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ORIGINAL RESEARCH

Behavioral health is brain health among men with brain injury in the criminal legal system

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Abstract

Cognitive impairments are associated with poor outcomes for persons in criminal justice. Traumatic brain injury (TBI) causes cognitive impairments, but cognitive impairments are also associated with other behavioral health comorbidities like mental illness, substance abuse, trauma history and suicidality. Research has not yet quantified the relative risk for cognitive impairments conferred by behavioral health and traditional brain injury-related vulnerabilities. This study examined clinical interview and computerized cognitive test data from 156 men in the criminal legal system with a reported history of traumatic brain injury that included a loss of consciousness (LOC). To identify which factors best predicted cognition, three hierarchical linear regressions were conducted with measures of learning, attention and inhibition as the independent variables. Age, history of mental illness and history of suicide attempt emerged as significant predictors of poor performance on measures of learning and attention. Men with a history of mental illness exhibited poorer impulse control. Overall, behavioral health comorbidities were significant predictors of cognitive outcomes and outperformed brain injury-related characteristics. Results from this study suggest that, while TBI is a risk factor for cognitive impairment, the adverse behavioral health comorbidities associated with TBI are even more critical. In this way, behavioral health is critical to brain health. Importantly, this group of vulnerable men is characterized by a history of substance abuse (97.1%), mental illness (77.6%) and attempts to die by suicide (37.8%) which is almost 10 times higher than the general population base rate of suicidal behavior. Understanding the vulnerabilities of these men, including the contributions of behavioral health comorbidities to cognitive impairment, can help prioritize interventions in systems where resources and staff time are limited.

Keywords

Traumatic brain injury; Jail; Probation; Mental illness; Behavioral health; Cognition

1. Introduction

Traumatic brain injury (TBI) is a disruption in the normal functioning of the brain caused by an external force, such as a bump, blow or jolt to the head. According to the Centers for Disease Control and Prevention, TBI impacts approximately 1.5 million Americans annually and is a major source of neurodiversity that can lead to short- and long-term health and behavioral problems [1]. In the criminal legal system, the average rate of significant TBI among individuals in jail or on probation is 54%, compared to approximately 8.5% in the general population [2, 3].

TBI can result in a broad range of cognitive sequelae, including problems with attention and concentration, memory, processing speed, executive functioning, problem-solving and judgement, language and communication and emotional and behavioral control [4–6]. Additionally, more serious TBI's have been linked to deficits in impulse control including increased aggression, impulsivity and emotional reactivity [7]. These deficits and maladaptive behaviors make individuals with cognitive impairments more vulnerable to becoming involved with the criminal legal system in the first place, often at a younger age [8, 9]. Cognitive impairments are also associated with poorer health and worse judicial outcomes for individuals in the criminal legal system. Specifically, adults who are in jail and have cognitive impairments are at greater risk for physical health problems, repeat arrests and limited participation in justice processes (*i.e.*, difficulty accessing legal aid, engaging in trials and participating in forensic evaluations) [10, 11]. For adults in community corrections (*e.g.*, probation and parole), TBI and related changes in cognitive functioning are associated with lower rates of successful probation completion and higher rates of reconviction [12]. Additionally, men with TBI in the criminal legal system with cognitive impairments are at greater risk for unemployment, divorce and poor community integration [1, 2, 13, 14].

The sequelae of TBI also includes behavioral health complaints like mental illness and substance abuse. Specifically, TBI is associated with worsening or new onset of several psychiatric disorders, including anxiety disorders, major mood disorders and posttraumatic stress disorder after injury [15–17] and a greater likelihood of requiring psychiatric hospitalization [18]. Individuals with TBI in the criminal legal system are almost twice as likely to develop psychiatric disorders than those without TBI. Among adults on probation with a history of significant TBI, a full 68% have been diagnosed with at least one mental illness [12].

TBI is also associated with increased risk for substance misuse. In the criminal legal system, individuals with TBI are more likely to have used illicit drugs and report higher levels of alcohol consumption than their peers without a brain injury history [19, 20]. These authors have previously reported that 92% of adults with TBI who were on probation reported a history of substance abuse [12]. The comorbidities are further complicated where individuals with TBI in the criminal legal system who have a history of substance abuse are at a significantly increased risk of developing depression, anxiety and difficulty regulating anger [21, 22].

A history of brain injury is also associated with violent victimization, specifically, being the victim of violence as a child, as an adult, or engaging in self-directed violence. Children and teenagers in the criminal legal system are more likely to have sustained a TBI prior to their crime and/or exposure to violence [23]. Assault is the most common mechanism of TBI among people in the criminal legal system [12, 24, 25]. In fact, the prevalence of violence-related TBI among men in jail or on probation is approximately 63%, compared to 11.5% in the general population [24, 26]. These authors previously reported that, among adults with TBI who were on probation, 47% were the victim of violence as an adult and 50% had been the victim of violence during their childhood [12]. Also, juveniles with TBI in the criminal legal system are significantly more likely to report being victimized by violence and to having witnessed violence relative to their peers without TBI [27].

Rates of self-directed violence are also high among persons with TBI. For example, one study reported that 35% of individuals with TBI exhibited clinically significant levels of hopelessness, 25% experienced suicidal ideation, and 18% had made at least one suicide attempt after their brain injury [28]. The risk of suicide has been reported to be two to three times higher among persons with a history TBI relative to persons without TBI in the community, with comorbid depression, posttraumatic stress disorder and substance use increasing the risk for suicide [29, 30]. The risk is even more acute for persons involved in the criminal legal system. These authors previously reported that 28% of adults on probation with a TBI history had made at least one suicide attempt [12].

These same behavioral health comorbidities are all also associated with cognitive impairment. Mental illness is commonly associated with cognitive impairment but often is not recognized or documented. Cognitive impairment often accompanies schizophrenic and depressive diagnoses in the forms of impaired concentration, memory and attention [31]. Cognitive impairment is a predictor of suicide risk among persons in the criminal legal system and is correlated with risk for suicide attempts over the lifetime [32]. Substance abuse disorders have also been linked with higher risk of cognitive impairment and even dementing disease among older people involved in the criminal legal system [33]. The converse is also true where another study reported that individuals with cognitive impairments in the criminal legal system were more likely to have alcohol abuse disorders than those without cognitive impairments [34].

Exposure to violence during childhood can include abuse, neglect and maltreatment and that trauma is also associated with cognitive impairment in adulthood, where deprivation and neglect exhibit the strongest association [35]. Exposure to childhood trauma is associated with poorer performance in processing speed, attention and executive functioning when measured in older adults [36]. Another study found that individuals who were exposed to trauma as adults exhibited a greater cognitive decline compared to individuals with early childhood traumatic experiences, all which reflect the cognitive risks associated with exposure to trauma [37]. Even suicidal ideation is associated with cognitive dysfunction. People with suicidal ideation and recent suicide attempts perform significantly worse on measures of cognitive functioning compared to people without suicidal ideation, particularly in the domains of processing speed, decision-making, attention and executive function [38]. One Spanish study reported that cognitive impairment is associated with a higher risk of suicide among young adults with depression [38]. Cognitive impairment, whether due to dementia, mood disorders, or anxiety, has long been associated with higher rates of suicide among older adults [39].

To date, no study has quantified the relative contributions of these common behavioral health comorbidities, including substance abuse, mental illness, trauma history and suicide attempts relative to brain injury-related factors like injury severity to cognitive impairment in a population of vulnerable men in the criminal legal system. Where cognitive impairments in learning and impulse control are directly related to poor judicial and treatment outcomes, understanding the drivers of the impairment can help prioritize interventions in systems where resources and staff are limited.

2. Materials and methods

This is a retrospective study conducted within the Colorado criminal legal system. This project originated from a program development partnership between the University of Denver, the Colorado Department of Human Services Brain Injury Program, and 11 county jail and probation systems in the Front Range region of Colorado. This program was designed to identify brain injury history in justice-involved populations, provide brain injury training and education to staff across multiple disciplines, and facilitate a continuity of care into the community for the individuals identified. In this program, justice-involved persons with both a TBI history and a gross cognitive deficit were identified, assessed, and provided feedback, modified therapies, and recommendations. These individuals were also determined to be eligible for jail-based interventions such as self-advocacy education and a referral was made to community-based resource facilitation services.

2.1 Measures

2.1.1 Brain injury

Data related to brain injury were taken from the administration of the Ohio State University Traumatic Brain Injury-Identification Method (OSU TBI-ID), a structured clinical interview designed for that purpose. The gold standard for the identification of TBI is a medical record review or full neuropsychological examination. Because this approach is not feasible in criminal justice settings, a structured interview is considered a suitable replacement. The OSU TBI-ID [40] was developed to identify reported TBI in populations thought to be at risk for TBI and its associated complications and who are unable to complete a full neuropsychological examination or review of records. It is a three-step interview that guides the interviewer to elicit key information about an interviewee's history of injury including duration of loss of consciousness (LOC), the number of past concussions, the age of their first brain injury, and the immediate sequelae of injury. The instrument is designed to identify TBI that confer risk for poor outcomes and the Colorado-revised scoring includes FIRST (any injury with a LOC before age 15), WORST (any injury with a LOC of more than 30 minutes), and MULTIPLE (three of more injuries in a short period of time). This scoring is designed to exclude uncomplicated mild TBI from additional consideration. The estimated severity of injury on the OSU TBI-ID is based on reported changes of consciousness. In addition to widespread clinical use, the OSU TBI-ID has been validated in correctional settings. For the analyses in the current study, injuries that included no LOC or what has been described as a grade 1 concussion (see Association of Speech and Hearing Association; ASHA) [41, 42] were excluded. While injuries without a LOC can confer risk for poor outcomes, these mild injuries are difficult to identify and are usually characterized by an uncomplicated recovery course and sometimes escape attention. To reduce variability in the data and ensure a more normal distribution in the level of TBI severity among the sample, these analyses were limited to only injuries that included any LOC.

2.1.2 Cognitive function

The Automated Neuropsychological Assessment Metric Core Battery (ANAM) [43] was used to assess cognitive function. The ANAM is a validated measure of several neuropsychological domains including Reaction Time, Learning, Attention/Processing Speed, Working Memory, Spatial Working Memory, Delayed Memory and Inhibition. Structural equation modeling (SEM) of all ANAM subtests suggests shared construct validity among these ANAM tests [44] so, for the current study, the domains of learning, attention, and inhibition were identified as clinically relevant to risk for poor community outcomes for persons involved in the criminal legal system. Throughput scores were extracted from participant score reports for two domains (code substitution = learning; procedural reaction time = attention/processing speed). The code substitution module measures components of learning, including visual searching, sustained attention and encoding abilities, by requiring participants to compare a single displayed symbol-number pair with a key consisting of a set of defined symbol-number pairs to identify the correct pairing. The procedural reaction time module measures visuomotor reaction time, simple processing and decision-making efficiency by requiring participants to differentiate between two sets of characters. Numbers 2, 3, 4 or 5 are displayed on the screen one at a time and participants must press the corresponding mouse key for each character (*i.e.*, left mouse key for 2 or 3 and right mouse key for 4 or 5).

Unique to ANAM, a throughput score is calculated for each subtest and is a corrected response rate ratio of accurate responses per minute or a proxy for cognitive efficiency. That same SEM study provided support for relying on throughput for analyses using complex mathematical models since the distribution of throughput scores is very close to normal and reduces the likelihood for inflated estimates [44]. The percentage of correct responses on the go/no-go task was used as the measure representing the domain of inhibition since throughput score is not calculated for this test. The go/no-go task measures inhibitory control by requiring participants to respond as quickly as possible to a target stimulus and not respond to a distractor stimulus.

2.1.3 Psychosocial vulnerabilities

Unstructured clinical interviews [45] were used to obtain historical data on self-reported history of mental illness, substance abuse, suicide attempts and exposure to violence as a child and as an adult.

2.2 Participants

In each of 11 participating settings, trained criminal justice professionals administered a modified version of the OSU TBI-ID [46] at the first available individual meeting (*e.g.*, intake or follow-up) and persons with a positive score reflecting a significant TBI history, were referred for a secondary, neuropsychological screening evaluation with a graduate student clinician. A total of 4002 adults were screened for reported TBI history using the OSU TBI-ID. Of the 4002 people screened, 1854 persons reported a significant TBI history. Individuals were included in this analysis if they participated in a neuropsychological screening evaluation between 2012 and 2020 and consented to have their de-identified data used for research purposes. The total possible sample consists of 974 individuals whose responses were coded into the Research Electronic Data Capture (REDCap) database. REDCap is a secure, web-based data capture application hosted at the University of Denver. REDCap provides (a) an intuitive interface for validated data entry, (b) audit trails for tracking data manipulation and export procedures, (c) automated export procedures for seamless data downloads to common statistical packages, and (d) procedures for importing data from external sources [47].

Participants included in the final data analysis were 156 adult men ages 18–67 (Mean (M) = 38.54, Standard Deviation (SD) = 10.40) with self-reported history of a traumatic brain injury (TBI) with a LOC. See Fig. 1 for detailed information on participant data inclusion and exclusion criteria for this study. Participants' self-reported race and ethnicity included American Indian/Alaska Native (1.9%), Black/African American (7.7%), White (62.8%), Hispanic (19.9%) and multiracial

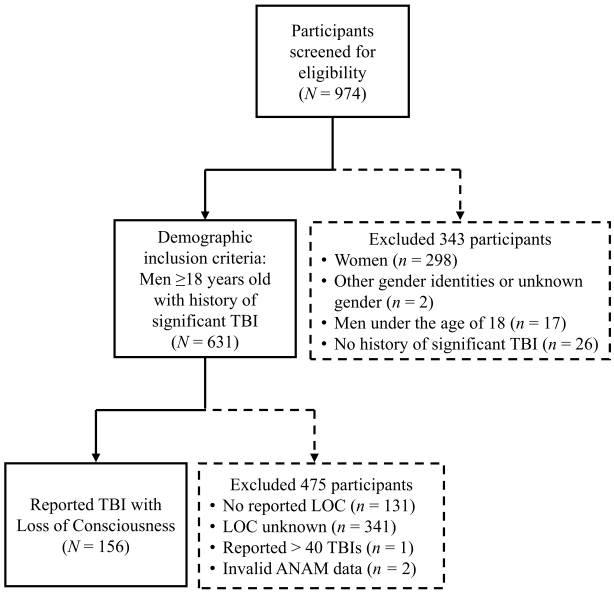

FIGURE 1. Flow chart of participant inclusion and exclusion. Participants were screened for program eligibility. Only men 18 years or older with a significant history of TBI, based on the Colorado-revised Ohio State University Traumatic Brain Injury-Identification Method, met eligibility criteria for this study. Of these, 156 reported a loss of consciousness (LOC) and were included in final data analysis. Abbreviations: ANAM: Automated Neuropsychological Assessment Metric Core Battery; LOC: loss of consciousness; TBI: traumatic brain injury.

(7.1%). Race and ethnicity were unknown or not reported for 0.6% of participants. A total of 121 (77.6%) participants reported having a mental health diagnosis which included anxiety disorder (37.8%), childhood or developmental disorder (5.1%), cognitive disorder (2.6%), dissociative disorder (1.3%), impulse control disorder (8.3%), mood disorder (59.6%), organic brain disorder (3.8%), personality disorder (5.1%), psychotic disorder (17.3%), sleep disorder (2.6%), trauma or stress disorder (32.1%) and other mental health disorder (9.0%). A total of 59 (37.8%) participants had attempted suicide. A total of 99 (97.1%) participants self-reported a history of substance abuse or misuse, which was too ubiquitous to be included as a predictor in the regression model. For history of abuse, 107 (68.6%) participants reported being a victim of childhood violence and 96 (61.5%) reported being the victim of violence as an adult. The number of reported TBIs with LOC ranged from 1 to 22 (M = 5.09, SD = 3.12). The longest length of LOC ranged from less than one minute to 31 days (about one month). The age of the first TBI ranged from less than one year old to 26 years old (M = 9.76, SD = 5.25). Data from a total of 102 (65.4%) participants were available for ANAM code substitution throughput, procedural reaction time throughput and go/no-go percent correct scores available.

2.3 Statistical analysis

To identify which psychosocial vulnerabilities best predicted cognitive abilities, three hierarchical linear regressions were conducted with ANAM scores as the independent variables including (1) code substitution throughput score, (2) procedural reaction throughput score and (3) percent correct on go/no-go. For each independent variable, a higher score represents better cognitive performance. For each set of regressions, psychosocial vulnerabilities were grouped into five blocks: (1) age, (2) history of mental illness, (3) history of exposure to violence, (4) TBI severity and (5) time incarcerated. The first block in the hierarchical regression included age (continuous). The second block added variables representing a history of mental illness including mental health diagnosis (1 = yes, 2 = no) and history of suicide attempt (1 = yes, 2 = no). The third block added variables representing a history of exposure to violence including being a victim of violence in childhood (1 = yes, 2 = no) and being an adult victim of violence (1 = yes, 2 = no). The fourth block added variables associated with TBI severity including the age of the youngest TBI, the total number of TBIs, and the length of the longest LOC in minutes. The fifth block added total length of time incarcerated in months. The number of TBIs, length of longest LOC and length of time incarcerated were non-normally distributed, those variables underwent a log transformation prior to the regression. Missing data were handled using pairwise deletion. Collinearity between predictors was examined using the Variance Inflation Factor (VIF).

3. Results

For each block of the hierarchical regression until all five blocks were added, significance was determined using a Bonferroni-corrected alpha level of 0.05/5 = 0.01. For individual regression coefficients, an alpha level of 0.05 was used to determine if the individual predictor had a significant effect on the dependent variable. Overall, variables associated with a history of mental illness were the strongest predictors of cognitive function. Specifically, the second block of the hierarchical regressions provided the largest increase in variance explained for code substitution and procedural reaction time. For code substitution, mental illness was the strongest predictor. For procedural reaction time, a history of suicide attempt was the strongest predictor. Variables associated with a history of exposure to violence, TBI severity and the length of time incarcerated did not explain a significant amount of variance in cognitive performance. For all models, the VIF was below 2 for each predictor, indicating that the predictor variables in each model were not highly correlated. Means and standard deviations for each dependent variable grouped by those with and without a mental health diagnosis are reported in Table 1. Means and standard deviations for each dependent variable grouped by those with and without a history of suicide attempt as reported in Table 2. The results of all five steps for the three hierarchical linear regressions are presented in Table 3. The individual beta weights for each predictor in the second block are reported in Table 4.

For the hierarchical regression with code substitution throughput (learning) as the outcome variable, all five blocks had significant F statistics, but the second block including age, history of mental health diagnosis, and history of suicide attempt as predictors showed a significant change in R^2 from the first block, $\Delta F(1, 62) = 5.10$, $p = 0.009$, $\Delta R^2 = 0.12$, and was the model that explained the largest percentage of the variance (25.5%). Within the second model, the individual regression coefficients indicated that age and mental health diagnosis accounted for a significant amount of variance in code substitution throughput, with increasing (older) age and a mental health diagnosis predicting lower (worse) code substitution throughput score (decreased learning). The individual regression coefficient for a history of suicide attempt did not significantly affect code substitution throughput scores in the final model.

For the hierarchical regression with procedural reaction time throughput (attention) as the outcome variable, both the second and third blocks had significant F statistics. However, the second block including age, history of mental health diagnosis, and history of suicide attempt as predictors showed a significant in R^2 from the first block, $\Delta F(1, 62) = 5.75$, $p = 0.005$, $\Delta R^2 = 0.15$, and was the model that explained the largest percentage of the variance (13.6%). Within the second model, the individual regression coefficients indicated that a history of a suicide attempt explained a significant amount of the variance in procedural reaction time throughput, with those with a history of a suicide attempt having lower (worse) procedural reaction time throughput scores or slower responses (decreased attention). The individual regression coefficients for age and mental health diagnosis did not significantly affect procedural reaction time throughput scores in the final model.

For the hierarchical regression with percent correct on go/no-go (inhibition) as the outcome variable, none of the models had significant F statistics. A lack of significant regression results was likely due to the limited scale of the percent correct measure. The second block including age, history of mental health diagnosis, and history of suicide attempt as predictors accounted for 3.4% of the variance, which was the highest percentage out of all five blocks. Despite the lack of significant regression results, there was still an indication of a relationship between inhibition and mental illness. Within the second block, the individual regression coefficients indicated that the mental health diagnosis predictor accounted for a significant amount of the variance, where men with a mental illness had a lower percentage of correct responses on the go/no-go task, representing poorer impulse control.

4. Discussion

Cognitive deficits in learning, attention/processing speed and impulse control can make successfully navigating the criminal legal system and accessing resources more difficult. Cognitive deficits are a very common sequelae of brain injury. Clinicians do not typically associate other psychosocial vulnerabilities with changes in cognitive function. These analyses suggest that the behavioral health comorbidities account for more variability in learning, attention/processing speed, and impulse control function than the features of the brain injury alone. That is to say, while TBI is a risk factor for cognitive impairment, the adverse behavioral health variables associated with TBI are even more critical. These results confirm that men's behavioral health is a significant contributor to brain health.

These regression models suggest that age, history of mental illness, and history of suicide attempt are significant predictors of cognitive dysfunction. Specifically, age and mental illness accounted for a significant amount of variance in learning function, where older age and mental illness predicted worse performance in learning on computerized cognitive testing, and older age, mental illness and suicide attempts predicted poorer procedural reaction time performance. Finally, mental illness accounted for a significant amount of the variance in performance on tests of inhibitory control. Importantly, in the current study, 97% of men with a significant traumatic brain injury who were involved in the criminal legal system also had a history of substance abuse so that psychosocial variable bears mentioning in the context of behavioral health vulnerabilities.

There are important clinical implications for these results. Screening for brain injury history is an important way to identify people who are at risk for poor outcomes and who may warrant additional services like behavioral healthcare. Specifically, these results suggest that men with brain injury should be screened for other behavioral health comorbidities. In this study, nearly all (97.1%) of the men with a significant reported brain injury history had a history of substance abuse, 77.6% of men had at least one mental illness, and 37.8% of them had attempted suicide at least one time. The prevalence self-harm history among men with brain injury history in the criminal legal system is nearly ten times higher than the 4.3% that is true for the general population [48] and warrants suitable acute services including crisis intervention and comprehensive mental health care. Barring additional screening after brain injury, these results suggest the system should offer behavioral health therapies to all men identified as having a brain injury history.

This manuscript aims to highlight the importance of cognitive dysfunction as a psychosocial vulnerability. Cognitive screening for all persons with brain injuries who are receiving behavioral health services in the criminal legal system could generate data to inform the adaptation of typical behavioral health therapies. Failing to accommodate cognitive differences

TABLE 1. Means and standard deviations of cognitive outcomes for participants with and without a mental health diagnosis.

	Mental Health Diagnosis (n = 81)		No Mental Health Diagnosis (n = 21)		Total (N = 102)	
ANAM Outcome	M	SD	M	SD	M	SD
Code substitution throughput	36.35	12.03	46.48	11.33	38.43	12.53
Procedural reaction time throughput	73.83	23.32	90.24	17.36	77.21	23.12
Go/no-go percent correct	87.25	11.16	94.14	3.71	88.67	10.45

ANAM: Automated Neuropsychological Assessment Metric Core Battery; M: Mean; SD: Standard Deviation.

TABLE 2. Means and standard deviations of cognitive outcomes for participants with and without a history of suicide attempt.

	History of Suicide Attempt (n = 38)		No History of Suicide Attempt (n = 64)		Total (N = 102)	
ANAM Outcome	M	SD	M	SD	M	SD
Code substitution throughput	37.58	12.18	38.94	12.80	38.43	12.53
Procedural reaction time throughput	67.87	22.72	82.75	21.69	77.21	23.12
Go/no-go percent correct	86.92	12.97	89.70	8.56	88.67	10.45

ANAM: Automated Neuropsychological Assessment Metric Core Battery; M: Mean; SD: Standard Deviation.

TABLE 3. Results of hierarchical linear regression to predict ANAM scores.

		Model Statistics			
DV	Block	R^2	Adj R^2	F	p
Code Substitution Throughput (Learning)					
	1	0.173	0.160	13.40	0.0005*
	2	0.290	0.255	8.44	<0.0001*
	3	0.300	0.241	5.13	0.0006*
	4	0.315	0.219	3.28	0.004*
	5	0.317	0.207	2.88	0.007*
Procedural Reaction Time Throughput (Attention)					
	1	0.023	0.007	1.49	0.227
	2	0.176	0.136	4.40	0.007*
	3	0.179	0.111	2.62	0.033
	4	0.225	0.116	2.06	0.055
	5	0.227	0.103	1.83	0.083
Go/No-Go Percent Correct (Inhibition)					
	1	0.002	−0.014	0.11	0.737
	2	0.079	0.034	1.77	0.163
	3	0.082	0.005	1.07	0.386
	4	0.122	−0.002	0.99	0.456
	5	0.134	−0.005	0.97	0.478

The model statistics three hierarchical regressions, each with five blocks. The predictor for block 1 was age (continuous). Block 2 added two predictors associated with mental illness including mental health diagnosis (1 = yes, 2 = no), and history of a suicide attempt (1 = yes, 2 = no). Block 3 added two predictors associated a history of abuse including being a victim of childhood violence (1 = yes, 2 = no) and being an adult victim of violence (1 = yes, 2 = no). Block 4 added three predictors associated with TBI severity including the number of TBIs (log transformed), the longest loss of consciousness in minutes (log transformed), and the age of the first TBI in years. Block 5 added the total length of time incarcerated in months (log transformed). Abbreviations: DV: dependent variable; Adj R^2: adjusted R^2.

**Significant at $p < 0.01$.*

TABLE 4. Individual standardized coefficients for the second block of each hierarchical regression.

		Standardized Coefficients	
DV	IVs	β	p
Code Substitution Throughput (Learning)			
	Age	−0.427	<0.001*
	Mental health diagnosis	0.342	0.003*
	History of suicide attempt	−0.002	0.985
Procedural Reaction Time Throughput (Attention)			
	Age	−0.180	0.125
	Mental health diagnosis	0.113	0.067
	History of suicide attempt	0.269	0.029*
Go/No-Go Percent Correct (Inhibition)			
	Age	−0.056	0.651
	Mental health diagnosis	0.252	0.050*
	History of suicide attempt	0.068	0.596

The standardized beta weights and p values are listed for each predictor from block 2 of each hierarchical regression, as this was the model which accounted for the largest percentage of variance for each dependent variable.
Abbreviations: IV: independent variables, β = standardized coefficient; DV: dependent variable.
**Significant at $p \leq 0.05$.*

in therapy might account for the high rates of treatment failure for persons with brain injuries in criminal legal settings [49]. Short of cognitive screening, clinicians can assume that making basic accommodations in therapy, like repeating key points, inviting clients to summarize, breaking large tasks into simple steps, minimizing distractions, and using visual aids like handouts, will benefit all clients. Clinicians can also target cognitive deficits more directly by practicing mindfulness strategies, emotion regulation, problem-solving skills and of course by encouraging self-advocacy. Tracking cognitive changes after therapies over time may also be useful in monitoring risk reduction.

This study has several limitations including the measurement of psychosocial vulnerabilities like mental illness and brain injury history. These vulnerabilities were assessed using traditional methods including structured and unstructured clinical interviews which are both limited by the recall of the client, a domain sometimes impaired among persons with brain injury. This study also excluded injuries with no loss of consciousness because of the difficulty in accurately quantifying those injuries and the variability that "no LOC" conferred to the analyses. Traumatic brain injuries not accompanied by any LOC are typically mild and recovery is expected, but research suggests that those injuries are not without risk for poor outcomes. A study of more than 350,000 veterans reported that mild TBI with no LOC was associated with more than a two-fold increase in the risk of dementing disease [50] and another recent paper suggests that patients with a history of TBI with or without LOC may have higher odds of developing neuropathology later in life [51]. Future research can evaluate differences in the brain injury history and psychosocial vulnerabilities among men in the criminal legal system with TBI who never lost consciousness with their injury/ies.

Future research should also examine the temporal relationship between brain injury and these other vulnerabilities including cognitive dysfunction. For example, if there was a clear direction of causality between brain injury and mental illness, then secondary prevention efforts might target the vulnerability more efficiently. For now, research suggests that persons with brain injury who have no history of mental illness are very commonly diagnosed with a clinically significant syndrome within a year of their injury [52] and persons with mental illness are more vulnerable to sustaining brain injuries in the year after their psychiatric diagnosis [53] so clinicians are on alert for both circumstances. New research in this area would inform prevention efforts but may also guide the delivery of interventions. Specifically, understanding whether the successful treatment of behavioral health comorbidities like mental illness can lead to an improvement in cognitive function for persons with significant brain injury history.

5. Conclusions

This study is a first step towards identifying the behavioral health vulnerabilities that confer a risk for the kinds of cognitive dysfunction associated with poorer outcomes for men in the criminal legal system. Importantly, this study affirmed the importance of behavioral health comorbidities in our growing understanding of the experience and treatment needs of a neurodiverse population of men with brain injury in the criminal legal system.

These results suggest that age, mental illness and suicide attempts are significant predictors of cognitive dysfunction in learning, attention and impulse control. This justice-involved population of men with a significant TBI history is the most clinically acute and clinically challenging in any setting. The group is characterized by a history of substance abuse, mental illness and attempts to die by suicide. This study opens the door for research on the benefits of behavioral healthcare to cognitive function and underscores the importance of knowing that behavioral health is critical to brain health where men are concerned.

ABBREVIATIONS

TBI, Traumatic brain injury; LOC, Loss of consciousness; OSU TBI-ID, Ohio State University Traumatic Brain Injury-Identification Method; ANAM, Automated Neuropsychological Assessment Metrics; SEM, Structural Equation Modeling; VIF, Variance Inflation Factor.

AVAILABILITY OF DATA AND MATERIALS

Due to the sensitive nature of the data, information created during and/or analyzed during the current study is available from the corresponding author, Kim A. Gorgens at Kimberly.Gorgens@du.edu, on reasonable request to bona fide researchers.

AUTHOR CONTRIBUTIONS

KAG—designed the original program and this research study and oversaw the writing of this manuscript. SM—analyzed the data. MP—leads the research team and contributed to the preparation and writing of this manuscript. JG and RP—helped write the introduction of the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This project was approved by the University of Denver Institutional Review Board Protocol No. 674894-16 and secured all Federal permissions for research and programming with persons in the criminal justice system. All participants consented to participate in this study.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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