**	.12	

Table A4 (Continued)

Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Intercept	20.51	4.64				R^2 = .265**
Age	-.08	.07	-.10	.27	.01	95% CI[.08, .35]
Gender	-2.20	1.78	-.12	.22	.01	
Race	1.36	1.80	.07	.45	.00	
Education	-.44	.86	-.05	.61	.00	
Number of Prior Arrests	.27	.11	.22	.017*	.05	
MAYSI Mental Health Problems	.39	.11	.32	.001**	.09	
Number of TBIs	.76	.31	.23	.015*	.05	
Intercept	23.38	6.00				R^2 = .208
Age	-.05	.10	-.06	.64	.00	95% CI[.00, .30]
Gender	-3.46	2.67	-.17	.20	.03	
Race	3.64	2.50	.20	.15	.03	
Education	.32	1.22	.04	.79	.00	
Number of Prior Arrests	.20	.16	.18	.19	.03	
MAYSI Mental Health Problems	.54	.21	.44	.012*	.11	
Lasting PCS	-.20	.19	-.18	.32	.02	

LHA Aggression

Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Age	-.01	.04	-.03	.79	.00	R^2 = .154*
Gender	-1.02	1.07	-.09	.35	.01	95% CI[.01, .24]
Race	.34	1.09	.03	.75	.00	
Education	.17	.52	.03	.75	.00	
Number of Prior Arrests	.11	.07	.16	.10	.02	
MAYSI Mental Health Problems	.25	.07	.36	.000**	.12	
Intercept	7.79	2.78				R^2 = .201**
Age	.00	.04	-.01	.93	.00	95% CI[.03, .29]
Gender	-.51	1.07	-.05	.64	.00	
Race	.74	1.08	.07	.49	.00	
Education	-.05	.52	-.01	.93	.00	
Number of Prior Arrests	.10	.07	.15	.12	.02	
MAYSI Mental Health Problems	.23	.07	.32	.001**	.09	
Number of TBIs	.44	.19	.23	.02*	.05	
Intercept	9.98	3.77				R^2 = .153
Age	.00	.06	.01	.94	.00	95% CI[.00, .23]
Gender	-1.50	1.68	-.12	.38	.01	

Table A4 (Continued)

Independent Variable	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Race	1.38	1.57	.12	.38	.01	
Education	.40	.77	.07	.60	.00	
Number of Prior Arrests	.10	.10	.14	.31	.02	
MAYSI Mental Health Problems	.33	.13	.45	.014*	.11	
Lasting PCS	-.13	.12	-.19	.29	.02	

Note. For gender, 1 = man, 2 = woman; MAYSI = Massachusetts Youth Screening Instrument; AQ = Aggression Questionnaire; TBI = Traumatic Brain Injury; PCS = Post-Concussion Syndrome; $n = 103$ for TBI models; $n = 59$ for PCS models.

*$p < .05$.
**$p < .01$.

Appendix E (Continued)

Table A5

Negative Binomial and Poisson Regression Results for Criminal History and Recidivism as a Function of TBI and PCS

DV: Prior Arrests							
Independent Variable	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	1.96	1.51, 2.42	.22				.056
Age	.01	.00, .02	.00	3.41	1.01	.001**	
Gender	-.39	-.58, -.20	.09	-4.11	.68	.000**	
Race	-.07	-.25, .12	.10	-.68	.94	.50**	
Education	-.16	-.25, -.07	.05	-3.32	.86	.001**	
MAYSI Mental Health Problems	.01	.00, .02	.01	1.43	1.01	.15	
Number of TBIs	.04	.00, .07	.02	2.15	1.04	.032*	
Independent Variable	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	2.02	1.41, 2.63	.30				.036
Age	.01	.00, .02	.00	2.52	1.01	.012*	
Gender	-.20	-.45, .07	.13	-1.50	.82	.13	
Race	.00	-.25, .27	.13	.03	1.00	.98	
Education	-.15	-.27, -.04	.06	-2.59	.86	.009**	
MAYSI Mental Health Problems	.02	.00, .04	.01	1.65	1.02	.10	
Lasting PCS	-.01	-.03, .00	.01	-1.66	.99	.10	
Prior Violent Arrests							
Independent Variable	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	.83	.47, 1.19	.18				.078
Age	.01	.00, .02	.00	2.90	1.01	.004**	
Gender	-.44	-.61, -.28	.08	-5.38	.64	.000**	
Race	.10	-.05, .25	.08	1.28	1.11	.20	
Education	-.09	-.17, .-01	.04	-2.25	.91	.025*	
MAYSI Mental Health Problems	.01	.00, .02	.01	1.84	1.01	.07	
Number of TBIs	.03	.00, .06	.01	2.33	1.03	.020*	
Independent Variable	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	.97	.48, 1.45	.24				.066
Age	.01	.00, .02	.00	2.01	1.01	.04*	
Gender	-.30	-.53, -.08	.11	-2.71	.74	.007**	
Race	.17	-.03, .37	.10	1.66	1.19	.10	
Education	-.10	-.20, -.01	.05	-2.07	.90	.039*	

Table A5 (Continued)

Independent Variable	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
MAYSI Mental Health Problems	.02	.01, .04	.01	2.55	1.02	.011*	
Lasting PCS	-.02	-.03, .00	.01	-2.31	.98	.021*	

General Rearrests

Predictor	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	-3.34	-4.44, -2.23	.49				.031
Age	-.01	-.03, .01	.01	-1.66	.99	.10	
Gender	-.18	-.65, .29	.21	-.89	.83	.37	
Race	-.35	-.83, .14	.21	-1.64	.70	.10	
Education	.04	-.20, .28	.11	.36	1.04	.72	
Number of Prior Arrests	.06	.03, .10	.02	3.96	1.07	.000**	
MAYSI Mental Health Problems	.01	-.03, .04	.01	.46	1.01	.64	
Number of TBIs	-.02	-.12, .08	.04	-.67	.98	.50	

Predictor	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	-2.75	-4.41, -1.04	.69				.032
Age	-.02	-.05, .01	.01	-1.67	.98	.10	
Gender	.14	-.54, .85	.30	.48	1.15	.63	
Race	-.22	-.92, .52	.31	-.69	.81	.49	
Education	-.13	-.45, .19	.14	-.94	.88	.35	
Number of Prior Arrests	.05	.01, .10	.02	2.51	1.05	.012*	
MAYSI Mental Health Problems	-.04	-.10, .03	.03	-1.36	.96	.17	
Lasting PCS	.02	-.03, .06	.02	.78	1.02	.44	

Violent Rearrests

Predictor	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	-5.32	-7.36, -3.25	.97				.075
Age	-.01	-.05, .03	.02	-.64	.99	.52	
Gender	-1.10	-2.14, -.11	.44	-2.52	.33	.012*	
Race	-.32	-1.26, .62	.42	-.76	.73	.45	
Education	.24	-.28, .76	.21	1.13	1.27	.26	
Number of Prior Arrests	.07	-.01, .15	.03	2.21	1.07	.027*	
MAYSI Mental Health Problems	.05	-.02, .13	.03	1.89	1.05	.06	
Number of TBIs	.03	-.14, .24	.06	.55	1.03	.58	

Table A5 (Continued)

Predictor[a]	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Intercept	-5.59	-7.45, -3.80	.93				.054
Age	-.02	-.05, .01	.02	-1.00	.98	.32	
Gender	-.51	-1.43, .28	.43	-1.18	.60	.24	
Race	.03	-.76, .75	.38	.08	1.03	.94	
Education	.00	-.35, .35	.18	.01	1.00	.99	
Number of Prior Arrests	.07	.02, .11	.02	3.09	1.07	.002**	
MAYSI Mental Health Problems	.04	-.02, .11	.03	1.25	1.04	.21	
Lasting PCS	.00	-.06, .05	.03	-.17	1.00	.86	

Note. For gender, 1 = man, 2 = woman; MAYSI = Massachusetts Youth Screening Instrument.
[a]Model is a Poisson regression.
*$p < .05$.
**$p < .01$.

Appendix F: Results of Exploratory Analyses

Table A6

Zero-Order Correlations between Main Study Variables

	1	2	3	4	5	6	7	8	10	11	12	13	14	15	16	17	18	19	20
1. MAYSI Mental Health Problems	–																		
2. CHAT PCS	.61*	–																	
3. CHAT Number of TBIs	.26*	.17*	–																
4. AQ Total	.37*	.30	.15	–															
5. LHA Aggression	.31*	-.03	.24	.53*	–														
6. LHA Total	.31*	-.03	.24	.56*	.93*	–													
7. Prior Arrests	.06	-.06	.10*	.09	.21	.26*	–												
8. Prior Violent Arrests	.07	-.07	.11*	.04	.13	.14	.63*	–											
10. General Rearrests	.07	.02	-.02	.05	-.05	-.03	.17*	.07	–										
11. Violent Rearrests	.09	.02	.05	.07	.12	.06	.12*	.13*	.27*	–									
12. Age	-.04	.04	.05	-.04	-.04	-.13	.09	.07	-.05	-.04	–								
13. Gender	.09	.19*	-.11*	-.11	-.05	-.13	-.16*	-.20*	-.04	-.08	.01	–							
14. Race	-.07	-.11	-.08	.17	.02	.06	-.02	-.03	.01	-.18*	-.16*	-.05	–						
15. Education	-.01	-.04	.09	-.02	-.04	-.09	-.14*	-.08	-.07	-.02	-.22*	.13*	-.09	–					
16. MAYSI Substance Use	.41*	.15*	.12*	.14	.29*	.33*	.21*	.16*	.06	.10	-.14*	-.11*	-.05	-.09*	–				
17. MAYSI Depressed-Anxious	.90*	.55*	.23*	.33*	.26*	.26*	.05	.06	.03	.08	-.01	.05	-.05	-.04	.38*	–			
18. MAYSI Somatic Complaints	.76*	.53*	.16*	.26*	.24*	.20	.04	.04	.02	.05	-.05	.26*	-.10	.02	.31*	.59*	–		
19. MAYSI Suicidal Ideation	.67*	.36*	.14*	.21	.16	.15	.01	.04	-.01	.02	-.02	.00	-.03	.01	.21*	.55*	.33*	–	
20. MAYSI Thought Disturbances	.61*	.37*	.13*	.37*	.26*	.30*	.11*	.10*	.13*	.15*	-.02	-.07	.07	-.07	.27*	.50*	.30*	.43*	–
21. MAYSI Traumatic Experiences	.75*	.36*	.30*	.31*	.28*	.33*	.04	.04	.08	.03	-.06	.10*	-.08	.04	.35*	.61*	.44*	.35*	.36*

Note. MAYSI = Massachusetts Youth Screening Instrument; CHAT = Comprehensive Health Assessment Tool; PCS = Post-Concussion Syndrome; TBI = Traumatic Brain Injury; LHA = Lifetime History of Aggression. For correlations with MAYSI subscales: $n = 399$ for PCS, $n = 722$ for number of TBIs, $n = 97$ for AQ, $n = 109$ for LHA, $n = 746$ for criminal history, and $n = 619$ for recidivism; for number of TBIs: $n = 399$ for PCS, $n = 93$ for AQ, $n = 105$ for LHA, $n = 731$ for criminal history, and $n = 607$ for recidivism; for PCS: $n = 55$ for AQ, $n = 61$ for LHA, $n = 399$ for criminal history, and $n = 325$ for recidivism.

*$p<.01$.

Appendix F (Continued)

Table A7

Regression Results for Aggression Scores as a Function of Mental Health Problems Subscales

AQ Total						
Independent Variable (in separate models)	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
MAYSI Depressed-Anxious	4.03	1.05	.42	.000**	.14	R^2 = .120-.197**
MAYSI Somatic Complaints	3.41	1.26	.30	.008**	.07	
MAYSI Suicidal	4.43	1.86	.25	.020*	.06	
MAYSI Thought Disturbances	7.70	2.22	.35	.001**	.11	
MAYSI Traumatic Experiences	5.53	1.59	.39	.001**	.11	
LHA Total						
Independent Variable (in separate models)	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
MAYSI Depressed-Anxious	.79	.32	.24	.015*	.05	R^2 = .195**-.259**
MAYSI Somatic Complaints	.69	.39	.17	.08	.03	
MAYSI Suicidal	.99	.53	.17	.06	.03	
MAYSI Thought Disturbances	2.04	.71	.26	.005**	.06	
MAYSI Traumatic Experiences	1.72	.50	.34	.001**	.09	
LHA Aggression						
Independent Variable (in separate models)	*B*	*SE(B)*	*ß*	*P*	sr^2	Fit
MAYSI Depressed-Anxious	.49	.19	.26	.011*	.06	R^2 = .152*-.182**
MAYSI Somatic Complaints	.48	.23	.21	.042*	.04	
MAYSI Suicidal	.63	.31	.19	.047*	.03	
MAYSI Thought Disturbances	1.01	.42	.24	.010*	.06	
MAYSI Traumatic Experiences	.84	.30	.29	.006**	.06	

Note. All covariates were included in models, but were omitted from this table to reduce redundancy. Subscale scores were included in separate models. For gender, 1 = man, 2 = woman; MAYSI = Massachusetts Youth Screening Instrument; AQ = Aggression Questionnaire.
*$p < .05$.
**$p < .01$.

Appendix F (Continued)

Table A8

Negative Binomial Regression Results for Criminal History and Recidivism as a Function of Mental Health Problems Subscales

DV: Prior Arrests Independent Variable (in separate models)	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
MAYSI Depressed-Anxious	.00	-.03, .04	.02	.07	1.00	.94	.077-.078
MAYSI Somatic Complaints	.01	-.03, .05	.02	.43	1.01	.67	
MAYSI Suicidal	-.01	-.07, .05	.03	-.31	.99	.75	
MAYSI Thought Disturbances	.05	-.04, .13	.05	1.00	1.05	.32	
MAYSI Traumatic Experiences	.02	-.03, .07	.03	.77	1.02	.44	
Prior Violent Arrests Independent Variable (in separate models)	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
MAYSI Depressed-Anxious	.01	-.02, .04	.02	.52	1.01	.61	.091-.092
MAYSI Somatic Complaints	.02	-.01, .06	.02	1.20	1.02	.23	
MAYSI Suicidal	.00	-.05, .05	.03	.10	1.00	.92	
MAYSI Thought Disturbances	.03	-.04, .10	.04	1.00	1.03	.37	
MAYSI Traumatic Experiences	.01	-.03, .06	.02	.65	1.01	.51	
General Rearrests Predictor (in separate models)	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
MAYSI Depressed-Anxious	-.03	-.12, .07	.04	-.67	.97	.50	030-.033
MAYSI Somatic Complaints	.00	-.11, .12	.05	.04	1.00	.97	
MAYSI Suicidal	-.07	-.23, .10	.07	-.94	.93	.35	
MAYSI Thought Disturbances	.14	-.08, .39	.12	1.43	1.16	.15	
MAYSI Traumatic Experiences	.08	-.05, .21	.06	1.32	1.08	.19	
Violent Rearrests Predictor (in separate models)	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
MAYSI Depressed-Anxious	.09	-.09, .26	.08	1.12	1.09	.26	.070-.091
MAYSI Somatic Complaints	.11	-.13, .35	.11	1.15	1.11	.25	
MAYSI Suicidal	.03	-.28, .34	.14	.20	1.03	.84	
MAYSI Thought Disturbances	.43	.03, .87	.26	2.49	1.53	.013*	
MAYSI Traumatic Experiences	.01	-.24, .26	.11	.08	1.01	.94	

Note. All covariates were included in models, but were omitted from this table to reduce redundancy. Subscale scores were included in separate models. For gender, 1 = man, 2 = woman; MAYSI = Massachusetts Youth Screening Instrument.

*$p < .05$.

**$p < .01$.

Appendix F (Continued)

Table A9

Cox Proportional Hazards Model Results Predicting Time to First Rearrest from Mental Health Problems Subscales

Predictor (in separate models)	*ß*	HR	95% CI	SE	*z*	*p*
MAYSI Depressed-Anxious	.02	1.02	.96, 1.08	.03	.67	.51
MAYSI Somatic Complaints	.03	1.03	.96, 1.11	.04	.87	.38
MAYSI Suicidal	.04	1.04	.94, 1.15	.05	.70	.49
MAYSI Thought Disturbances	.04	1.05	.91, 1.20	.07	.65	.52
MAYSI Traumatic Experiences	.05	1.05	.97, 1.13	.04	1.12	.26

Note. All covariates were included in models, but were omitted from this table to reduce redundancy. Subscale scores were included in separate models. For gender, 1 = man, 2 = woman; MAYSI = Massachusetts Youth Screening Instrument.
*$p < .05$.
**$p < .01$.

Appendix F (Continued)

Table A10

Regression Results for Aggression Scores as a Function of TBI

AQ Total Independent Variable (in separate models)	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Earliest Age of Injury	.67	.54	.17	.22	.02	R^2 = .270-.370***
Duration Unconscious	.28	2.41	.03	.88	.00	
Hospitalization for Injury	14.68	7.20	.26	.047*	.06	
LHA Total Independent Variable (in separate models)	*B*	*SE(B)*	*ß*	*p*	sr^2	Fit
Earliest Age of Injury	.11	.17	.09	.52	.01	R^2 = .206-.235*
Duration Unconscious	.87	.85	.18	.32	.02	
Hospitalization for Injury	1.90	2.29	.11	.41	.01	
LHA Aggression Independent Variable (in separate models)	*B*	*SE(B)*	*ß*	*P*	sr^2	Fit
Earliest Age of Injury	.15	.10	.21	.16	.05	R^2 = .185-.229
Duration Unconscious	.27	.51	.09	.60	.01	
Hospitalization for Injury	.97	1.42	.09	.50	.01	

Note. In Step 2, all covariates were included in models, but were omitted from this table to reduce redundancy. Subscale scores were included in separate models. For gender, 1 = man, 2 = woman; MAYSI = Massachusetts Youth Screening Instrument; AQ = Aggression Questionnaire.

*$p < .05$.

**$p < .01$.

Appendix F (Continued)

Table A11

Negative Binomial Regression Results for Criminal History and Recidivism as a Function of TBI

Prior Arrests Results							
Independent Variable (in separate models)	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Earliest Age of Injury	.01	-.01, .02	.01	1.09	1.01	.28	.054-.059
Duration Unconscious	-.02	-.08, .04	.03	-.69	.98	.49	
Hospitalization for Injury	.03	-.21, .26	.12	.22	1.03	.83	
Prior Violent Arrests Results							
Independent Variable (in separate models)	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Earliest Age of Injury	.01	.00, .02	.00	1.19	1.01	.23	.082-.086
Duration Unconscious	-.04	-.09, .01	.03	-1.43	.96	.15	
Hospitalization for Injury	.00	-.19, .19	.10	.00	1.00	.99	
General Rearrests Results							
Predictor (in separate models)	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Earliest Age of Injury	.01	-.02, .05	.01	1.08	1.01	.28	.028-.033
Duration Unconscious	.08	-.08, .25	.08	1.09	1.08	.27	
Hospitalization for Injury	.19	-.45, .84	.33	.70	1.21	.48	
Violent Rearrests Results							
Predictor (in separate models)	*B*	95% CI	*SE*	*z*	IRR	*p*	$R^2_{deviance}$
Earliest Age of Injury[a]	.00	-.05, .03	.02	-.19	1.00	.85	.058-.065
Duration Unconscious[a]	.03	-.16, .20	.09	.32	1.03	.75	
Hospitalization for Injury[a]	.13	-.57, .81	.40	.38	1.14	.70	

Note. All covariates were included in models, but were omitted from this table to reduce redundancy. Subscale scores were included in separate models. For gender, 1 = man, 2 = woman; MAYSI = Massachusetts Youth Screening Instrument.

*$p < .05$.

**$p < .01$.

[a]Model is a Poisson regression.

Appendix F (Continued)

Table 12

Cox Proportional Hazards Model Results Predicting Time to First Rearrest from TBI

Predictor (in separate models)	*ß*	HR	95% CI	SE	*z*	*p*
Earliest Age of Injury	-.01	.99	.97, 1.01	.01	-.81	.42
Duration Unconscious	-.07	.93	.84, 1.04	.05	-1.24	.22
Hospitalization for Injury	.06	1.06	.71, 1.57	.20	.29	.77

Note. All covariates were included in models, but were omitted from to reduce redundancy. Subscale scores were included in separate models. For gender, 1 = man, 2 = woman; MAYSI = Massachusetts Youth Screening Instrument.
*$p < .05$.
**$p < .01$.

Appendix F (Continued)

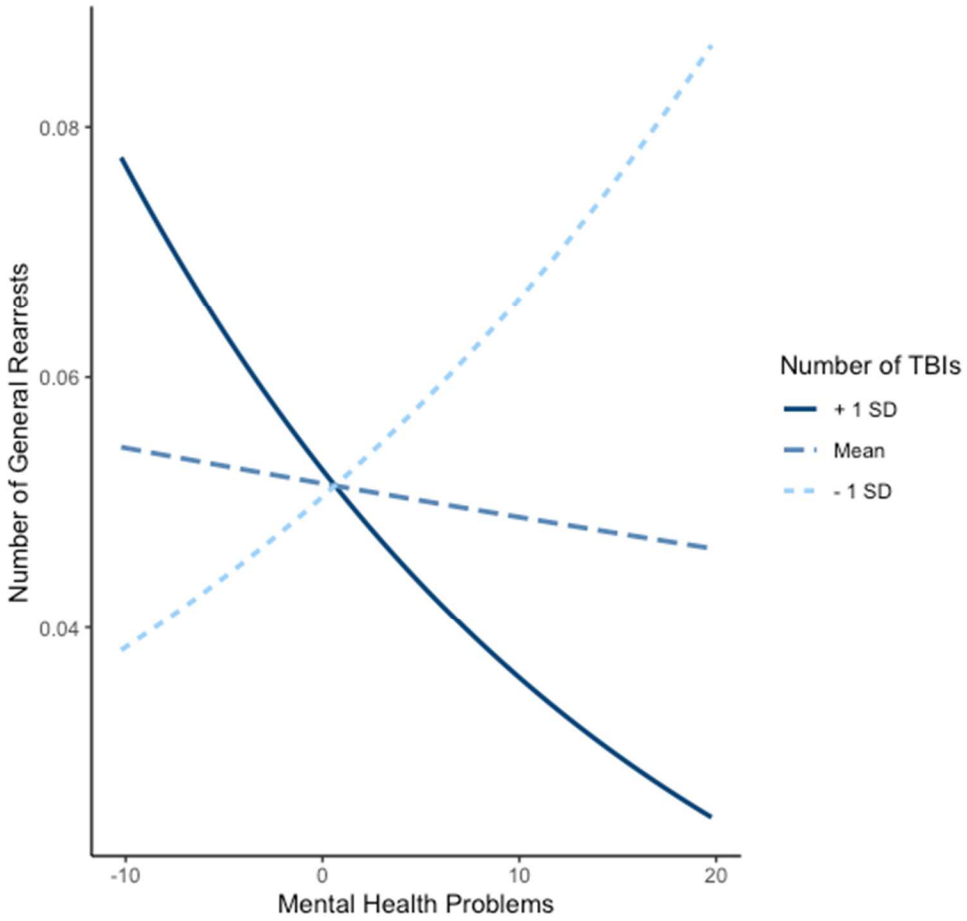

Figure A14

Results of Simple Slopes Analyses Involving Number of TBIs as a Moderator of the Relationship between Mental Health Problems and Number of General Rearrests.