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Racial/Ethnic Disparities In Longitudinal Trajectories Of Arrest Probability After Traumatic Brain Injury

Mickeal Pugh Jr
Virginia Commonwealth University

RACIAL/ETHNIC DISPARITIES IN LONGITUDINAL TRAJECTORIES OF ARREST PROBABILITY AFTER TRAUMATIC BRAIN INJURY

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Science at Virginia Commonwealth University

Mickeal Pugh Jr., M.S.

Master of Science, Loyola University Maryland, May 2017

Master of Science, Virginia Commonwealth University, December 2019

Director: Paul B. Perrin, Ph.D.

Associate Professor of Psychology

Department of Psychology

Virginia Commonwealth University

Richmond, Virginia

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ABSTRACT

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By Mickeal Pugh Jr

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Science at Virginia Commonwealth University

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Major Director: Paul B. Perrin
Associate Professor
Department of Psychology

Traumatic Brain Injury (TBI) is one of the leading causes of disability across the globe, and epidemiological studies have documented a rise in this condition over the recent years. Post-TBI functional impairments can persist beyond the acute phase of the injury, and specific psychosocial and injury-related factors have predicted variability in these outcomes. Previous literature has documented profound racial/ethnic disparities in TBI risk, cause, treatment, and rehabilitation. Prior investigation has revealed an overlap between incarceration and TBI, which showed that incarcerated persons typically endorsed a history of TBI. Criminal justice literature has shown stark racial/ethnic differences in incarceration rates, which are consistent among TBI populations. The current study included participants from the national TBI Model System's study. An aim of the current study was to evaluate whether racial/ethnic disparities in traumatic brain injury acquisition and rehabilitation, which have been supported by previous literature, occurred within the current study sample. An additional aim of this research was to examine racial/ethnic disparities in arrest probability trajectories and whether injury and sociodemographic characteristics contributed to these longitudinal arrest trajectories. This study utilized a series of hierarchical linear models (HLMs) to assess longitudinal trajectories of arrest

probability over the span of ten years post-injury, racial/ethnic disparities longitudinal arrest trajectories, and socio-demographic and injury-related predictors of these identified disparities. Preliminary study results supported previous literature which has shown racial/ethnic disparities in TBI cause and rehabilitation. Arrest probability trajectories generally decreased over the course of ten years post-discharge. White persons with TBI had lower arrest probability trajectories than Black and Native American persons, and Asian individuals with TBI had lower arrest probability trajectories than White, Black, Latinx, and Native American persons. When sociodemographic and injury related characteristics were entered in the models, the racial/ethnic differences in longitudinal arrest probability trajectories were no longer significant for the White vs. Black, Latinx vs. Asian, White vs. Native American, and Latinx vs. Native American comparisons. However, disparities remained in the White vs. Asian, Black vs. Asian, and Asian vs. Native American comparisons. These findings suggest that arrest probability trajectories occur differentially as a function of racial/ethnic group membership, though these differences can only in part be accounted for by injury and sociodemographic considerations. As such, the current study findings yield clinical, public health, and criminal justice implications, aimed to lessen arrest probability outcomes for persons with TBI who possess certain sociodemographic features in addition to racial/ethnic minority group membership.

Vita

Mickeal Pugh Jr was born on April 30, 1993 in Baltimore County, Maryland. He received his Bachelor of Science in Psychology, with a minor in Philosophy, from Lebanon Valley College, Annville, PA, in 2015 and subsequently received a Master of Science in Clinical Psychology from Loyola University Maryland in 2017.

Overview of the Literature Review

This literature review will begin by discussing the etiology and prevalence of traumatic brain injury (TBI). This will be followed by a description of the cognitive and behavioral effects of TBI in the acute stage, and then present relevant research concerning long-term outcomes. The bulk of the literature review will discuss racial/ethnic disparities associated with TBI risk, cause, and outcomes, generally. Then the literature review will present research within the context of criminal justice. Research has suggested that several factors contribute to the likelihood that individuals with TBI may experience involvement with the criminal justice system following TBI, such as pre-injury arrests, injury characteristics, neighborhood contexts, and socio-demographic information. Although TBI can present similarly across different racial/ethnic groups, several factors may yield differential outcomes for racial/ethnic minority populations. The purpose of this section of the literature review is to discuss how specific functional outcomes associated with TBI, as well as sociodemographic considerations, may contribute to criminal arrest probability. The final portion of the literature review will discuss how injury and sociodemographic factors may contribute to racial/ethnic disparities in arrest probability trajectories for individuals with TBI.

TBI Etiology and Prevalence

TBI is defined as an alteration in brain function, or other evidence of brain pathology, caused by an external force (Menon, Schwab, Wright, & Maas, 2010). Research has also classified TBI as an impact to the head, rapid movement, or displacement of the brain inside of the skull (American Psychiatric Association, 2013). Previous literature has described different definitions of TBI, which differentially considered the mechanism of injury, processes of injury progression, clinical outcomes, and functional limitations over the past 50 years, and these changes in conceptualization, in part, have led to variability in identification and treatment (Menon et al., 2010). However, the consensus is that complications due to TBI must be associated with an external, non-organic cause. Although researchers have used the phrase "head injury" to conceptualize the sequelae of issues associated with TBI, the neuropsychological literature has witnessed a growing awareness of the phrase "TBI," as opposed to the former. This consensus in phrasing may be attributable to how “brain injury” and “head injury” are fairly inconsistent terminology, and ultimately refer to separate etiologies and features. The definition of “TBI” is quite consistent across literature; additionally, injury severity and functioning upon sustaining the injury can provide further clarification of the TBI diagnosis.

Several classification systems supply information on the type, observed complications, and severity of the TBI. The International Classification of Diseases – 11 (ICD-11; World Health Organization, 2019) categorizes TBI as mild, moderate, or severe. These severity classifications consider the loss of consciousness (LOC), alteration of consciousness or awareness (AOC), and post-traumatic amnesia (PTA). According to Scherer and colleagues’ (2020) case definition report on the post-traumatic confusional state (PTCS), the literature has defined PTA variably. Namely, the researchers and clinicians have used PTA to describe a broad set of neurobehavioral signs including attentional, memory, orientation, judgement, irritability, agitation, and perceptual disturbances. Scherer and colleagues’ (2020) proposed to use PTCS rather than PTA, given the historical inconsistency. A major purpose of this case definition was to incorporate the wide range of neurobehavioral features that have historically associated with PTA. Stuss and colleagues (1999) originally proposed the term PTCS, and stated that it better described this post-injury state better than PTA which is consistent with Scherer and colleagues case definition. According to ICD-11 standards, evaluation of TBI severity would assess the sustained duration of LOC as "brief" (< 6 hours; ranging from ≤ 30 mins, to 1-6 hours), "intermediate" (6 hours to <24 hours), "prolonged" (<24 hours), or "persistent" (>24 hours and until discharge), displayed AOC, and PTA. The ICD-11 classification system also presents information about TBI etiology and location (e.g., focal or diffuse injury) and provides contexts for identifying impaired lobes and brain regions.

Using a similar approach, the Diagnostic and Statistical Manual of Mental Disorders -5 (DSM-5; American Psychiatric Association, 2013) uses a severity rating system for TBI. However, the DSM-5 classifies TBI under mild or major neurocognitive disorders which focuses on symptom expression and not underlying organic etiology. The diagnostic criteria are relatively similar between the DSM-5 and ICD-11; the differentiating factor is the prior conceptualizes the complications associated with the TBI as an independent disorder (e.g., neurocognitive disorder), and only assesses symptom manifestation. Further, the DSM-5 specifies that the neurocognitive disorder is due to TBI. The diagnosis of TBI is not typically given by a psychologist, initially, but rather emergency room or acute rehabilitation physicians., The evaluating clinician must also consider the individual's level of functional independence to differentiate between mild and major TBI specifiers. For example, the system would classify an individual with TBI who reports general independence with minimal assistance as "mild neurocognitive disorder." Further, the DSM-5 also acknowledges with or without behavioral disturbance as a specifier that refers to any clinically significant psychotic, mood, agitation, apathy, or other behavioral characteristics and these symptoms would appear to create functional issues for the person with TBI. To meet diagnostic criteria for a neurocognitive disorder, all diagnostic criteria must be met in addition to evaluating functional independence, which includes cognitive decline from previous levels of performance across one or more domains (e.g., complex attention, learning and memory, executive function, language, etc.). Neuropsychological assessment or imaging must confirm these deficits and delirium or any other mental status/disorder cannot describe these impairments.

The Glasgow Coma Scale (GCS; Teasdale & Jennett, 1974) is one of the most common diagnostic tools that both ICD-11 and DSM-5 classification utilize and is the standard evaluation tool to assess functioning among brain-injured persons. The GCS assesses eye-opening, from a score of 4 (spontaneous, opening with blinking at baseline) to 1 (no response), verbal response, from a score of 5 (oriented) to 1 (no response), and motor functioning, from 6 (obeys command for movement) to 1 (no response), and yields a head injury classification. Generally, scores range from severe (e.g., 8 or less) to moderate (e.g., 9 – 12 total score), to mild (e.g., 13 – 15 total score; Adopted from the American College of Surgeons, 2004). Research has shown that functioning observed through the GCS is associated with mortality (Arbabi et al., 2004), length of PTA (Sherer, Struchen, Yablon, Wang, & Nick, 2007) and the Glasgow Outcome Scale (GOS; e.g., a measure of patient status; Marmarou et al., 2007). A systematic review by Zuercher, Ummenhofer, Baltussen, and Walder (2009) that described the utility of the GCS reported that the European Brain Injury Consortium, the American College of Emergency

Physicians, the American College of Surgeons, the Brain Trauma Foundation, and the American Association of Neurological Surgeons include the GCS as a major facet of their TBI treatment programs. In sum, many differences exist in assessment and diagnosis procedures between the ICD-11 and DSM-5 classification systems. Despite these different approaches, evaluation via the GCS and its conceptualization is relatively consistent.

There has been growing concern regarding TBI over recent years, and it has accounted for a large proportion of global hospitalizations. Research has shown that the rates of TBI grew between 1990 and 2016 from 3.6% to 8.4% global prevalence (Badhiwala, Wilson, Fehlings, 2018). Research has also shown that in 2016, there were approximately 27 million new cases of TBI (Global Burden of Disease Study 2016 Traumatic Brain Injury and Spinal Cord Injury Collaborators, 2019). More recent reports from the Centers for Disease Control and Prevention have shown that 288,000 TBI-related hospitalizations occurred in the U.S. alone, and approximately 23,000 of these injuries were pediatric cases (CDC TBI-related Hospitalizations Data Tool). Research has also shown that the high prevalence of these injuries places a grave burden on emergency departments of hospitals. Roughly 2.9 million emergency department visits, hospitalizations, and deaths (EDHDs) were reported in 2014, in the U.S. (CDC; 2019), and approximately 56,800 of these cases were TBI-related deaths. Research from the Healthcare Cost and Utilization Project's (HCUP) Nationwide Emergency Department Sample for Emergency Department Visits showed a 53% increase of total TBI-EDHDs, from 1.88 million to just shy of 2.88 million from 2006 to 2014. Thus, research supports that there is a growing concern for TBI occurrence, as prevalence rates for these injuries have increased over the majority of the decade.

Although emergent research has attended to the prevalence and etiology of TBI, it is often a survivable condition and has become one of the leading causes of disability among young people in the U.S. (Ghajar, 2000). Approximately 8.1 million new global cases of TBI-caused long term disability (e.g., at least one year of disability) occurred in 2016 (Global Burden of Disease Study 2016 Traumatic Brain Injury and Spinal Cord Injury Collaborators, 2019). Research has shown a better prognosis for individuals who sustained mild TBI, and evidence suggested that injured persons observed nearly full neurological recovery with minor attention and concentration complications (American Psychiatric Association, 2013). Regarding moderate TBI, research has suggested that patients presented with psychological and neurological issues that hindered functional independence, such as lethargy, diminished processing speed, or apathy. This particular study also found that half of the sample of people with severe TBI returned to preinjury leisure activities, and slightly less than half did not obtain post-injury employment (Ponsford et al., 2014). Diffuse axonal injury (DAI) classifies some distinct presentations of TBI, which is the angular or rotational acceleration and deceleration process that shears axons and results in damage to white matter (Meythaler, Peduzzi, Eleftherioue, & Novack, 2001; Scheid, Walther, Guthke, Preul, & Cramon, 2006; Levin, 1990; Mapou, 2013; Goetz, Pappert, & Schmitt, 1999). Further, research has shown that DAI is the most common type of TBI, which has widespread effects on cognitive and behavioral functioning since it affects multiple cerebral pathways (Goetz et al., 1999).

Impairments with TBI

Research has shown that symptoms following TBI typically present across several major clusters: cognitive, physical, emotional/mood, and behavior (e.g., social and sleep; CDC, 2019; Laforce, Jr. & Martin-Macleod, 2001). Regarding cognitive functioning, people with TBI will typically experience difficulty with thinking, sustaining attention, encoding new memories, and processing quickly. Physical presentations of TBI symptom clusters include visual impairments (e.g., sensitivity to light and acuity issues), nausea, auditory sensitivity, and fatigue. Concerning the mood/emotional cluster of symptoms, changes in emotional functioning, such as increased nervousness, anxiety, irritability, and sadness are common following TBI. Individuals who sustain TBI endorse changes in behavioral functioning, including changes in social behaviors (e.g., extracurricular activity engagement; Laforce, Jr. & Martin-Macleod, 2001) and sleep problems (e.g., hyper- or insomnia; CDC, 2019).

Cognitive. Although the CDC presents these broad symptoms clusters, the literature vastly expands upon each of these features of TBI. Belanger and colleagues (2005) reported that cognitive issues following TBI include deficits in attention, executive functioning (e.g., cognitive switching), memory encoding and retrieval, language processing, visuospatial functioning, and psychomotor performance. Further, many of these cognitive symptoms can present in combination or individually among individuals with TBI. Secondary injury is a primary factor contributing to a range of cognitive outcomes. The term "primary injury" refers to the neurological damage that occurs at the time of injury, whereas secondary injury encompasses the neurological complications associated with the TBI and recovery (Marshall et al., 1991). Research has shown that intracranial pressure is the leading cause of secondary injury with an increased likelihood of ischemia as a result of cerebral perfusion or cerebral edema, and this process typically yields restricted oxygenated blood flow to the brain (Graham et al., 1989; DeWitt, Jenkins, & Prough, 1995). As such, this cascade of events can lead to more severe and long-term brain damage, in addition to TBI. Cerebral hypoxia (e.g., oxygen deprivation) and hypotension (e.g., low blood pressure) also contribute to the likelihood of sustained secondary injury, resulting in more severe cognitive complications (Chesnut et al., 1992; Fearnside Cook, McDougall, & McNeil, 1993).

Injury onset is another element that contributes to post-TBI cognitive functioning. The acute phase refers to the first 24 hours after sustaining head trauma and is an essential period for cognitive outcomes associated with TBI, especially concerning injury severity. Research has shown that individuals with mild TBI may exhibit deficits in cognition within the first few hours following TBI (Veeramuthu, et al., 2015; Kou et al., 2013; Comerford, Geffe, May, Medland, & Geffen, 2002; Blostein, Jones, Buechler, & Vandongen, 1997). Impairments in executive functioning, immediate, short, and delayed recall, processing speed, attention, and working memory typically present following mild TBI (McCauley et al., 2014; Sivák et al., 2014; Barker-Collo, et al., 2015) and can present for up to 1 year following injury (Theamdon et al., 2016). Several factors, such as previously sustained TBI and loss of consciousness, contributed to post-TBI cognitive functioning whereby individuals with a longer reported loss of consciousness and prior TBI displayed markedly higher associations to global cognitive impairment (Nelson et al., 2018; Norris, Ssms, Lundblad, Frantz, & Harris, 2014; Sorg et al., 2014; Belanger, Spiegel, & Vanderploeg, 2010).

The cascade of cognitive impairments following TBI clusters together in a theoretical chain whereby the acute attention and memory deficits contributed to additional impairments in executive functioning, psychosocial functioning, and other complex cognitive tasks (Arciniegas, Held, & Wagner, 2002). Tsaousides and Gordon (2009) defined attention as the complex mental activity individuals experience when internally processing external stimuli. This particular cognitive process is malleable following brain injury, and research suggested that differences in TBI severity (e.g., longer PTA duration or LOC) yielded a range of attentional abilities and long-term outcomes. Specifically, these studies showed that individuals with severe TBI typically reported corresponding deficits in attention, which contributed to impaired processing speed, multitasking (e.g., walking and talking), and delayed reaction time (Tsaousides & Gordon, 2009; Halbauer et al., 2009). Importantly, attentional abilities do not operate independently of other cognitive and behavioral functioning. Research has shown attention process training (APT; Tsaousides & Gordon, 2009) improved visual and auditory attention by targeting the five areas of attention: focused, selected, sustained, alternating, and divided, and this particular set of changes can depend on acute post-injury ability.

Continuing along this cascade of cognitive impairments following TBI, research has suggested that memory was the most common cognitive deficit following TBI, was the most recognized difficulty by those who sustained TBI, and showed longer delays in rehabilitation compared to other domains of cognitive functioning (Rees, Marshall, Macki, & Weiser, 2007). Connected to memory is language, which is a complex cognitive process that encompasses the integration of verbal and nonverbal information and is associated with TBI-induced attentional and memory deficits. Language and communication disorders following TBI are classified by four distinct categories, which are apraxia, aphasia, dysarthria, and cognitive-communication disorder. Apraxia is defined as deficits in motor functioning despite intact motor and sensory neurological pathways. The three types of apraxia are ideomotor, ideational, and constructional (Halbauer et al., 2009). Ideomotor apraxia is conceptualized as the inability to complete a motor act when verbally prompted. Ideational apraxia is a disturbance of voluntary movement when the individual with this functional status is unable to conceptually comprehend the use of an object's utility. For example, someone with apraxia may not be able to use scissors because a language barrier exists wherein they have difficulty comprehending the use of the scissors. Halbauer and colleagues (2009) define constructional apraxia as the inability to assemble or construct objects despite verbal assistance. Among the language and communication disorders is aphasia, which is a type of speech impairment characterized by the severity and location of the brain injury (Ozbudak, Görgülü, & Köseoglu, 2006). Research has shown that Broca's aphasia is the most common presentation of this condition, followed by anomic and transcortical motor aphasias. Dysarthria refers to muscular damage that creates impairments with speech. Individuals with this condition have functional limitations in controlling the tongue, larynx, vocal cords, and other surrounding muscles used in speech (Morgan, Mageandran, & Mei, 2010). Research has also shown that dysarthria is associated with difficulties in swallowing, breathing, and speech sound production, resonance, plus prosody (Morgan et al., 2010). Taken together, cognitive-communication disorders can present as word-finding errors, delayed word recall, limited emotional-verbal expression, and language processing (Larkins, 2007).

This cascade of diminished cognitive functioning includes visuoperceptual abilities and executive functioning. Among severe TBI cases, observed difficulties in visuospatial ability, such as unilateral neglect or constructional ability, typically present following sustained injury. These deficits, in tandem with other cognitive impairments, can present functional barriers to adequate rehabilitation and injury recovery trajectory (McKenna, Cooke, Fleming, Jefferson, & Ogden, 2006). Further, visuospatial processing is associated with attentional, perceptual, and memory abilities. Regarding visuospatial attention, Hill-Jarrett, Gravano, Sozda, and Perlstein (2015) assessed alerting, orienting, and executive control components of attention. Their findings showed that individuals with TBI responded much more slowly to visuospatial stimuli than matched healthy controls. These results suggest that persons with TBI experience deficits across different forms of visuospatial attention, specifically concerning recognition, discrimination, and inhibition behaviors. As previously mentioned, DAI is a common type of TBI, and individuals with this condition have endorsed a wide array of cognitive impairment, which included encoding and retrieval of visual information (Mapou, 2013). Concerning executive functions, this set of cognitive processes prompts individuals to initiate a behavior, set short-term and task-oriented goals, flexibly solve problems, integrate response information, and reflects the degree to which an individual can independently engage in purposive self-serving behavior (Lezak, Howieson, & Loring, 2004). Individuals with TBI typically experience difficulties with executive functioning, which may appear to be behavioral self-regulatory complications, dysfunctional regulation, and impairments with metacognition (Stuss, 2007). Overall, persons with TBI experience impairment in memory and attention domains. These complications typically co-present and contribute to other functional domains.

This sequelae of attention and memory deficits, plus associated complications across various domains of neurocognitive functioning, present a wide array of concerns for cognitive rehabilitation. Despite the executive, language, and visuospatial impairment within TBI, these processes have varying degrees of malleability concerning a plethora of injury and comorbid health characteristics. Classic cognitive rehabilitation research suggested that individuals with brain injury were one of the most heterogeneous groups of people who received cognitive rehabilitation (Dikmen, McLean, Temkin, & Wyler, 1986). Aside from the documented cognitive outcomes of TBI, research has suggested that neurocognitive symptoms tend to subside over the course of 3 months following TBI, excluding severe TBI cases (Rohling et al., 2011). Thus, cognitive ability is uniquely dependent on injury severity, which has significant implications for post-injury prognosis. However, cognitive disability following TBI can yield serious implications for impairments in activities of daily living (ADLs) and other aspects of physical functioning.

Physical. Some of the most common aspects of physical impairment following TBI include balance and coordination issues, along with sleep disturbances, headaches, fatigue, sensory impairment, and overall physical weakness (Rosenthal & Ricker, 2000; Draper et al., 2008; Whyte, Hart, Laborde, & Rosenthal, 2005). The summation of these physical complications can have carry-over effects on specific aspects of individual activities of daily living (IADLs) and ADLs. Research has shown that persons with TBI commonly experienced issues with eating, dressing, and personal hygiene (Bottari, Swaine, & Dutil, 2007). Research has also shown that persons with traumatic orthopedic injury (TOI) and people with TBI similarly reported lower levels of physical functioning on multiple assessments, compared to healthy controls (Dahm & Ponsford, 2015). These findings underscore how physical impairments can contribute to disability among TBI populations.

Emotional/psychological. In addition to cognitive and physical complications following TBI, changes in emotional functioning (e.g., depression, anxiety, PTSD, etc.) commonly occurs as well. Identifying mental health concerns following TBI is essential to rehabilitation because these features can impede rehabilitation procedures (Arciniegas et al., 2002). The CDC (2019) has reported that irritability, sadness, nervousness or anxiety, and marked changes in emotional processing typically follow TBI. The onset of these psychological features typically classifies individuals with TBI as having met the criteria for major depressive or generalized anxiety disorders (Koponen et al., 2002). This literature has also shown that individuals with TBI typically reported increased depression and anxiety symptoms and were likely to meet diagnostic criteria for a depressive or generalized anxiety disorder (Koponen et al., 2002). As previously mentioned, cognitive difficulties can have overlapping effects on individuals' psychological functioning, whereby observed impairments can contribute to increased agitation or anxiety associated with functional ability. Among a sample of college students, research has shown that individuals with a positive history of TBI reported higher emotional distress to similar-aged controls (Marschark, Richtsmeir, Richardson, Crovitz, & Henry, 2000). In addition to anxiety, previous literature has documented that individuals with TBI are more at risk for depression compared to non-TBI populations and are at risk for sustaining a depressive disorder during the first-year post-injury (Bombardier et al., 2010). Persons with TBI typically have associated emotional and psychological impairments that may be directly associated with the injury.

The assessment of long-term TBI outcomes allows for differentiation between psychological adjustment to acute injury and organic causes of mood/emotional changes. Research has shown that emotional outcomes tend to display a greater degree of flexibility than cognitive/neurological outcomes. Specifically, Fann, Hart, and Schomer's (2009) review manuscript noted that over 60% of individuals with TBI reported long-term complications with a mood disorder. Although the literature cites depression as one of the most common psychological complications following TBI, research has also shown anxiety and substance use disorders as comorbid diagnoses (Gordon et al., 2006). Concerning long-term emotional outcomes, individuals with TBI endorsed depression, anxiety, and PTSD symptoms, and these symptoms were persistent up to thirty years (Arciniegas et al., 2002; Tsaousides & Gordon 2009). Several factors contributed to this string of psychological issues following TBI, which were structural changes to neural anatomy and neurotransmitter activity. This process directly impacts emotional management in the limbic system (Cervos-Navarro & LaFuente, 1991). Social/functional issues associated with adjusting to disability (Lukow et al., 2015) have also contributed to poor psychological functioning. The literature supports that psychological symptoms following TBI are among the cascade of outcomes, and this population may meet diagnostic criteria for depressive, anxiety, or substance use disorders beyond the acute phase of injury. Further, this particular set of complications is associated with physical and cognitive limitations, as well as contributes to behavioral functioning.

Behavioral. Research has shown that neurobehavioral symptom clusters tend to create the most substantial impairments immediately following TBI (Institute of Medicine, 2011). Thus, noticeable behavioral changes should be viewed in tangent with other functional limitations following TBI, and other deficits should not overshadow these outcomes (DeLisa, Gans, & Walsh, 2005). Additional research has shown that people with TBI reported less independent living and were less likely to participate in leisure activities (Andelic et al., 2010; Bier, Dutil, & Couture, 2009). The CDC noted specific behavioral outcomes regarding sleep, such that hyper-or hyposomnia and sleep onset issues typically arise following TBI (CDC, 2019). However, behavioral aspects of post-TBI functioning broadly include insomnia/hypersomnia among behavioral outcomes, which includes anger, agitation, and both verbal and physical aggression.

Research has extensively examined aggression within post-TBI behavioral functioning. A plethora of studies has examined how the display of aggressive behavior and its prevalence among individuals with TBI. Rao and colleagues (2009) have reported that aggression and aggression-based behaviors are common among individuals with TBI. These particular issues with managing behaviors can have negative implications for rehabilitation, treatment goals, and social functioning development. Some literature hypothesized that aggressive behaviors might possess an organic cause and suggested that decreased prefrontal lobe activity and poor emotion regulation contributed to observed aggression among individuals with TBI (Miles et al., 2017; Shin et al., 2006). However, researchers' previous reports of aggressive behaviors among populations of people with TBI ranges. This lack of concordance considering this particular set of behavioral function may be a culmination of inconsistent operationalization throughout the literature. For example, research from Tateno and colleagues (2003) found that approximately one-third of the sample of persons with TBI displayed aggressive behaviors at six months post-discharge, which would present as a fairly uncommon behavioral outcome. However, a review by Baguley, Cooper, and Felmingham (2006) suggested that this study (e.g., Tateno et al., 2003) used more stringent assessments of aggression, which can contribute to differential reported aggression data. Nonetheless, these findings contribute to the literature because they noted that a range of behavioral functioning issues persisted following brain injury and subsequent rehabilitation.

Neuroanatomical structures of the brain might be associated with aggression of behavioral dyscontrol. In particular, research has identified the amygdala and other limbic prefrontal regions (e.g., the orbitofrontal and anterior cingulate cortices) to serve as key neuroanatomical structures that influence aggression (Rosell & Siever, 2015). Concerning the amygdala, previous literature has reported an association between aggression and reduced amygdala volume (Rosell & Siever, 2015). As a brain structure, it is responsible for relaying external sensory and motivational stimuli to multiple cortical and subcortical regions. These specific pathways represent the role that the amygdala has, wherein it is responsible for emotionally valanced learning and memory, within the context of cognitive, affective, motor, and sympathetic responses to the stimuli aforementioned (Salzman & Fusi, 2010; Fernando, Murray, & Milton, 2013). At the fundamental level, the amygdala possesses the basolateral, central/centro-medial, and superficial/cortical nuclear complexes (Sah, Faber, Lopez de Armentia, & Power, 2003). However, the neuroimaging literature that documents the amygdala's role in aggression is limited to mostly clinical populations, pathological forms of aggression, and males. Among broader samples, research has implicated two limbic systems in the prefrontal cortex (PFC), namely, the orbitofrontal cortex (OFC) and anterior cingulate cortex (ACC; Walton, Croxson, Behrens, Kennerley, & Rushworth, 2007; Rudebeck & Murray, 2014). Research has identified these particular neurological pathways as integral components in the generation of coherent, nuanced, and behaviorally appropriate responses to external stimuli (Walton et al., 2007, Rudebeck & Murray, 2014). Between these systems, prior literature found smaller left OFC gray matter volume to associate with higher levels of trait aggression. This relationship is similar among child and adolescent populations concerning reduced right ACC volumes (Boes, Tranel, Anderson, Nopoulos, 2008; Ducharme et al., 2011). In addition to changes to structures within the limbic system, research has also reported that differential amygdala-PRF connectivity associated with higher reported trait aggression (Hoptman et al., 2009).

Within TBI literature, aggression typically refers to symptoms of disinhibition, anger, irritability, and additional syndromes of behavioral and emotional dyscontrol (Arciniegas & Wortzel, 2014). Research has shown that post-TBI aggression was associated with neuroanatomical structural changes, such as frontal lobe lesions (Baguley et al., 2006; Greve et al., 2002; Rapoport et al., 2002), in addition to psychiatric concerns and sociodemographic considerations. To date, research has not evaluated whether the effects of aggression were more attributable to neuroanatomical structural changes or injury-related characteristics, such as longer duration of PTA and higher functional disability (Roy et al., 2017), as well as rehabilitation concerns, like increased caregiver need and restrictions in workforce participation (Sabaz et al., 2014). Thus, it should be noted that aggression within the context of post-TBI functioning should consider both neuroanatomical concerns in addition to injury and rehabilitation considerations.

Furthermore, these predictors of aggression can indeed inform one another, whereby frontal lobe lesions or disrupted limbic system connectivity can associate with behavioral disinhibition, substance use issues, and psychiatric concerns. In sum, research has extensively examined the different factors that may contribute to the development of aggressive behaviors within the context of TBI, and these considerations can be a correlate of poor rehabilitation gains.

Within the context of TBI rehabilitation, several factors can contribute to observed aggressive behaviors, such as injury-related characteristics and pre-injury features. Concerning demographic correlates, research has shown that lower education was associated with aggressive behaviors at three months post-injury and males with TBI were more likely to report aggressive behaviors at 6 months post-injury (Roy et al., 2017). Concerning age, research has found that younger persons with TBI were more likely to display aggressive behaviors at six, 24, and 60 months post-discharge (Baguely et al., 2006). Regarding psychological functioning, this study also showed that patients with comorbid depression had higher aggression. Another major finding of this study was that an interaction between depression symptoms and age predicted aggression behaviors across six, 24, and 60 months whereby younger persons with TBI and depression symptoms reported higher aggression behaviors than the rest of the sample. Other foundational studies have shown that PTSD (Bryant, Marosszeky, Crooks, Baguley, & Gurka, 2001), mood and substance use disorders (Tateno et al., 2003; Cassidy, 1994), psychosis, and medical delirium (Cassidy, 1994) related to aggressive behaviors within TBI patient populations. Concerning health-related factors, persons with comorbid non-TBI injuries had a higher likelihood of displaying aggressive behaviors (Neumann et al., 2017). Findings from this study also suggested that TBI patient populations presented with higher levels of different types of aggression (e.g., physical, verbal, anger, and hostility). Research has shown aggressive behaviors correlated with greater functional limitations, and negatively impact rehabilitation. Findings from Bogner, Corrigan, Fugate, Mysiw, and Clinchot's (2001) study displayed how persons with TBI and aggression also observed longer stays on rehabilitation units. More recent findings concerning rehabilitation outcomes have shown that PTSD symptom clusters at admission associated with irritability, aggression, and anger at discharge among a sample of veterans with TBI (Miles et al., 2020).

Concerns for antisocial behavior and potential implications for arrests and incarceration arise given the widespread effects of cognitive impairment on aggression. The breadth of research concerning prison populations and individuals within the criminal justice system has documented a variety of outcomes regarding prevalence rates, history, and untreated courses of TBI. Broadly, meta-analyses have shown that incarcerated persons with a history of TBI who had a higher risk of being involved in violent and non-violent legal infarctions (Piccolino & Solberg, 2014; Shiroma, Ferguson, & Pickelsimer, 2012). Additional literature has suggested that over half of a sample of incarcerated individuals in the U.K. self-reported history of head injury (including TBI) over their lifetime (Williams et al., 2010b). Further, 16% of this sample reported having sustained a moderate-to-severe TBI, and about half of the sample endorsed a history of mild TBI.

Criminal justice concerns are important to consider in this cascade of outcomes because many individuals who are currently incarcerated have a history of TBI or head trauma.
A study by Slaughter, Fann, and Ehde (2003) showed a local prison had similar prevalence rates of persons with TBI history compared to higher security prisons. Another finding from this study was that underlying neuropsychological functioning and psychiatric diagnoses were more common among incarcerated persons with TBI. Scholars considered aggression among this

cascade of outcomes, and they found that it was more frequent among individuals who reported a previous history of TBI compared to others in the sample. Research has also shown that approximately 60% of a sample of incarcerated persons in a New Zealand correctional facility reported a history of sustaining at least one TBI, and many were mild in severity (Mitchell, Theadom, du Preez, 2017). Research by Matheson and colleagues (2020) addressed a gap in the literature whereby no research before their date of publication considered time since TBI as a factor. Their findings showed that 13% of a Canadian sample of incarcerated persons was previously diagnosed with a TBI within the five years before incarceration. Additionally, this study reported that of people with a positive history of TBI, 17% of the sample was charged with a serious offense (Matheson et al., 2020).

A gap in the literature exists in current prevalence rates of TBI among incarcerated individuals in the U.S. Concerning racial/ethnic disparities in the context of incarceration and socio-demographic characteristics. Previous research has shown that Black and Latinx individuals with TBI were more likely to have been incarcerated before sustaining a TBI compared to White persons with TBI (Sander et al., 2017). Nonetheless, it is essential to assess how the summation of neurological, psychological, and behavioral components of functioning may associate with a growing public health concern, which is the mass representation of incarcerated persons who also have a history of TBI. Importantly, this is not to disregard social and racial/ethnic justice aspects that contribute to incarceration, which will be discussed in subsequent sections of this document.

Racial/Ethnic Disparities in TBI

Racial/Ethnic Differences in Injury. Racial/ethnic differences in TBI hospitalization rates showed that American Indian/Alaskan Natives had the highest rates of age-adjusted hospitalization, whereas the Asian TBI patient population had the lowest (Rutland-Brown, Wallace, Faul, & Langlois, 2005). Research has suggested that the incidence rates for TBI are much higher for Black persons than White, with 485 per 100,000 compared to 399 per 100,000, respectively (Langlois, Rutland-Brown, & Thamas, 2006). Furthermore, the nature of this relationship is consistent regarding Native American populations (Langlois et al., 2003). Several studies have identified age and gender as TBI risk factors among racial/ethnic minority groups (Burnett, Silver, Kolakowsky-Hayner, & Cifu, 2000; Kreutzer et al., 2003; Gary et al., 2009; Vanderploeg, Curtiss, Duchnick, & Luis, 2003; Johnstone et al., 2003). Among a sample of persons with moderate-to-severe TBI, prior literature has documented that Asian and Black individuals had higher rates of mortality than White patients (Bowman, Martin, Sharar, & Zimmerman, 2007). Additional pre-injury disparities that were more common among racial/ethnic minority groups included marital status (Kreutzer et al., 2003; Arango-Lasprilla et al., 2009), income and socioeconomic status, and health insurance coverage (Arango-Lasprilla et al., 2009; Johnstone et al., 2003; Cardoso, Romero, Chan, Dutta, & Rahimi, 2007; Arango-Lasprilla et al., 2007b). Concerning marital status, study findings have shown that Black and Latinx persons with TBI were less likely to be married. This literature has also documented that racial/ethnic minority groups with TBI were more likely to experience marriage instability as a function of higher perceived disability (Whaley, 2002). Additionally, these groups typically earned less annual income compared to White individuals with TBI and also were less likely to have health insurance coverage at the time of injury. Regarding injury etiology, research has shown that Black, Latinx, and Native American groups were more likely to sustain a violent cause of injury, compared to White persons with TBI (Kreutzer et al., 2003; Arango-Lasprilla et al., 2008a; Arango-Lasprilla et al., 2009; Gary et al., 2009; Arango-Lasprilla et al., 2007a;

Langlois et al., 2003; Linton & Kim, 2014). Overall, research has extensively documented the racial/ethnic disparities in pre-injury characteristics within TBI populations, and these differences can associate with symptom presentation and long-term rehabilitation outcomes.

Racial/Ethnic Differences in Symptoms and Rehabilitation. As previously discussed, several symptoms associated with TBI are malleable post-injury. Given the wide range of observed functional deficits, it is integral to examine the role of race/ethnicity on these factors. Previous research has shown that Latinx individuals with TBI reported higher disability one-year post-injury than White individuals (Arango-Lasprilla et al., 2007a). In line with this research, research has shown that Black TBI patient populations were more likely to report worse functional independence and higher disability than White counterparts (Hart et al., 2007). Holistically, racial/ethnic minorities were more likely to have experienced higher disability and functional limitations compared to White people with TBI at one-year post-injury (Arango-Lasprilla et al., 2007b; de la Plata et al., 2007). From an assessment perspective, research has shown that Black patients with TBI who endorsed more traditional cultural beliefs, such as religiosity, cultural distrust, and family values, showed lower overall neuropsychological performance (Kennepohl, Shore, Nabors, & Hanks, 2004). Similarly, on assessments, research has shown that White patients with TBI had better language/verbal ability and visuoperceptual performance compared to Black and Latinx individuals (Donders & Nesbit-Greene, 2004). As such, these findings have documented that disparities in functional limitations, or the assessment of outcomes, exist for these racial/ethnic minority groups, and they persist at one-year post-injury.

Assessing underlying contributing factors to these racial/ethnic disparities in post-TBI functioning is essential. One of the mechanisms that might contribute to these disparities is racial insensitivity to treatment. Research has shown that Black persons with TBI were more likely to be treated by a resident physician than a staff physician, compared to White individuals with TBI (Bazarian, Pope, McClung, Cheng, & Flesher, 2005). Given that previous research has shown substantial differences in insurance coverage and pre-injury income status, further disparities exist concerning access and discharge to quality treatment. Racial disparities exist concerning post-injury hospitalization (Burnett et al., 2002), rehabilitation referrals (Johnestone et al., 2003), and post-hospital discharge location (Chang et al., 2008). As expected, findings from these studies have shown racial/ethnic minority groups were less likely to be hospitalized following TBI, were more likely to be discharged home, and were less likely to be placed in rehabilitation facilities than White persons with TBI.

Another contributing factor to observed disparities in post-TBI functioning is the post-discharge quality of life and functioning. Research has vastly shown that minority-identified individuals were less likely to attain employment following injury compared to White individuals with TBI (Arango-Lasprilla et al., 2008c; Gary et al., 2009). Research has shown among individuals who were able to attain employment, Latinx people with TBI were less likely to receive disability-related support from their employers compared to White people (Cardoso et al., 2007). These health disparities exist even after controlling for several underlying factors associated with pre-injury information, such as education and cause of injury (Gary et al., 2009; Rosenthal & Ricker, 2000). Research conducted by Arango-Lasprilla and colleagues (2009) showed Black persons with TBI reported lower overall satisfaction with life scores compared to White and Asian groups. Research has shown disparities in other mental health aspects of post-injury functioning, such as higher depression among Black patients with TBI (Seel et al., 2003) and a greater degree of symptom clusters similar to PTSD compared to White TBI patients

(Greenspan et al., 2006). Research has shown Black, Asian, and Latinx persons with TBI reported lower community integration (e.g., a person's capability to be involved in their expected community role in both leisure and productive activities; Esselman, Ptacek, Kowalske, Cromes, & Engrav, 2001), compared to White TBI patients (Wagner, Hammond, Sasser, Wiercisiewski, & Norton, 2000; Hart et al., 2005). Follow-up research conducted by Arango-Lasprilla and colleagues (2007a) found that these differences remained after controlling for injury and demographic characteristics. Prior literature has found Black, Asian, Latinx, and Native American persons with TBI were approximately two times more likely to be nonproductive at a one-year follow-up compared to White TBI patients. These differences remained consistent after controlling for preinjury productivity, education, and cause of injury (Sherer et al., 2003). Concerning employment, prior literature has shown Black, Latinx, Asian, and Native American people with TBI were more likely to be unemployed than stably employed (Arango-Lasprilla et al., 2008c). Overall, racial/ethnic disparities exist in TBI functional and injury-related outcomes; however, many of these disparities relate to psychosocial functioning as well.

Thus, this summation of research has shown the well-documented racial/ethnic disparities concerning TBI injury-related features such as the risk of sustaining TBI, etiology, and severity. Furthermore, these disparities also exist within the context of pre-injury social factors and demographic features. From a social justice approach, it is essential to recognize that the social experience of race and ethnicity plays an integral role in observed health disparities between these groups. For example, referring to Kennepohl and colleagues' (2004) study, Black people with TBI who endorsed less acculturative values were more likely to yield lower performance on verbal and visuoperceptual assessments. An important takeaway from this finding is that these data reflect the assessment and diagnostic biases that racial/ethnic minority communities, specifically Black and Latinx persons, face in assessment, diagnosis, and treatment of TBI. However, from a strengths-based perspective, Black and Latinx patients with TBI who reported higher symptom severity similarly endorsed better marriage stability compared to other groups (Arango-Lasprilla et al., 2008a). Nonetheless, these racial/ethnic disparities persist at all levels of rehabilitation for racial/ethnic minority groups, specifically Black and Latinx people. Research has discussed the behavioral implications of TBI in-depth, cited previously, but has minimally explored how race/ethnicity may contribute to patterns observed in research. Prior literature has shown 1/3 of a sample of incarcerated persons reported a history of aggressive behavior and people with TBI who were incarcerated also had substantially higher frequencies of legal interventions to alleviate aggressive behavior, before sustaining the injury (Tateno et al., 2003). These findings also showed that major depression, history of alcohol and substance use, and frontal lobe lesions associated with aggressive behaviors among incarcerated persons with TBI. However, a limitation of this research was that the majority of the sample were White males, and their investigation did not account for the racial/ethnic disparities in TBI, as previously discussed. Thus, the following sections of this document will use a social justice approach to document how racial/ethnic disparities in TBI literature may overlap within the criminal justice system.

Arrests and Criminal Justice Concerns

Perkinson (2010) classified the criminal justice system as a system of racial and social control instead of its intent to alleviate crime. Research that has shown trends in incarceration and crime rates supported this claim. Specifically, the imprisonment rate in the U.S. is approximately six to seven times higher than the rates of other developed nations; and despite these stark numbers, crime rates have steadily declined over the last several decades (Western &

Weldeman, 2009; Alexander, 2010). The U.S. Census Bureau (2001) reported that racial/ethnic minority populations disproportionately represent incarcerated people and persons sentenced to execution. Findings from the Bureau of Justice Statistics (2003) showed that one in three Black and one in six Latino men will be incarcerated in their lifetime, compared to six percent of White men (The Sentencing Project, 2013). Concerning Native American populations, research has shown this group received harsher sentences compared to White, Black, and Latinx persons convicted of a similar offense (Franklin, 2011). Moreover, these findings displayed that young Native American men received more punitive sentences compared to age-matched Black and Latino men. Racial/ethnic inequality in incarceration data showed that Black individuals made up approximately 36% of the prison population but represented 12% of the U.S. population (Carson & Golinelli, 2013). Referring back to Perkinson (2010) and additional research, racial disparities in incarceration rates have grown from a ratio of 2:1 to 7:1 since the civil rights movement, meaning that for every White person who was incarcerated, seven Black people were incarcerated (Oliver 2001; Murakawa & Beckett, 2010). This ratio is 3.3:1 among Latinx individuals within New York State, which means that for every White person incarcerated, there are approximately three Latinx individuals incarcerated (The Sentencing Project, 2016). Research has also shown that Latinx youth are 1.5 times more likely to be incarcerated than White counterparts (Coalition for Juvenile Justice, 2010). Cultural considerations among this group are essential within the scope of criminal justice given that prior literature has documented that the Latinx population is of the fastest-growing groups among incarcerated persons (The Sentencing Project, 2013) in addition to the arrest/criminal justice disparities previously noted. Racial/ethnic disparities research for Asian populations in arrests and criminal justice contexts is sparse. However, among a sample of young adults aged 18 to 34, research has shown that Asian individuals had a lower lifetime prevalence of arrests (19%) compared to White (29%), Black, (38%), and Native American (40%) groups (Barnes, Jorgensen, Beaver, & Boutwell, 2015).

These social issues underscore racial/ethnic disparities in incarceration and also provide context to introduce how TBI can further contribute to these observed disparities. Silver and colleagues (2001) found that 8.5% of the general population had a history of TBI, whereas these proportions are much higher for adults and juveniles who are currently incarcerated at 60% and 30%, respectively (Farrer & Hedges, 2011; Frost, Farrer, Primosch, & Hedges, 2013; Shiroma, Ferguson, & Pickelsimer, 2012). Biological features, such as damage to the frontal and parietal lobes, associated with TBI can contribute to these stark differences (Fabian, 2010; Raine, 2002). These features also contributed to long-term TBI outcomes, and research has well-assessed contributing factors to recidivism. A study by Vaughn, Salas-Wright, DeLisi, and Perron (2014) presented prevalence rates of TBI among a sample of incarcerated persons, predictors of arrest history, and long-term correlates of recidivism. These findings showed that one-third of the sample screened positive for TBI, with approximately 64% of them mild, and each 12% as moderate and severe. They also showed that a positive history of TBI associated with a higher likelihood of psychiatric diagnosis, a greater number of previous lifetime arrests, and atypical TBI cause. Vaughn and colleagues (2014) conducted a survival analysis among a prison population predicting recidivism, and their results showed that more than half (53%) of the sample was rearrested between 12- and 30-months following release, and prior history of TBI, racial/ethnic minority status, and prior arrests contributed to this outcome. Outside of TBI contexts, previous findings have incorporated racial/ethnic and societal factors that considered structural conditions, such as racial/ethnic inequality and poverty disparities. These studies have shown systemic racial/ethnic inequality of resource allocation and state-level criminal policy contributed to higher recidivism rates for Black and ex-convicted persons (Kubrin & Stewart, 2006; Reisig, Bales, Hay, & Wang, 2007; Visher & Travis, 2003). Thus, the longitudinal nature of criminal arrests may be more associated with these social constructs in addition to complex symptom clusters of TBI, which disproportionately impact Black, Latinx, and Native American individuals.

Prior literature has documented the associations between criminal arrests and the sequelae of cognitive, physical, and emotional functional impairments of TBI. Additionally, literature has assessed the long-term arrest outcomes, particularly among TBI patient populations. The longitudinal nature of arrest probabilities is supported by these findings, which showed that a positive TBI history associated with the subsequent likelihood of reoffending (Williams, Cordan, Mewse, Tonks, & Burgess, 2010a). Although these long-term outcomes exist among TBI patient populations, research is contradictory concerning precipitating factors associated with arrests. For example, some findings have suggested that emotional and psychological dysfunction was associated with common TBI impairments, such as irritability, affect lability, and cognitive/behavioral disinhibition (Wortzel & Arciniegas, 2013; Arciniegas & Wortzel, 2014). However, findings have also shown no significant relationship between aggression or violent criminal offending and TBI (Colantonio, Stameova, Abramowitz, Clarke, & Christensen, 2007; Davies, 2012). Inconsistent results from these studies may be explained by the generalizability of the sample to solely psychiatric populations (e.g., Colantonio et al., 2007) and currently incarcerated youth (e.g., Davies, 2012). Additionally, the range of findings in the literature may be explained by differences in the countries that these data were gathered from and how recent these studies were conducted. For example, previous research has supported a relationship between TBI and criminal offense in the U.S. (Ommaya, Salazar, Dannenberg, Chervinsky, & Schwab, 1996), Sweden (Fazel, Lichtenstein, Grann, & Långström, 2011), and Finland (Luukkainen, Riala, Laukkanen, Hakko, & Räsänen, 2012); however, older and conflicting research has shown no relationship among these constructs (Virkkunen, Nuutila, & Huusko, 1976).

Despite the range in findings of associations between criminal behavior, incarceration, and TBI, research regarding injury and demographic characteristics has consistently shown significant relationships between these features and criminal arrests. Considering demographic characteristics, research has shown that individuals with TBI who identified as male, (Kolakowsky-Hayner & Kreutzer, 2001; Colantonio et al, 2007; Perron & Howard, 2008), were younger in age (Colantonio et al., 2007), reported lower educational achievement, and endorsed previous arrest history, were more likely to have reported criminal behavior and earlier history of illegal conduct (Williams et al., 2010a; Perron & Howard, 2008). Considering psychological functioning, prior research has shown that previous psychological treatment (Kolakowsky-Hayner & Kreutzer, 2001), diagnosed antisocial personality disorder (Colantonio et al., 2007, Schofield, 2006), major depression (Schofield, 2006; Moore, Indig, Haysom, 2014), and higher alcohol consumption and substance use (Perron & Howard, 2008; Schofield, 2006; Moore et al., 2014) predicted criminal arrest outcomes. In addition to psychological and demographic correlations, research has noted that violent cause of TBI, particularly assaults, were associated with criminal behavior (Kolakowsky-Hayner & Kreutzer, 2001).

In conclusion, research has extensively documented racial/ethnic disparities in TBI risk, onset, and outcomes. Research showed Native American populations had the highest TBI rates (Langlois et al., 2003). Findings from previous literature suggested that Black, Latinx, and Native American TBI patients were more likely to have sustained violent TBI (Kreutzer et al., 2003; Arango-Lasprilla et al., 2008a; Arango-Lasprilla et al., 2009; Gary et al., 2009; Arango-Lasprilla et al., 2007a; Langlois et al., 2003; Linton & Kim, 2014). Research has also shown Asian and Black TBI populations had the highest mortality (Bowman, Martin, Sharar, & Zimmerman, 2007). Earlier literature found that Latinx persons with TBI reported higher disability than White individuals with TBI (Arango-Lasprilla et al., 2007a). Additionally, post-injury hospitalization, rehabilitation referrals, and post-hospital discharge location have all witnessed racial/ethnic disparities among TBI populations (Johnestone et al., 2003; Chang et al., 2008; Burnett et al., 2000). Considering post-discharge functioning, previous literature has shown that racial/ethnic minority groups reported less community integration and employment compared to White TBI patients (Wagner et al., 2000; Gary et al., 2009; Arango-Lasprilla et al., 2008c; Arango-Lasprilla et al., 2009). Further disparities exist concerning functional independence, whereby Black TBI patient populations have reported higher disability than White people with TBI (Hart et al., 2007).

Arango-Lasprilla and Kreutzer (2010) presented a comprehensive review of the racial/ethnic disparities literature concerning TBI functional outcomes. Specifically, they presented cultural considerations for clinical practice, research, and training that emphasized critical evaluation of societal and cultural experiences among these groups that may contribute to observed disparities. In the context of the criminal justice system, a high proportion of people who are currently incarcerated are likely to have sustained a head injury, including TBI. Racial/ethnic disparities are well-documented concerning criminal justice and incarceration rates. Specifically, Black and Latinx individuals disproportionately make up prison populations, with one in three Black and one in six Latino males having been arrested. Additionally, research has shown younger Native American men received harsher sentences compared to Black, White, and

Latino men (Franklin, 2011). The overlap between the racial/ethnic disparities in incarceration and the high prevalence of TBI rates among these populations raise concern for stark differences concerning functional outcomes. For example, prior literature has found that a sustained TBI was associated with a higher likelihood of reoffending (Williams et al., 2010a). Overall, the longitudinal trajectories of arrest outcomes may be closely linked to racial/ethnic disparities observed in TBI risk, cause, and post-injury outcomes, given racial/ethnic differences in arrests, social structures that contribute to reoffending, and the higher likelihood of functional impairment for racial/ethnic minority groups with TBI.

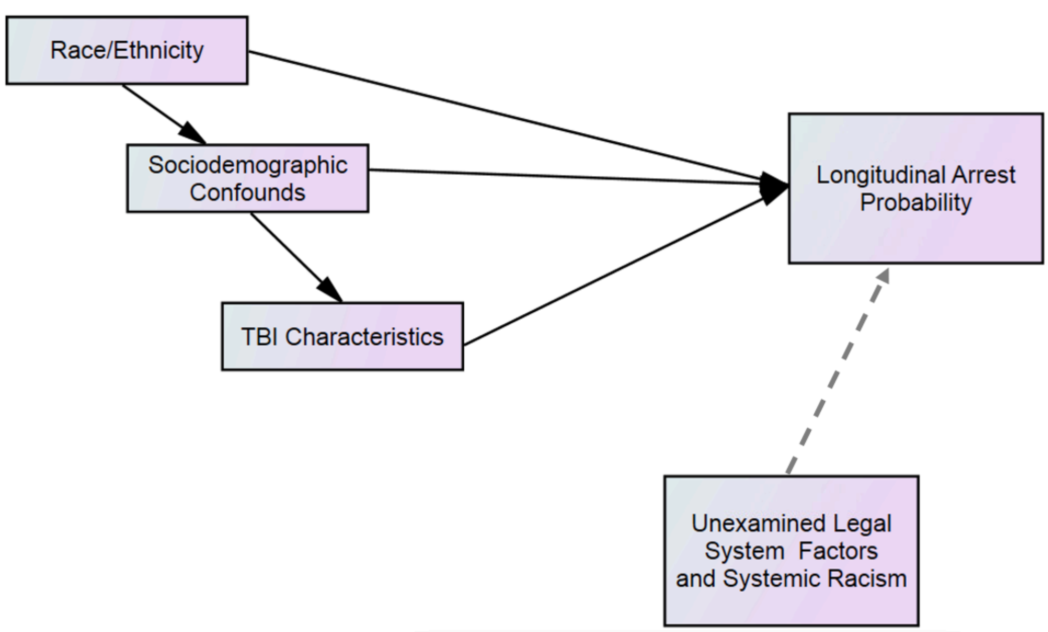
Current Study Objectives

Research regarding the longitudinal nature of arrests, criminal outcomes, and associated predictors is sparse. Of note, few studies have assessed the longitudinal predictors of arrests among individuals with TBI. Consistent with multiple findings from previous research, Elbogen and colleagues (2015) found that young, less-educated males were more likely to be arrested after sustaining TBI. Concerning TBI injury features, these data showed that individuals who sustained TBI with greater LOC and intact motor functioning were at greater risk for future arrests. The major premise of this study was to document longitudinal predictors of criminal arrests. To assess these relationships, researchers constructed three separate samples for participants with TBI at years one, two, and five. Furthermore, they entered demographic, premorbid functioning, and TBI characteristics as predictors into a simultaneous multiple regression model at each respective time point. They evaluated the associations of these predictors on criminal arrests as an outcome at one, two, and five years. Importantly, these researchers did not find significant differences in race/ethnicity as a predictor of criminal arrests; however, they created orthogonal dummy codes, whereby they identified White patients as the reference group and all other racial/ethnic minority-identified individuals with TBI were placed in the comparison group. Methodological characteristics of this study were that a) three separate analyses were run to identify different predictors of criminal arrests at one, two, and five years, b) all racial/ethnic minority-identified individuals were placed in the same comparison group, and c) longitudinal predictors were reported at each time point and did not account for potential contributions on the outcome from data of previous follow-up periods.

An additional study assessed these outcomes among a veteran population with TBI and found that moderate TBI, pre-injury arrest history, having received mental health treatment, moderate to heavy alcohol use, and having one more follow-up interviews independently contributed to post-TBI arrests across the span of ten years (Miles et al., 2021). Of note, this study did not find significant racial/ethnic differences in arrest outcomes when comparing Black vs. White, Hispanic vs. White, and “Other race/ethnicity” vs. White. The researchers suggested that the nature of these findings was supportive of previous literature, which has shown civilians with more severe TBI to be more likely to report post-TBI arrests at one, two, or five year follow-up periods (Elbogen et al., 2015). The findings from these studies contribute to the current study design by providing context for potential predictors in the current study analyses (e.g., age, sex, injury characteristics, pre-injury mental health treatment and substance use issues, and pre-injury arrest history), which are also supported by previous research.

Thus, a gap in the literature exists wherein no research to date has explored the longitudinal trajectories of arrest probabilities among individuals with TBI, particularly while considering racial/ethnic disparities in TBI risk and rehabilitation. The purpose of the current study was to evaluate the degree to which racial/ethnic disparities in TBI outcomes may operate within the context of criminal arrests probability. Previously cited research above (e.g., Vaughn et al., 2014; Elbogen et al., 2015; Kolakowsky-Hayner & Kreutzer, 2001; Colantonio et al., 2007; Perron & Howard, 2008; Williams et al., 2010b) has shown that gender, younger incarceration history, psychiatric history, violent TBI, lower education, less community integration, problematic premorbid substance use, functional ability, and previous arrest history associated with recidivism among persons with TBI. As such, this study aimed to examine whether age, sex, preinjury arrest history, prior mental health service utilization, injury severity, premorbid education attainment, employment status at baseline, preinjury substance use, and post-TBI functional independence at discharge contributed to these potential racial/ethnic disparities in arrest probabilities. Thus, the current study suggests a theoretical framework (Figure 1) wherein racial/ethnic group membership will contribute to disparities in sociodemographic confounds that are associated with more severe and violent causes of TBI. All three of these sources of variables combine with (unexamined in this study) legal system and systemic racism to produce a higher likelihood of arrest probabilities for Black, Latinx, and Native American individuals with TBI.

Figure 1. *Current study theoretical model*.



Additionally, the theoretical framework maps onto previous research that has shown racial/ethnic disparities among these confounds, such as younger age, male sex, lower achieved education, pre-injury arrest history, pre-injury substance use issues, and non-competitive pre-injury employment. These confounds have been shown to contribute to stark differences in injury characteristics (e.g., violent cause of injury, severity level, functional independence at discharge). Finally, unexamined legal system factors and systemic racism, which were not assessed in the current study, were modeled to have a unique contribution to longitudinal arrest probability. The theoretical framework of the current study posits that the effects of racial/ethnic disparities in the acquisition and features of TBI, as well as additional sociodemographic confounds, will in part account for longitudinal arrest probability trajectories. Taken altogether, the current study has several aims.

Aim 1

This study aims to assess and report the preinjury arrest history prevalence among the current sample. Further, the current study will present demographic and injury-related characteristics in the scope of arrest history.

Hypothesis 1. Previous literature has found racial/ethnic disparities in criminal arrests within non-TBI populations. Specifically, research has shown that racial/ethnic minority populations disproportionately represented those who were currently incarcerated, and persons sentenced to execution (U.S. Census Bureau, 2001). Findings from Barnes and colleagues (2015) reported that Asian individuals had a lower lifetime prevalence of arrests compared to other racial/ethnic groups. As such, it is expected that Black, Latinx, and Native American persons will report pre-injury arrests at a higher rate than the White and Asian persons within the sample.

Aim 2

This study aims to examine racial/ethnic differences in longitudinal arrest probability trajectories after TBI.

Hypothesis 2. Findings from the Elbogen and colleagues (2015) and Miles and colleagues (2021) studies documented demographic and injury-related characteristics that predicted longitudinal arrest outcomes. However, the Elbogen and colleagues (2015) study had several methodological flaws, whereby three separate analyses were run to identify different predictors of criminal arrests at one, two, and five years, all racial/ethnic minority-identified individuals were placed in the same comparison group, and longitudinal predictors were reported at each time point. This study design did not assess for true longitudinal effects and contributing factors to arrest outcomes, nor did it consider racial/ethnic differences. The Miles and colleagues (2021) study was conducted among a sample of veterans and service members with TBI, and this study did not find racial/ethnic differences in arrest outcomes. Given the racial/ethnic disparities among violent TBI, criminal arrests, and functional outcomes outline above, it is expected that Black, Latinx, and Native American persons with TBI will show higher arrest probability trajectories compared to White and Asian groups.

Hypothesis 2.1. Previous literature has documented injury and demographic characteristics associated with arrest outcomes after TBI. Specifically, past findings suggested that younger age (Colantonio et al., 2007), male sex (Kolakowsky-Hayner & Kreutzer, 2001; Colantonio et al., 2007; Perron & Howard, 2008), lower educational achievement, and previous arrest history (Williams et al., 2010b; Perron & Howard, 2008) predicted arrests. Major depression (Schofield, 2006; Moore et al., 2014), prior mental health service utilization (Miles et al., 2021), and alcohol consumption were psychological/behavioral factors that were associated with a higher likelihood of criminal arrest outcomes (Miles et al., 2021; Perron & Howard, 2008;

Schofield, 2006; Moore et al., 2014). Informed by this literature, it is hypothesized that racial/ethnic differences in incarceration rates will in part be accounted for by injury-related (e.g., severity, post-TBI functional independence, and violent cause of injury) and sociodemographic variables (e.g., age, sex, pre-injury arrest history, employment status, pre-injury substance use, prior mental health service utilization, and education).

Method

Participants

The current study included participants who were enrolled in the National Database of the National Institute for Disability, Independent Living, and Rehabilitation Research (NIDILRR) Traumatic Brain Injury Model System (TBIMS) study. The TBIMS is comprised of individuals with newly acquired TBI, who receive comprehensive inpatient rehabilitation services at one of the TBIMS sites in the United States. Sixteen TBIMS sites and three longitudinal follow up centers contributed to the dataset that was used for this study. Given that variables are periodically added and deleted from the TBIMS study protocol, the start and end dates for the current study were selected as a function of the “key variables” (e.g., the variables that are consistent across protocol revisions). Inclusion criteria for the TBIMS National Database include (a) 16 years of age or older at the time of injury, (b) medically diagnosed TBI from the TBIMS center (e.g., mild complicated, moderate, or severe TBI), (c) either Glasgow Coma Scale score of ≤ 12 upon emergency admission, > 24-hour duration of posttraumatic amnesia (PTA), loss of consciousness (LOC) >30 minutes, or evidence of intracranial trauma on neuroimaging, (d) admission to the respective TBIMS acute care hospital within 72 hours of injury, and (e) enrollment and completion of inpatient rehabilitation services within the TBIMS center. For the time covered by this study, race/ethnicity was coded as a mixed variable rather than two separate variables in the TBIMS National Database. Race and ethnicity were coded as White, Black, Asian/Pacific Islander, Native American, Hispanic origin (re-named in this document as "Latinx"), other, or unknown. Inclusion criteria for the current study were (a) age 16 or older at the time of injury, (b) reported race/ethnicity, (c) have preinjury arrest data, and (d) have arrest data for at least one of the follow-up time points of interest (one, two, five, and ten years). Data for participants with missing race/ethnicity data or arrest data from all follow-up time points will not be included in the current study. In other words, if participants had race/ethnicity data, preinjury arrest data, and arrest data from at least one follow-up time point, they were included in the current sample. These inclusion criteria resulted in a sample of 13,195 participants.

Measures

Arrests. Participants' caregivers or representatives reported pre-injury arrest information at the baseline data collection with a response to the prompt "Did the person with brain injury have any penal incarceration with convictions for felony prior to (their) injury?" To determine whether the person with TBI was arrested during the past year, participants or their proxy responded to the prompt, "if the person with brain injury has been arrested during the past year," at each respective time point. Both of these responses were dichotomized as 0 (no) and 1 (yes). Of note, the question that assesses pre-injury arrests requires several conditions, which are: a) arrested prior to their injury, b) penal incarceration for said offense, and c) conviction for felony. Thus, pre-injury arrest history reflects incarceration with a conviction for felony, as opposed to criminal arrests, with no respective incarceration or conviction as assessed post-injury.

Injury Characteristics. TBIMS sites collect data on TBI features such as the cause (e.g., falls, motor-vehicle accident, assault, etc.) and severity of the injury (PTA), and length of LOC. The TBIMS National Data and Statistical Center's Standardized Operating Procedure (2019) defines TBI as damage to brain tissue caused by an external force evidenced by medically documented LOC or PTA due to cerebral trauma or by radiological findings that are consistent with TBI on examination or evaluation of mental status. Additionally, the TBIMS National Data and Statistical Center classified penetrating wounds as TBI if they were consistent with the prior definition. Thus, the current study conceptualized TBI as brain trauma caused by external mechanical force evidenced by medical documentation of LOC, PTA, or imaging results that reflected the presence of TBI. The current study operationalized violent TBI as TBI caused by "gunshot wounds," "assault with a blunt instrument," or "other violence," per the TBIMS classification system. PTA will be the indicator for injury severity. Conceptually, PTA's interpretation will be consistent with Sherer and colleagues' (2020) case definition of PTCS. The purpose of this system is to distinguish severe TBI from less severe TBI. The TBIMS database calculated PTA by the number of days since admission to date emerged from PTA. TBIMS centers defined emergence from PTA as two consecutive scores of full orientation on the Galveston Orientation and Amnesia Test (GOAT; a score of $\geq$ 76; Levin, O'Donnell, Grossman, 1979), Revised GOAT (a score of $\geq$ 11; Bode, Heinemann, & Semik, 2000), Orientation-Log (a score of $\geq$25; Jackson, Novack, Dowler, 1998), Non-Verbal Orientation Log ($\geq$ 8; Novack, Dowler, Bush, Glen, & Schneider, 2000), or as a basis of clinical judgment if a clinician is unable to assess orientation due to language impairments. For the purpose of the current study, Department of Defense/Veteran's Affairs (VA/DoD, 2016) clinical practice guidelines for classification of TBI was used, as a PTA of 0 to 1 day indicated mild TBI, > 1 day and < 7 days for moderate, and > 7 days as severe.

Post-TBI Functional Independence. The Functional Independence Measure (FIM; Dodds, Martin, Stolov, & Dayo, 1993) is an 18-item assessment that examines the functional status of persons with disabilities. Respondents rate each item on a 7-point scale which assesses motor and cognitive functional dimensions. Responses range from 1 (total assistance; complete dependence) to 7 (complete independence). Total scores range from 18 to 126, and higher values on this measure reflect greater independence. Previous research has shown that the FIM has strong internal consistency, particularly for TBI populations (α = .93; Dodds, Martin, Stolov, & Dayo, 1993) and this was consistent for the current study (α = .85). Participants reported FIM at admission, discharge, and follow-up, although only the discharge score was used as a covariate.

Substance Use. TBIMS centers assess pre- and post-injury substance use by items adapted from the CDC's risk Factor Surveillance System (CDC, 1998). Participants indicated the frequency of alcohol consumption and the approximate amount consumed per occasion. The CDC (1998) and the Substance Abuse and Mental Health Services Administration (1998) established problematic substance use criteria as 14 drinks per week for men and seven for women, or consumption of five or more drinks on one occasion. TBIMS centers screened for alcohol and illicit substance use behaviors in the month before the injury.

Mental Health and Psychiatric History. The TBIMS centers assess mental health service utilization history via "have you ever received treatment for any mental health problems (Examples include depression, anxiety, schizophrenia, and alcohol/drug abuse)," and this question is followed up by whether the service use occurred within the year prior to the injury.

Demographics. Participants' demographic information was recorded by the respective TBIMS center they received treatment. This included age (e.g., years), sex (e.g., male or female), race/ethnicity, years of education, and employment status. Participants or caregivers when applicable self-reported their race/ethnicity using the 1990 and 2000 U.S. Census guidelines. Race/ethnicity data were coded as White (1), Black (2), Asian/Pacific Islander (3), Native American (4), Hispanic origin (5), other (7), or unknown (9).

Procedure

The current study was a secondary data analysis. The protocol received institutional review board approval and followed guidelines to obtain the database of corresponding variables. After enrolling participants in the TBIMS, their health and social history were collected from medical records and participant/family interviews. Interviews of patients with TBI and their respective family members were used to gather psychosocial history. TBIMS research staff collected follow-up data via telephone interviews, and participants could either choose an in-person interview or complete a self-administered questionnaire. Participants and their families were contacted at one, two, five, and ten years as close to the injury anniversary date as possible to assess functioning and medical/social history for the prior year. Family members or a primary caregiver were contacted to provide such information for patients who were unable to complete assessments.

Results

Preliminary Analyses

All analyses were conducted using SPSS Version 26.0 and two-tailed significance was established at an alpha level of .05. The current study computed descriptive statistics (i.e., means, standard deviations, frequencies, and percentages) for sample demographics, psychosocial features, and injury characteristics (Table 1). Further, statistically significant differences in the main study predictor variables among race/ethnic groups using analyses of variance (ANOVAs) or chi-squared analyses were calculated (Table 1).

Table 1. *Sample demographic and injury information*

Variable	*p*-value	White (*n* = 9,045)	Black (*n* = 2,409)	Latinx (*n* = 1,316)	Asian (*n* = 344)	Native American (*n* = 81)
Age, M	<.001	42.30_{abc}	37.96_{aef}	36.37_{bfg}	41.17_{aeg}	37.40_{c}
Sex, % male	<.001	71.2_{a}	77.7_{ab}	77.5_{ac}	70.1_{bc}	69.1
Education, M	<.001	12.98_{a}	11.77_{ab}	10.5_{abc}	13.7_{abc}	11.99_{ac}

Competitively Employed, %	<.001	65.1_{ab}	55.7_{a}	69.3_{ac}	60.9_{c}	47.4_{bc}
Pre-injury Substance Use, % yes	<.001	43.0_{a}	44.4_{b}	41.3_{d}	25.8_{abd}	60.5_{ad}
Pre-injury arrests, % yes	<.001	7.2_{ab}	16.7_{a}	10.6_{ab}	3.5_{ab}	19.8_{ab}
Injury Cause, % violent	<.001	6.2	26.4	16.0	10.3	14.8
Injury Severity, %						
Mild		12.6	10.7	10.4	12.9	7.6
Moderate		11.7	11.8	9.4	13.6	13.6
Severe		75.8	77.6	80.2	73.5	78.8
FIM Total at Discharge, M	<.001	91.27_{a}	88.41_{abe}	89.36_{cd}	93.22_{bc}	96.10_{de}
Past Year Arrests, % yes						
Year 1		5.2	7.1	5.8	1.6	11.4
Year 2		5.6	7.7	5.4	2.3	7.6
Year 5		5.5	7.0	9.3	2.9	16.3
Year 10		4.7	7.5	6.7	3.9	5.9
Post-Rehabilitation Discharge Location, %						
Private Residence		82.81	84.06	86.98	84.55	83.95
Nursing Home		10.08	9.53	6.09	8.45	7.41
Adult Home		2.56	2.75	2.28	1.46	2.47
Correctional Institution		0.04	0.12	0.08	0.29	0
Hotel/Motel		0.30	0.21	0.08	1.17	0
Homeless		0.08	0.12	0.15	0.00	0
Hospital: Acute Care		1.77	1.17	1.29	2.04	3.70
Hospital: Rehabilitation		1.53	1.21	1.75	1.46	1.23
Hospital: Other		0.44	0.62	0.76	0.29	1.23
Other		0.39	0.21	0.53	0.29	0

Note. Variables sharing a subscript were significantly different ($p < .05$).

As strictly an exploratory analysis, among the Latinx subsample, racial differences regarding the descriptive statistics noted above were computed. Significant differences between White- and Black-identified Latinx persons concerning injury, demographic, and psychosocial factors are reported in Table 2.

Table 2. *Racial differences among Latinx persons*

	White	Black
N	170	29
Sex, %		
Male	77.6	86.2

Female	22.4	13.8
Age, M ± *SD*	33.79 ± 17.39	34.17 ± 14.13
Education, M ± *SD*	12.55 ± 2.47	12.12 ± 2.47
Employment		
Competitively Employed, %	70.6	65.5
Pre-injury Substance Use, %	41.2	44.8
Pre-injury Arrest History**, %	7.1	27.6
Injury Cause*		
Violent, %	8.2	20.7
Injury Severity		
Mild, %	7.1	0
Moderate, %	6.5	10.3
Severe, %	67.1	62.1
FIM, M ± *SD*	90.54 ± 23.48	88.07 ± 26.37

Note. * = p <.05, ** = p < .01, *** = p < .001.

The study also created a correlation matrix to examine bivariate correlations among demographic and injury-related variables with arrest history at each time point (Table 3). The following coding scheme was used: participant sex, female = 0 and male = 1; pre-injury employment, 0 = not competitively employed and 1 = competitively employed; pre-injury substance use, 0 = no and 1 = yes; pre-injury arrest history, 0 = no and 1 = yes; injury severity, 1 = mild, 2 = moderate, and 3 = severe; injury cause, 0 = non-violent and 1 = violent; and arrest in prior year, 0 = no and 1 = yes).

Table 3. *Correlation matrix.*

	1	2	3	4	5	6	7	8	9	10	11	12
1. Sex												
2. Age	-.091***											
3. Education	-.057***	.139***										
4. Employment	.142***	-.251***	.108***									
5. Pre-Injury Substance Use	.161***	-.271***	-.104***	.053***								
6. Pre-Injury Arrest History	.136***	-.051***	-.180***	-.022*	.190**							
7. Injury Cause	.104***	-.085***	-.117***	-.039***	.141**	.147***						
8. Injury Severity	.113***	-.315***	-.090***	.143***	.128***	.059***	.020*					
9. FIM	.043***	-.121***	.062***	.118***	.090***	.015	.028**	-.075***				
10. Arrests: Year 1	.078***	-.133***	-.093***	-.019*	.152***	.118***	.050***	.057***	.086***			
11. Arrests: Year 2	.078***	-.141***	-.098***	-.003	.150***	.105***	.065***	.038***	.088***	.260***		
12. Arrests: Year 5	.078***	-.138***	-.106***	-.026*	.136***	.119***	.033**	.048***	.077***	.162***	.194***	
13. Arrests: Year 10	.068***	-.125***	-.090***	-.030	.103**	.081***	.043**	.022	.044**	.073***	.108***	.145***

Note. Values represent correlation coefficients. * = p <.05, ** = p < .01, *** = p < .001.

Normality tests for the main study continuous predictor variables (e.g., participant age and education) were conducted with a critical value cutoff of 2.0. Skewness ranged from -.14 to .63, and kurtosis ranged from -.57 to 1.33; thus continuous predictor variables did not exceed the critical value of 2.0. Transformation of continuous data was not used given no main study variables yielded severely non-normal distributions. Additionally, data were checked for multicollinearity via correlation coefficients among all predictor variables (with a goal $r < .70$ among all predictors; Table 3).

A series of independent-samples t-tests or chi-square tests were performed to assess for selection bias between those whose data were and were not included in the current analysis. As such, the current retained sample reflected that older participants were more likely to drop out ($p < .001$). Additionally, individuals with lower discharge FIM scores ($p < .001$), less severe injuries ($p < .001$), violent injury cause ($p < .001$), pre-injury non-competitive employment ($p < .001$), woman ($p = .002$), non-problematic pre-injury substance use ($p = .023$), or preinjury arrest history ($p = .038$) were less likely to be retained by the current study sample criteria. Participant education ($p = .694$) was not significantly different between the non-selected sample and retained sample. Finally, the racial/ethnic distribution of the retained sample was significantly different ($p < .001$) from the initial participant pool such that Latinx individuals were the most likely to have missing data and Native American and White individuals had the lowest rates of missing data. Thus, the summation of these significant differences suggest that the sample selected for the current study is unique compared to the broader TBIMS sample. This is generally a known and well-established characteristic of the database (Corrigan et al., 2012).

Regarding missingness, the study calculated the percentage of missing arrest data at preinjury, one year, two years, five years, and ten years. The percentage of missing data for arrest data were 9.7, 22.5, 45.8, and 70.4 at one, two, five, and ten years, respectively. Missingness of the data was assessed using Little's Missing Completely At Random (MCAR) test. Results of this test were significant (χ^2 [28] = 190.82, $p < .001$) and indicated that the data were not missing completely at random. Full information maximum likelihood (FIML) estimation procedures were used without imputation to include all participants with missing data, as listwise deletion would result in a biased sample, based on the results of the Little's MCAR test. In order to consider potential reasons for loss-to-follow-up, the current study used the TBIMS code for administratively withdrawn due to valid contact information with no responses to contact (i.e., passive refusal) and valid contact information with the participant not physically or cognitively available. The number of participants that may have been lost-to-follow-up for these reasons was 330, 359, 201, and 86 at each respective time point. It is of course unknown how many of these individuals were currently incarcerated at the time of data collection, but these numbers likely represent an upper limit. Finally, pre-injury mental health service utilization was not used in the study's main analyses given that 90% of these data were missing because the variable did not exist for the majority of the data collection period included in this study.

Primary Analyses

Main Study Analysis: Identifying Curvature Models

Several sets of HLMs were performed with arrests within the prior year at each follow-up period as the outcome, and this variable was dichotomized into yes and no. HLM was used to examine trajectories of arrest probability across one, two, five, and ten years as opposed to separate predictions of arrest probability at each independent follow up period. The current study conducted a conditional (null) model to assess data clustering of arrest probability variance, which indicated HLM was appropriate. The unconditional model yielded a statistically significant estimated participant variance of .011 (Wald $Z = 26.45$, $p < .001$), as well as a statically significant estimated residual variance of .044 (Wald $Z = 100.54$, $p < .001$). The intraclass correlation coefficient was calculated to be .20, indicating that approximately 20% of the total variance of arrest probability was associated with the participant grouping and that the assumption of independence was violated. This suggested there was appropriate clustering of arrest probability variance within participants to proceed with HLM.

The unconditional growth model determined whether a linear (e.g., straight line), quadratic (e.g., U-shaped), or cubic (e.g., S-shaped) model most accurately reflected arrest probability across pre-injury, one, two, five, and ten years after discharge. In all models, time was coded to reflect actual temporal spacing among data collections such that one year = 0, two years = 1, five years = 4, and ten years = 9. Unconditional growth (linear), quadratic (U – shaped), and cubic (e.g., S-shaped) models were examined without predictors. Results indicated that a quadratic (e.g., U-shaped) trajectory of arrest probability was the best fit (Table 4) given that the critical χ^2 value exceeded 3.84.

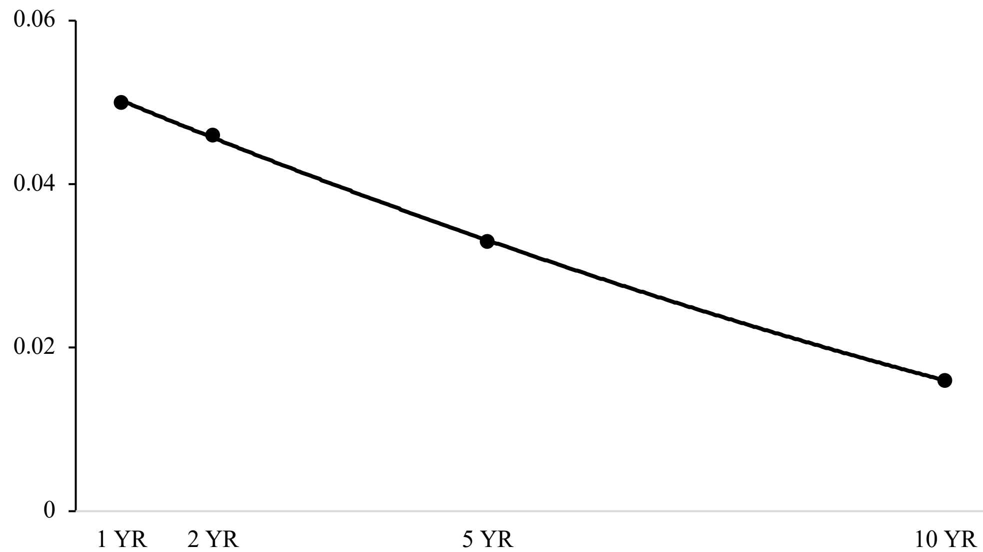
Table 4. *Trend analysis comparison*

Model	DF	-2 Log Likelihood	Change
Linear	5	-3623.78	-
Quadratic	6	-3629.25	5.47
Cubic	7	-3629.79	.54

Note. Critical χ^2 value for significant difference is ≥ 3.84 for $DF = 1$ and ≥ 5.99 for $DF=2$ at $\alpha = .05$ from the previous model.

This pattern displayed a gradual decrease across one, two, five, and ten years with a very slight leveling off of the curve, contributing to the quadratic movement (Figure 2).

Figure 2. *Proportion of arrests post-injury across time.*



Main Study Analysis: Racial/Ethnic Differences

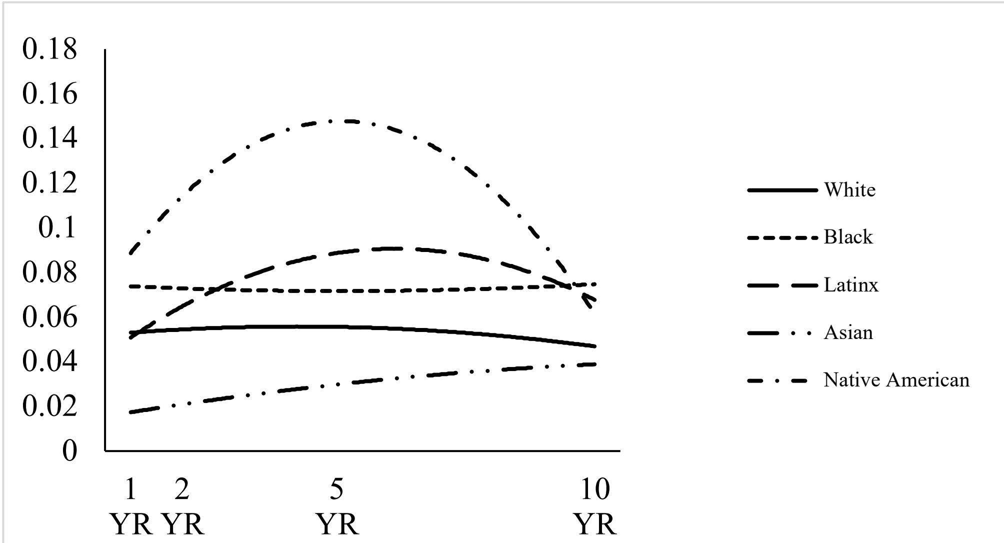
A second set of HLM analyses (ten total) examined whether significant differences in arrest probability over time were present between racial/ethnic groups. This was accomplished by creating orthogonal dummy codes (e.g., 0 vs. 1) for White, Black, Asian, Native American, and Latinx racial/ethnic groups. For each analysis, only members of the two racial/ethnic groups under comparison were included. White arrest probability was compared over time with Black, Asian, Native American, and Latinx arrest probability, and race/ethnicity was entered as a fixed effect; in the subsequent HLMs, Black and Asian, Black and Native American, and Black and Latinx arrest probability were compared; and the following HLMs compared Asian and Native American and Asian and Latinx arrest probability; Native American and Latinx arrest probabilities were compared in the final HLM. Race/ethnicity, quadratic time, and linear time were included in the models as fixed effects. All statistically significant and non-significant racial/ethnic differences analyzed in the ten HLMs, as well as their *b*-weights and *p*-values, appear in Table 5. Additionally, all of the significant racial/ethnic effects observed in these analyses are graphed in Figure 3.

Table 5. *Main effect of race/ethnicity on arrest probability trajectory.*

Comparison	b-weight	p-value	95% CI
White vs.			
Black	-.02	<.001	-.03, -.01
Latinx	-.01	.059	-.02, .00
Asian	.03	<.001	.01, .05
Native American	-.06	.002	-.09, -.02
Black vs.			
Latinx	.01	.117	-.00, .02
Asian	.05	<.001	.03, .07
Native American	-.04	.093	-.08 - .00
Latinx vs.			
Asian	.04	<.001	.02, .06
Native American	-.05	.028	-.09, -.01
Asian vs.			
Native American	-.09	<.001	-.12, -.05

Relative to White individuals with TBI, Black and Native American individuals had elevated arrest probability trajectories over time. Asians with TBI had a lower arrest probability trajectory than White, Black, Latinx, and Native American individuals. Finally, Latinx individuals with TBI had a lower arrest probability trajectory than Native American individuals.

Figure 3. *Racial/ethnic differences in arrest probability trajectories over time.*



Main Study Analysis: Differential Effects Race/Ethnicity Over Time

A third set of HLM analyses was performed to examine whether the main effects of race/ethnicity on arrest probability trajectories found in the previous analyses also were accompanied by differential movement over time. For this set of analyses, quadratic time * race/ethnicity interaction term was added, as well as the lower order interaction term (e.g., linear time * race/ethnicity). The results of these analyses appear in Table 6.

Table 6. *Examining differential change in arrest probability trajectories over time as a function of race/ethnicity.*

Interaction with Quadratic Time	*b*-weight	*p*-value	95% CI
White vs. Black * Time * Time	-.0003	.416	-.001, .0004
White vs. Asian * Time * Time	-.0002	.861	-.002, .002
White vs. Native American * Time * Time	.002	.252	-.002, .006
Black vs. Asian * Time * Time	.0002	.890	-.002, .002
Latinx vs. Asian * Time * Time	-.001	.330	-.003, .001
Latinx vs. Native American * Time * Time	.001	.537	-.003, .006
Asian vs. Native American * Time * Time	.002	.196	-.001, .006

This series of analyses found that for the previously significant main effect variables, there was no differential change in arrest probability trajectories over time as a function race/ethnicity.

Main Study Analysis: Accounting for Racial/Ethnic Differences

The next set of HLM analyses was performed for all statistically significant racial/ethnic trajectory comparisons originally found and introduced demographic and injury-related characteristics as possible covariates to examine whether they accounted for these racial/ethnic differences. In this set, linear time, quadratic time, age, sex, pre-injury arrest history, employment status, pre-injury substance use, education, injury severity, post-TBI functional independence, and violence as a cause of injury were added as covariates. All statistically significant and non-significant racial/ethnic differences in arrest outcomes over time after including demographic and injury-related characteristics as covariates appear in Table 7.

Table 7. *Main effect of race/ethnicity on arrest probability trajectory controlling for covariates.*

Comparison	*b*-weight	*p*-value	95% CI
White vs.			
Black	-.00	.900	-.01, .01
Asian	.02	.034	.00, .04
Native American	-.04	.073	-.08, .00
Black vs.			
Asian	.04	.008	.01, .06
Latinx vs.			
Asian	.02	.055	-.00, .05
Native American	-.05	.062	-.09, .00
Asian vs.			
Native American	-.08	< .001	-.13, -.04

White individuals with TBI had higher arrest probability trajectories than Asian individuals, even after covarying for demographic and injury characteristics. In this model, the significant predictors were age (b = -.00, p < .001), male sex (b = .02, p < .001), education (b = -.01, p < .001), pre-injury problematic substance use (b = .05, p < .001), competitively employed at injury (b = -.03, p < .001), FIM at discharge (b = .00, p < .001), and arrest history (b = .07, p < .001). Black persons with TBI had higher arrest probability trajectories than Asian individuals, even after covarying for sociodemographic factors and injury characteristics. This model found that age (b = -.00, $p < .001$), male sex (b = .03, p = .002), pre-injury substance use (b = .04, p < .001), competitively employed at injury (b = -.03, p = .006), FIM at discharge (b = .00, $p < .001$), and arrest history (b = .04, p = .003) were significant predictors. Asian individuals with TBI were shown to have lower arrest probability trajectories compared to Native American individuals. In this model, age (b = -.00, p = .014) and pre-injury substance use (b = .06, p = .002) were significant predictors. Conversely, the differences in arrest probability trajectories previously found between White and Black, White and Native American, Latinx and Asian, and Latinx and Native American were no longer significant after controlling for covariates.

Main Study Analysis: Differential Effects of Race/Ethnicity over Time

In order to examine whether there were different slopes of arrest probability trajectories as a function of any statistically significant fixed effects from the previous HLM, a follow up set of HLMs was conducted. In this set, the fixed effects were the observed statistically significant covariates in the previous model including race/ethnicity, linear and quadratic time, the interaction terms between linear and quadratic time and each of these variables, quadratic time * race/ethnicity * significant covariate, and the lower order interaction terms (e.g., linear time * age * race/ethnicity). A significant interaction between the quadratic time * race/ethnicity * significant covariate would indicate that the slopes of arrest probability trajectories differenced significantly as a function of the specified covariate. Out of all the possible interactions for the White and Asian, Black and Asian, and Asian and Native American comparisons, no significant interactions were observed which suggests that the slopes of arrest probability trajectories did not vary over time as a function the previously observed significant covariates for each of the group comparisons.

Discussion

The aim of the current study was to assess racial/ethnic disparities in arrest probability trajectories over the course of ten years following hospital discharge among a population of people with TBI. Regarding preliminary analyses, results from the current study documented stark racial/ethnic disparities in TBI cause, functioning at hospital discharge, and sociodemographic and psychosocial features of the TBI population. Namely, racial/ethnic minority persons with TBI tended to be younger and had acquired less education (aside from the Asian group) than White individuals with TBI. Pre-injury arrest history was highest for Native American individuals, followed by Black, Latinx, White, and then Asian individuals. Additionally, racial/ethnic differences were observed regarding injury cause, such that a greater proportion of violent cause of injury occurred for racial/ethnic minority groups. Finally, racial/ethnic disparities were observed regarding TBI patient functional independence at discharge, such that Native American individuals with TBI reported the highest FIM scores, followed by the Asian, White, Latinx, and then Black racial/ethnic groups.

The main set of HLM analyses showed that arrest probability generally decreased over ten years post-discharge with a slight leveling off or plateauing of the curve, suggesting quadratic movement. Regarding racial/ethnic differences in these longitudinal trends, the results showed that Asian persons with TBI had lower overall arrest probability trajectories compared to White, Black, Latinx, and Native American individuals. Additionally, White TBI patients had lower longitudinal arrest probability trajectories than Black and Native American people with TBI, and Latinx individuals had lower arrest probability trajectories than Native Americans. Within models including covariates, younger age, male sex, lower educational achievement, pre-injury substance use issues, non-competitive employment at injury, higher functional independence at discharge, and arrest history were significant predictors in the White vs. Asian model. Similarly, younger age, male sex, pre-injury substance use, non-competitive employment at injury, higher functional independence at discharge, and arrest history were significant predictors in the Black vs. Asian model. In the Asian vs. Native American model, younger age and pre-injury substance use were significant predictors. The differences in arrest probability trajectories found between White and Black, White and Native American, Latinx and Asian, and Latinx and Native American were no longer significant when these models covaried for sociodemographic and injury-related characteristics. Thus, the current study results generally map well onto the theoretical model (Figure 1), which proposed that racial/ethnic group membership would have contributed to disparities in sociodemographic confounds that have been shown to be associated with more violent causes of TBI, and perhaps as a result, lower functional independence at hospital discharge. Furthermore, racial/ethnic group membership, sociodemographic considerations, and TBI injury characteristics were expected to contribute collectively to higher longitudinal arrest probability for Black, Latinx, and Native American individuals with TBI, in addition to pre-existing legal system and systemic racism factors (unexamined in this study).

Racial/Ethnic Injury-Related and Demographic Differences

Regarding general arrest probability disparities among different racial/ethnic groups, the current study findings that showed Native American people with TBI had the highest pre-injury arrest prevalence rates, followed by Black and Latinx individuals. Of note, the Native American subsample had the smallest sample size, had the least percentage of missing data, and only had one person who reported a prior arrest at the ten-year follow-up period. Thus, the Native American trajectories should be tempered within the context of these features. This prevalence rates finding is in line with previous work that has modeled a similar lifetime arrest prevalence rates among these groups (Barnes et al., 2015). Regarding general demographic features of the sample, the current study findings that showed racial/ethnic differences in age, gender, and education supports previous literature, which documented that racial/ethnic minority TBI populations were typically younger, were more likely to be men, and had lower achieved education (Burnett, et al., 2000; Gary et al., 2009; Vanderploeg et al., 2003). The current study also found that Native American individuals with TBI had higher pre-injury substance use issues compared to White and Asian groups which is in line with the literature that has shown this particular population to be at risk for pre-injury substance use disorders (Zeiler & Zeiler, 2017). Additionally, Bombardier, Rimmele, and Zintel, (2002) found Native American individuals with TBI had the highest prevalence rates of at-risk drinking behaviors prior to injury, although no statistical analyses were conducted to evaluate this observed difference. Outside of brain injury contexts, research has suggested that Native American individuals have a higher prevalence of past year and lifetime substance use disorder, and this diagnosis often goes untreated (Chartier & Caetano, 2010; Greenfield & Verner, 2012; Substance Abuse and Mental Health Services Administration [SAMHSA, 2016]), and the results of this study are consistent with this disparity.

Regarding injury and rehabilitation factors, the current study supports research that has shown racial/ethnic disparities in violent injury cause. Specifically, these findings align with literature that has shown Black, Latinx, and Native American persons with TBI to have a higher likelihood of violent injury cause compared to White and Asian groups (Kreutzer et al., 2003; Arango-Lasprilla et al., 2008a; Arango-Lasprilla et al., 2009; Gary et al., 2009; Arango-Lasprilla et al., 2007a; Langlois et al., 2003; Linton & Kim, 2014). Arango-Lasprilla and colleagues (2007a) found that Latinx individuals with TBI reported higher functional disability compared to White individuals at one-year follow-up. Although the current study did not assess functional independence at each follow-up period, the present study results showed that Latinx individuals reported significantly lower functional independence scores at discharge compared to Asian and Native American individuals with TBI. The high functional independence scores for Native Americans at hospital discharge may be a function of idiosyncratic features of the small (n = 81) Native American subsample. Of note, it is unclear if the nature of these racial/ethnic differences more broadly in functional independence scores would have remained significant at one-year follow-up as found by Arango-Lasprilla and colleagues (2007a). Additionally, Hart and colleagues (2007) found that Black people with TBI reported worse functional outcomes compared to White people, and the current study findings supported this disparity. Although discharge location was not included in the main study analyses, the current study findings found similar discharge locations across racial/ethnic group. Thus, these findings do not support the racial/ethnic disparities in rehabilitation discharge location reported by Chang and colleagues (2008); however, the significance and magnitude of these differences were not assessed in the present study.

Arrest Probability Trajectories

The present study showed that 9.3% of the full sample had history of penal incarceration with conviction of felony history of incarceration. Results regarding the curvature of longitudinal arrest probability over time contributes to the literature such that little research has documented longitudinal arrest probability trends among individuals with TBI. Across the full sample, the current study findings yielded a quadratic (e.g., U-shaped) trajectory of arrest probability over the span of ten years post-discharge. Previous research has shown arrest prevalence rates varied across a ten-year follow-up period among a sample of veterans and service members (Miles et al., 2021). Specifically, Miles and colleagues (2021) showed that the percentage of arrests increased from years one to five years, and then decreased at ten years. As such, the current study findings may reflect that arrest probability is lower for persons with TBI as they progress further out from initial injury, at least in the current mostly civilian sample. Results from this study also build upon previous literature which assessed recidivism rates among a sample of recently released incarcerated persons. Vaughn and colleagues (2014) found that 53% of their sample of individuals who were released from prisons were rearrested between twelve and thirty months following their release, and that racial/ethnic minority status, previous arrest history, and prior history of TBI were contributing factors to this finding. Although the current study did not examine longitudinal predictors of recidivism, the findings showed that arrest probability was higher across the general sample during the first two years following injury. Overall, results from this study reflect novel longitudinal trends of arrest probability across a sample of individuals with newly sustained TBI across a ten-year follow up period; however, these trajectories varied differentially by race/ethnicity.

The current study hypothesized that racial/ethnic disparities would emerge regarding longitudinal arrest outcomes and the results of this study robustly supported this hypothesis. It was expected that Black, Latinx, and Native American individuals with TBI would show higher arrest probability trajectories compared to White and Asian individuals. The current study findings showed main effects of race/ethnicity, such that Asian individuals had significantly lower arrest probability trajectories compared to White, Native American, Latinx, and Black individuals. These findings build upon previous literature which conversely did not reveal significant racial/ethnic differences in arrest outcomes post-injury (Elbogen et al., 2015; Miles et al., 2021). These particular racial/ethnic disparities found in the current study may have been a function of the creation of orthogonal dummy codes in order to directly compare all racial/ethnic groups to one another, rather than comparing racial/ethnic minority groups to the White group only. Additionally, Miles and colleagues (2021) did not find racial/ethnic disparities in arrest outcomes even though they created separate race/ethnic group comparisons for each analysis and compared different racial/ethnic groups to the White group. Thus, the general racial/ethnic disparities observed in this study may have been a function of both differential group comparisons, and novel trajectory modeling given that it used longitudinal analyses whereas Miles and colleagues (2021) conducted cross-sectional analyses at different time points. The present study showed that Asian individuals with TBI showed the lowest arrest probability trajectories, and it is possible that this finding was a function of unique cultural protective factors, as well as methodological flaws in the incarceration literature that has underassessed arrest data among this group. For example, criminal justice policies and policing that disproportionately target Black, Latinx, and lower income communities (Alexander, 2010) may explain lower arrest rates within the Asian population. Additionally, many studies that have assessed incarceration rates have failed to include an Asian-American subsample or categorized this group as "other." From a criminal justice perspective, Asian individuals do not face similar barriers to incarceration and arrest outcomes as the Black, Latinx, and Native American communities, such as harsher sentencing and heavy policing for example (Alexander, 2010; Barnes et al., 2015). From a TBI perspective, the study showed that this group was older, reported less substance use issues, better post-TBI functional independence, and had a lower proportion of severe and violent injuries. Thus, the current study finding that showed lower arrest probability trajectories for this group may be better explained by the social inequalities which generally do not specifically target the Asian community in the U.S, as well as the seemingly least amount of psychosocial risk features that have been shown to contribute to post-TBI arrest outcomes.

The disparities in post-injury arrest outcomes observed in the present study are comparable to previous research that has shown 19% of Asian/Pacific Islander young adults (aged 24-34) reported an arrest history, compared to the 29% observed in the White group, 38 % in the Black group, and 40% in the Native American group (Barnes et al., 2015). However, participants in the present study's age were less likely to fall within the range used in Barnes and colleagues (2015) study. The Statistical Briefing Book tool available by the Office of Juvenile Justice and Delinquency Prevention (2020) showed that approximately 3.2% of adults surveyed were arrested in 2019. This rate was much more pronounced for Black (7%) and Native American (e.g., American Indian; 6.7%) groups. The Asian group had an arrest rate of less than 1%. In the present study, the disparities in arrest rates were similar, although higher compared to these data available from the Office of Juvenile Justice and Delinquency Prevention, and this trend remained consistent over the ten-year follow-up period. This finding may suggest that TBI populations observed a higher likelihood of arrest, compared to non-TBI populations. Nonetheless, the effects of race/ethnicity on arrest probability for people with TBI are the first contribution of their kind to the research literature. Although previous literature has assessed arrest outcomes for individuals with TBI, no research to date has presented these stark racial/ethnic disparities on this particular outcome.

The analyses addressing Hypothesis 2.1 assessed whether injury and sociodemographic characteristics accounted for these disparities, and results showed that a number of the previously found racial/ethnic disparities in arrest probability trajectories did indeed go away when injury-related and demographic confounds were added as covariates. This set of findings builds upon previous literature which has found that men, individuals with pre-injury arrest history, violent cause of TBI, lower education, problematic premorbid substance use, and higher functional independence had a higher likelihood of post-injury arrest outcomes (Miles et al., 2021; Vaughn et al., 2014; Elbogen et al., 2015; Kolakowsky-Hayner & Kreutzer, 2001; Colantonio et al., 2007; Perron & Howard, 2008; Williams et al., 2010b).

The fact that a number of racial/ethnic disparities persisted (e.g., Asian vs. White, Black, and Native American), even after controlling for these confounds, likely reflects unexamined systemic racism and legal system factors that could disproportionately affect Black and Native American, and Latinx individuals, as presented in previous research (Alexander, 2012; Bureau of Justice Statistics, 2003; The Sentencing Project, 2013; Barnes et al., 2015) and as outlined in the current study's theoretical model. Further, all of the other racial/ethnic comparisons in arrest probability trajectories that had previously been significant (with the exception of White vs. Black) just moved into the non-significant *p*-value range with the addition of covariates (e.g., all ps > .05 but < .10). As a result, the racial/ethnic differences were nearly still present. The continued differences in arrest outcomes between Black and Asian people after adding covariates is novel to the literature; however, the observed significant covariates support previous research which has identified these features as key predictors of arrest outcomes for people with TBI, such as younger age, male sex, lower education, previous arrest history, and problematic pre-injury substance use (Elbogen et al., 2015; Colantonio et al., 2007; Kolakowsky-Hayner & Kreutzer, 2001; Perron & Howard, 2008; Williams et al., 2010b). A similar trend was observed in the analysis comparing Asian and Native American individuals with TBI, with younger age and problematic pre-injury substance use as unique predictors of arrest probability trajectories. In the White vs. Asian comparison, younger age, male sex, less education, pre-injury substance use issues, non-competitive employment, functional independence, and pre-injury arrest history were similarly significant predictors. Taken together, the results from the current study partially support Hypothesis 2.1, such that injury and sociodemographic features might account for racial/ethnic disparities in longitudinal arrest probability trajectories. It should be noted that the previous literature has also suggested that pre-injury mental health utilization uniquely contribute to arrest outcomes (Miles et al., 2021; Elbogen et al., 2015; Moore et al., 2014), but this variable was unavailable for the current study and this effect could not be examined. It should also be noted that a positive pre-injury arrest history was indicated by several criteria: a) a criminal arrest, b) conviction for felony, and c) subsequent incarceration. Thus, this variable and the post-injury arrest variable are fundamentally different and the interpretation of the "pre-injury arrests" variable should be conceptualized through this lens. Overall, the current study findings contribute to the budding criminal justice post-TBI literature (Miles et al., 2021; Sander et al., 2017; Elbogen et al., 2015), and this study is the first to identify racial/ethnic disparities in longitudinal arrest probabilities after TBI.

Clinical and Public Health Implications

The current study findings have several implications for TBI rehabilitation and future directions for public health opportunities. Clinical practice guidelines for TBI treatment typically focus on functional improvement, the minimization of expected complications that may lead to morbidity, and the improvement of overall quality of life (McMilla et al., 2013; Wheeler & Acord-Vira, 2016; Department of Labor and Employment, 2013; VA/DoD, 2016). Research has suggested that clinical practice guidelines have been inconsistent previously as a result of a variety in stakeholder involvement and research development (Lee et al., 2019). However, a review of the clinical practice guidelines literature conducted by Bayley and colleagues (2018) provided 35 new recommendations for rehabilitation program structure, as well as over 100 new recommendations for assessment and rehabilitation of brain injury. Notably, the full recommendations are available at www.braininjuryguidelines.org. These researchers presented that the rehabilitation treatment plan should be goal oriented. Given the current study findings, it is suggested that TBI rehabilitation clinics integrate potential disparities in post-TBI arrest outcomes into treatment goals, with an aim to identify demographic and injury-related factors associated with increased arrest probability. The integrated structure of treatment may have overarching effects on attaining appropriate rehabilitation goals. Regarding community rehabilitation, Bayley and colleagues (2018) added that clinical practice guidelines should incorporate a peer-support intervention model, which intends to address psychosocial adjustment and community reintegration.

Given that the current study findings showed that generally Native American individuals had the highest overall arrest probability trajectories, followed by Black, Latinx, White, and then Asian individuals, it is suggested that the rehabilitation teams consider aligning patients from these more at-risk backgrounds—particularly those who also in various combinations are younger, men, lower educated, unemployed at injury, who had pre-injury substance use or arrest backgrounds, and with higher functional independence at discharge—with community-based services that emphasize occupational readiness training, which could buffer partially the observed disparities in arrest outcomes. Additionally, rehabilitation specialists could incorporate occupational readiness programming in treatment, which could introduce employment trials in order to provide a more seamless discharge plan. Research has reported that pre-injury victimization can contribute to arrest outcomes (Vaughn et al., 2014), and it is suggested that rehabilitation protocols include the assessment of pre-injury trauma and similar symptomology that could contribute to poorer long-term post-discharge outcomes, especially among the groups that were shown to have higher longitudinal arrest probability trajectories in the current study (i.e., Native American, Black, and Latinx).

Given the observed disparities in pre-injury features and injury characteristics among Native American, Black, and Latinx groups, the current study findings suggest that rehabilitation teams evaluate pre-injury vulnerability for potential treatment complications based on factors such as younger age, male sex, pre-injury substance use, arrest history, and lower education level. Previous research has supported that individuals with higher functional independence were at risk for post-injury arrest outcomes (Miles et al., 2021; Elbogen et al., 2015). Thus, individuals from Black, Latinx, or Native American backgrounds with severe TBI, as well as adequate functional independence may be more at risk for arrest outcomes, in addition to factors of the legal system and systemic racism. The evaluation of these injury and functional characteristics could avail the possibility for additional psychosocial supports during the acute-rehabilitation stage, as well as provide future directions for post-discharge planning. Thus, clinicians should follow clinical practice guidelines presented by Bayley and colleagues (2018) that prompt evaluators to identify and discuss potential barriers to positive rehabilitation, especially among these specific racial/ethnic minority groups. For example, the results from the Miles and colleagues (2021) study showed lower post-TBI arrest rates among veterans and service members with TBI compared to civilian populations, and these researchers hypothesized that the lower rates may be in part due to the diverse post-rehabilitation opportunities available to veterans and service members. As such, the current study findings suggest that clinicians and interventionists aim to connect civilians who sustain TBI with community and post-rehabilitation resources that are akin to those available for veterans and service members. Furthermore, rehabilitation specialists should assess the nature of the post-discharge resources available for veterans and service members of color, who are likely to experience similar systemic barriers that contribute to arrest outcomes.

The current study findings showed that arrest probability is highest during the first two years following rehabilitation discharge, generally, and interdisciplinary rehabilitation teams could alleviate this specific risk by introducing telehealth services that could assess post-discharge barriers and complications throughout these respective time points. For the Native American, Black, and Latinx groups, arrest probability trajectories remained elevated compared to White and Asian groups, and this finding should prompt clinicians to provide additional, culturally sensitive post-rehabilitation discharge support for these groups past the five-year mark. Although the current study did not assess the unexamined systemic racism and criminal justice disparities that disproportionately target Black, Latinx, and Native American populations, the present study findings suggest that rehabilitation professionals should collaborate with community representatives who could provide education about criminal justice rights for these particular populations, given that TBI features are an additional contributing factor to arrest outcomes.

Limitations and Future Directions

The current study findings should be interpreted within the context of several limitations, and thus opportunities for future research. First, the current study found that Native American individuals had the highest longitudinal trajectories of arrest probabilities compared to all other racial/ethnic groups. The relatively small subsample of Native Americans may have warped the curves shown in the arrest probability figure, as only one Native American person with TBI had been arrested over the past year at the 10-year follow-up data collection. Future research should aim to recruit a more sizeable sample of Native Americans with TBI in order to examine whether this is a true post-TBI arrest trajectory for this population. Next, the current study found that the statistical models accounted for approximately 20% of the within-subject variance of arrest probability over time. Although this percentage was adequate and appropriate for HLM, this account of arrest probability variance showed that less recidivism (i.e., repeated and consistent arrests over time) within each participant which is desirable overall. As such, future research should examine which community, systemic, and personal factors may alleviate recidivism among persons with TBI who reported an arrest history. Previous research has shown that the TBIMS national database is not a representative of broader TBI patient populations (Corrigan et al., 2012). Thus, another limitation of the current study is that the retained sample was shown to be younger, male, have higher reported functional independence, sustain more severe TBI and non-violent injury cause, reported pre-injury competitive employment, problematic pre-injury substance use, and have no preinjury arrests. These findings reflect limited generalizability of the TBIMS database that Corrigan and colleagues (2012) identified, and future research should assess predictors of longitudinal arrests probability among a broader sample of TBI patient populations. Although state-of-the-art full information maximum likelihood estimation was used within HLM to address missingness, the current study findings should be interpreted within the context that a moderate degree of missingness for arrest probability data was found. This finding suggests that data were not completely missing at random. Additionally, the current study used cross-sectional data at baseline as predictors; so, it is suggested that future research utilize cross lagged panel design or structural equation modeling to identify theoretical causality of racial/ethnic disparities of arrest probability, while incorporating unexamined legal system and systemic racism factors.

Previous research has shown that mental health treatment history significantly predicted arrest outcomes among veterans (Miles et al., 2021) and civilian populations (Schofield, 2006; Moore et al., 2014), but this variable was not available for the current study in sufficient numbers to include. As such, future TBIMS research should incorporate an available assessment of mental health history, and other psychosocial variables that could contribute to rehabilitation and community integration in order to evaluate their role in racial/ethnic disparities in arrest probability outcomes. Although each TBIMS site is nested in a metropolitan area and is able to recruit diverse samples, future research could evaluate whether TBIMS site as a nested variable given that there may be geographic, cultural, and local/state legislature differences that might contribute to criminal arrest outcomes.

A limitation of the current study findings is that violent injury cause in addition to race/ethnicity may have been a repetitive predictor of arrest probability, given the reported notable disparities that have shown racial/ethnic minority groups to be more likely to sustain violent causes of TBI. In order to address this potential recursive predictor, the current study covaried for race/ethnicity and violent cause of injury in each of the models and did not find violent injury cause to significantly contribute to arrest probability trajectories. However, future TBI literature would benefit from taking a stepwise approach to assessing whether violent TBI uniquely and independently associates with arrest probability outcomes. An additional limitation and opportunity for future research is that the current study did not evaluate whether functional changes to the brain were significant predictors of racial/ethnic disparities in arrest probability trajectories. Previous research suggests that frontal and parietal lobe damage contributed to higher recidivism rates among individuals with TBI (Fabian, 2010; Raine, 2002). Thus, future research should incorporate functional measures of neuroanatomical changes, as well as evaluate disparities in these features. Finally, future research should assess the types of daily activities and integration practices that groups who reported lower arrest probability trajectories engage, as well as explore race-based factors that could contribute to positive rehabilitation among racial/ethnic minority persons with TBI, for whom possessed lower arrest probability outcomes.

Conclusion

The current study examined racial/ethnic disparities in longitudinal trajectories of arrest probability and potential factors that could account for these observed disparities among individuals with TBI. Results suggested that racial/ethnic disparities in longitudinal trajectories of arrest probability exist. Specifically, Asian individuals were shown to have the lowest arrest probability trajectories, whereas Native American and Black individuals were shown to have the highest arrest probability trajectories. Although arrest probability decreased over time, current study findings suggest racial/ethnic disparities in injury features and sociodemographic factors contribute to racial/ethnic disparities in arrest probability outcomes between Asian people with TBI and Black and White individuals. Racial/ethnic disparities remained in some cases, even after covarying for injury and sociodemographic features, and these findings suggest that broader unexamined systemic racism factors may better account for arrest probability outcomes among these respective groups. Furthermore, this study supports future exploration of the “acute-rehab to prison pipeline,” especially among Black and Latinx individuals with TBI, and growing evidence for the Native American population. Although the present study showed a rather small proportion of the sample were arrested post-TBI, these data underscore racial/ethnic disparities in arrest outcomes among TBI populations. Given these findings, it is recommended that rehabilitation facilities utilize culturally informed support for these racial/ethnic groups with TBI and incorporate community integration-based practices for post-discharge efforts to alleviate racial/ethnic disparities in arrest probability outcomes for people with TBI.

References

Alexander, M. (2012). *The new Jim Crow: Mass incarceration in the age of colorblindness*. The New Press.

American College of Surgeons. (2004). *ATLS. Advanced trauma life support program for doctors*. Chicago: American College of Surgeons

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (DSM-5®)*. American Psychiatric Publishing.

Andelic, N., Sigurdardottir, S., Schanke, A.-K., Sandvik, L., Sveen, U., & Roe, C. (2010). Disability, physical health and mental health 1 year after traumatic brain injury. *Disability and Rehabilitation*, *32*(13), 1122–1131. https://doi.org/10.3109/09638280903410722

Arango-Lasprilla, J. C. & Kreutzer, J. S. (2010). Racial and ethnic disparities in functional, psychosocial, and neurobehavioral outcomes after brain injury. *Journal of Head Trauma Rehabilitation*, *25*(2), 128–136. https://doi.org/10.1097/htr.0b013e3181d36ca3

Arango-Lasprilla, J. C., Ketchum, J. M., Dezfulian, T., Kreutzer, J. S., O'neil-Pirozzi, T. M., Hammond, F., & Jha, A. (2008a). Predictors of marital stability 2 years following traumatic brain injury. *Brain Injury, 22*(7-8), 565–574. https://doi.org/10.1080/02699050802172004

Arango-Lasprilla, J. C., Ketchum, J. M., Gary, K. W., Kreutzer, J. S., O'Neil-Pirozzi, T. M., Wehman, P., de la Plata, C. M., & Jha, A. (2008b). The Influence of minority status on job stability after traumatic brain injury. *PM&R*, *1*(1), 41–49. https://doi.org/10.1016/j.pmrj.2008.07.001

Arango-Lasprilla, J. C., Ketchum, J. M., Gary, K., Hart, T., Corrigan, J., Forster, L., & Mascialino, G. (2009). Race/ethnicity differences in satisfaction with life among persons with traumatic brain injury. *NeuroRehabilitation*, *24*(1), 5–14. https://doi.org/10.3233/nre-2009-0449

Arango-Lasprilla, J. C., Ketchum, J. M., Williams, K., Kreutzer, J. S., Marquez de la Plata, C. D., O'Neil-Pirozzi, T. M., & Wehman, P. (2008c). Racial differences in employment outcomes after traumatic brain injury. *Archives of Physical Medicine and Rehabilitation*, *89*(5), 988–995. https://doi.org/10.1016/j.apmr.2008.02.012

Arango-Lasprilla, J. C., Rosenthal, M., DeLuca, J., Cifu, D. X., Hanks, R., & Komaroff, E. (2007a). Functional outcomes from inpatient rehabilitation after traumatic brain injury: How do Hispanics fare? *Archives of Physical Medicine and Rehabilitation*, *88*(1), 11–18. https://doi.org/10.1016/j.apmr.2006.10.029

Arango-Lasprilla, J. C., Rosenthal, M., Deluca, J., Komaroff, E., Sherer, M., Cifu, D., & Hanks, R. (2007b). Traumatic brain injury and functional outcomes: Does minority status matter? *Brain Injury*, *21*(7), 701–708. https://doi.org/10.1080/02699050701481597

Arbabi, S., Jurkovich, G. J., Wahl, W. L., Franklin, G. A., Hemmila, M. R., Taheri, P. A., & Maier, R. V. (2004). A Comparison of Prehospital and Hospital Data in Trauma Patients. *The Journal of Trauma: Injury, Infection, and Critical Care*, *56*(5), 1029–1032. https://doi.org/10.1097/01.ta.0000123036.20919.4b

Arciniegas, D. B., & Wortzel, H. S. (2014). Emotional and behavioral dyscontrol after traumatic brain injury. *Psychiatric Clinics*, *37*(1), 31-53. https://doi.org/10.1016/j.psc.2013.12.001

Arciniegas, D. B., Held, K., & Wagner, P. (2002). Cognitive impairment following traumatic brain injury. Current Treatment Options in Neurology, 4(1), 43–57. https://doi.org/10.1007/s11940-002-0004-6

Baguley, I. J., Cooper, J., & Felmingham, K. (2006). Aggressive behavior following traumatic brain injury. *Journal of Head Trauma Rehabilitation*, *21*(1), 45–56. https://doi.org/10.1097/00001199-200601000-00005

Barker-Collo, S., Jones, K., Theadom, A., Starkey, N., Dowell, A., McPherson, K., Ameratunga, S., Dudley, M., Te Ao, & Feigin, V. (2015). Neuropsychological outcome and its correlates in the first year after adult mild traumatic brain injury: A population-based New Zealand study. *Brain Injury*, *29*(13-14), 1604–1616. https://doi.org/10.3109/02699052.2015.1075143

Barnes, J. C., Jorgensen, C., Beaver, K. M., Boutwell, B. B., & Wright, J. P. (2014). Arrest prevalence in a national sample of adults: The role of sex and race/ethnicity. *American Journal of Criminal Justice*, *40*(3), 457–465. https://doi.org/10.1007/s12103-014-9273-3

Bayley, M. T., Lamontagne, M. E., Kua, A., Marshall, S., Marier-Deschênes, P., Allaire, A. S., Kagan C., Truchon, C., Janzen, S., Teasell, R., & Swaine, B. (2018). Unique features of the INESSS-ONF rehabilitation guidelines for moderate to severe traumatic brain injury: responding to users' needs. *The Journal of head trauma rehabilitation, 33*(5), 296-305. https://doi.org/10.1097/htr.0000000000000428

Bazarian, J. J., McClung, J., Cheng, Y. T., Flesher, W., & Schneider, S. M. (2005). Emergency department management of mild traumatic brain injury in the USA. *Emergency Medicine Journal*, *22*(7), 473–477. https://doi.org/10.1136/emj.2004.019273

Belanger, H. G., Curtiss, G., Demery, J. A., Lebowitz, B. K., & Vanderploeg, R. D. (2005). Factors moderating neuropsychological outcomes following mild traumatic brain injury: A meta-analysis. *Journal of the International Neuropsychological Society*, *11*(3), 215–227. https://doi.org/10.1017/s1355617705050277

Bier, N., Dutil, E., & Couture, M. (2009). Factors affecting leisure participation after a traumatic brain injury. *Journal of Head Trauma Rehabilitation*, *24*(3), 187–194. https://doi.org/10.1097/htr.0b013e3181a0b15a

Blostein, P. A., Jones, S. J., Buechler, C. M., & Vandongen, S. (1997). Cognitive screening in mild traumatic brain injuries: Analysis of the neurobehavioral cognitive status examination when utilized during initial trauma hospitalization. *Journal of Neurotrauma*, *14*(3), 171–177. https://doi.org/10.1089/neu.1997.14.171

Bode, R.K., Heinemann, A.W. & Semik, P., 2000. Measurement properties of the Galveston Orientation and Amnesia Test (GOAT) and improvement patterns during inpatient rehabilitation. *Journal of Head Trauma Rehabilitation*, *15*(1), pp.637–655. http://dx.doi.org/10.1097/00001199-200002000-00004.

Boes, A. D., Tranel, D., Anderson, S. W., & Nopoulos, P. (2008). Right anterior cingulate: A neuroanatomical correlate of aggression and defiance in boys. *Behavioral Neuroscience, 122*(3), 677–684. https://doi.org/10.1037/0735-7044.122.3.677

Bogner, J. A., Corrigan, J. D., Fugate, L., Mysiw, W. J., & Clinchot, D. (2001). Role of agitation in prediction of outcomes after traumatic brain injury. *American Journal of Physical Medicine and Rehabilitation*, *80*(9), 636–644. https://doi.org/10.1097/00002060-200109000-00002

Bombardier, C. H., Fann, J. R., Temkin, N. R., Esselman, P. C., Barber, J., & Dikmen, S. S. (2010). Rates of major depressive disorder and clinical outcomes following traumatic brain injury. *Jama*, *303*(19), 1938-1945. https://doi.org/10.1001/jama.2010.599

Bombardier, C. H., Rimmele, C. T., & Zintel, H. (2002). The magnitude and correlates of alcohol and drug use before traumatic brain injury. *Archives of Physical Medicine and Rehabilitation, 83*(12), 1765–1773. https://doi.org/10.1053/apmr.2002.36085

Bottari, C., Swaine, B., & Dutil, É. (2007). Interpreting activity of daily living errors for treatment and discharge planning. *Journal of Head Trauma Rehabilitation*, *22*(1), 26–30. https://doi.org/10.1097/00001199-200701000-00003

Bowman, S. M., Martin, D. P., Sharar, S. R., & Zimmerman, F. J. (2007). racial disparities in outcomes of persons with moderate to severe traumatic brain injury. *Medical Care*, *45*(7), 686–690. https://doi.org/10.1097/mlr.0b013e31803dcdf3

Bryant, R. A., Marosszeky, J. E., Crooks, J., Baguley, I. J., & Gurka, J. A. (2001). Posttraumatic stress disorder and psychosocial functioning after severe traumatic brain injury. The *Journal of Nervous and Mental Disease*, *189*(2), 109–113. https://doi.org/10.1097/00005053-200102000-00006

Bureau of Justice Statistics (2003) Criminal Offenders Statistics. http://www.Ojp.Usdoj.Gov/Bjs/Crimoff.Htm.

Burnett, D. M., Kolakowsky-Hayner, S. A., White, J. M., & Cifu, D. X. (2002). Impact of minority status following traumatic spinal cord injury. *NeuroRehabilitation*, *17*(3), 187–194. https://doi.org/10.3233/nre-2002-17303

Cardoso, E. da S., Romero, M. G., Chan, F., Dutta, A., & Rahimi, M. (2007). Disparities in vocational rehabilitation services and outcomes for Hispanic clients with traumatic brain injury. *Journal of Head Trauma Rehabilitation*, *22*(2), 85–94. https://doi.org/10.1097/01.htr.0000265096.44683.6b

Cassidy, J. W. (1994). Neuropharmacological management of destructive behavior after traumatic brain injury. *Journal of Head Trauma Rehabilitation*, *9*(3), 43–60. https://doi.org/10.1097/00001199-199409000-00005

Cervós-Navarro, J., & Lafuente, J. V. (1991). Traumatic brain injuries: Structural changes. *Journal of the Neurological Sciences*, *103*, 3–14. https://doi.org/10.1016/0022-510x(91)90002-o

Chang, P.-F. J., Ostir, G. V., Kuo, Y.-F., Granger, C. V., & Ottenbacher, K. J. (2008). Ethnic differences in discharge destination among older patients with traumatic brain injury. *Archives of Physical Medicine and Rehabilitation*, *89*(2), 231–236. https://doi.org/10.1016/j.apmr.2007.08.143

Chartier, K., & Caetano, R. (2010). Ethnicity and health disparities in alcohol research. *Alcohol Research & Health*, *33*(1-2), 152.

Chesnut, R. M., Marshall, L. F., Klauber, M. R., Blunt, B. A., Baldwin, N., Eisenberg, H. M., Jane, J. A., Marmarou, A., & Foulkes, M. A. (1993). The role of secondary brain injury in determining outcome from severe head injury. *The Journal of Trauma: Injury, Infection, and Critical Care*, *34*(2), 216–222. https://doi.org/10.1097/00005373-199302000-00006

Christensen, B. K., Colella, B., Inness, E., Hebert, D., Monette, G., Bayley, M., & Green, R. E. (2008). Recovery of cognitive function after traumatic brain injury: A multilevel modeling analysis of Canadian outcomes. *Archives of Physical Medicine and Rehabilitation*, *89*(12), S3–S15. https://doi.org/10.1016/j.apmr.2008.10.002

Colantonio, A., Stamenova, V., Abramowitz, C., Clarke, D., & Christensen, B. (2007). Brain injury in a forensic psychiatry population. *Brain Injury*, *21*(13-14), 1353–1360. https://doi.org/10.1080/02699050701785054

Comerford, V. E., Geffen, G. M., May, C., Medland, S. E., & Geffen, L. B. (2002). A rapid screen of the severity of mild traumatic brain injury. *Journal of Clinical and Experimental Neuropsychology*, *24*(4), 409–419. https://doi.org/10.1076/jcen.24.4.409.1044

Corrigan, J. D., & Mysiw, W. J. (1988). Agitation following traumatic head injury: Equivocal evidence for a discrete stage of cognitive recovery. *Archives of Physical Medicine and Rehabilitation*, *69*(7), 487-492.

Corrigan, J. D., Cuthbert, J. P., Whiteneck, G. G., Dijkers, M. P., Coronado, V., Heinemann, A. W., Harrison – Felix, C., Graham, J. E. (2012). Representativeness of the traumatic brain injury model systems national database. *Journal of Head Trauma Rehabilitation, 27*(6), 391–403. https://doi.org/10.1097/htr.0b013e3182238cdd

Dahm, J., & Ponsford, J. (2015). Comparison of long-term outcomes following traumatic injury: What is the unique experience for those with brain injury compared with orthopaedic injury? *Injury*, *46*(1), 142–149. https://doi.org/10.1016/j.injury.2014.07.012

Davies, R. C., Williams, W. H., Hinder, D., Burgess, C. N. W., & Mounce, L. T. A. (2012). Self-reported traumatic brain injury and postconcussion symptoms in incarcerated youth. *Journal of Head Trauma Rehabilitation*, *27*(3), E21–E27. https://doi.org/10.1097/htr.0b013e31825360da

De la Plata, C. M., Hewlitt, M., de Oliveira, A., Hudak, A., Harper, C., Shafi, S., & Diaz-Arrastia, R. (2007). Ethnic differences in rehabilitation placement and outcome after tbi.

Journal of Head Trauma Rehabilitation, *22*(2), 113–121. https://doi.org/10.1097/01.htr.0000265099.29436.56

DeLisa, J. A., Gans, B. M., & Walsh, N. E. (Eds.). (2005). *Physical medicine and rehabilitation: principles and practice* (Vol. 1). Lippincott Williams & Wilkins.

Department of Labor and Employment. Traumatic brain injury medical treatment guidelines. State of Colorado: Department of Labor and Employment, Division of Workers' Compensation; 2013.

DeWitt, D. S., Jenkins, L. W., & Prough, D. S. (1995). Enhanced vulnerability to secondary ischemic insults after experimental traumatic brain injury. *New Horizons*, *3*(3), 376-383.

Dikmen, S., McLean, A., Temkin, N. R., & Wyler, A. R. (1986). Neuropsychologic outcome at one-month postinjury. *Archives of physical medicine and rehabilitation*, *67*(8), 507-513.

Dodds, T. A., Martin, D. P., Stolov, W. C., & Deyo, R. A. (1993). A validation of the Functional Independence Measurement and its performance among rehabilitation inpatients. *Archives of Physical Medicine and Rehabilitation*, *74*(5), 531–536. https://doi.org/10.1016/0003-9993(93)90119-u

Donders, J., & Nesbit-Greene, K. (2004). Predictors of neuropsychological test performance after pediatric traumatic brain injury. *Assessment*, *11*(4), 275–284. https://doi.org/10.1177/1073191104268914

Draper, K., & Ponsford, J. (2008). Cognitive functioning ten years following traumatic brain injury and rehabilitation. *Neuropsychology*, *22*(5), 618–625. https://doi.org/10.1037/0894-4105.22.5.618

Ducharme, S., Hudziak, J. J., Botteron, K. N., Ganjavi, H., Lepage, C., Collins, D. L., … Karama, S. (2011). Right anterior cingulate cortical thickness and bilateral striatal volume correlate with child behavior checklist aggressive behavior scores in healthy children. *Biological Psychiatry, 70*(3), 283–290. https://doi.org/10.1016/j.biopsych.2011.03.015

Elbogen, E. B., Wolfe, J. R., Cueva, M., Sullivan, C., & Johnson, J. (2015). Longitudinal predictors of criminal arrest after traumatic brain injury: results from the Traumatic Brain Injury Model System National Database. *Journal of head trauma rehabilitation*, *30*(5), E3-E13.

Esselman, P. C., Ptacek, J. T., Kowalske, K., Cromes, G. F., deLateur, B. J., & Engrav, L. H. (2001). Community integration after burn injuries. J*ournal of Burn Care & Rehabilitation*, *22*(3), 221–227. https://doi.org/10.1097/00004630-200105000-00007

Fabian, J. M. (2010). Neuropsychological and neurological correlates in violent and homicidal offenders: A legal and neuroscience perspective. *Aggression and Violent Behavior*, *15*(3), 209–223. https://doi.org/10.1016/j.avb.2009.12.004

Fann, J. R., Hart, T., & Schomer, K. G. (2009). Treatment for depression after traumatic brain injury: A systematic review. *Journal of Neurotrauma*, *26*(12), 2383–2402. https://doi.org/10.1089/neu.2009.1091

Farrer, T. J., & Hedges, D. W. (2011). Prevalence of traumatic brain injury in incarcerated groups compared to the general population: A meta-analysis. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *35*(2), 390–394. https://doi.org/10.1016/j.pnpbp.2011.01.007

Fazel, S., Lichtenstein, P., Grann, M., & Långström, N. (2011). Risk of violent crime in individuals with epilepsy and traumatic brain injury: A 35-Year Swedish population study. *PLoS Medicine*, *8*(12), e1001150. https://doi.org/10.1371/journal.pmed.1001150

Fearnside, M. R., Cook, R. J., McDougall, P., & McNeil, R. J. (1993). The Westmead Head Injury Project outcome in severe head injury. A comparative analysis of pre-hospital, clinical and CT variables. *British Journal of Neurosurgery*, *7*(3), 267–279. https://doi.org/10.3109/02688699309023809

Fernando, A. B. P., Murray, J. E., & Milton, A. L. (2013). The amygdala: Securing pleasure and avoiding pain. *Frontiers in Behavioral Neuroscience, 7*. https://doi.org/10.3389/fnbeh.2013.00190

Franklin, T. W. (2011). Sentencing Native Americans in US federal courts: An Examination of disparity. *Justice Quarterly*, *30*(2), 310–339. https://doi.org/10.1080/07418825.2011.605072

Frost, R. B., Farrer, T. J., Primosch, M., & Hedges, D. W. (2013). Prevalence of traumatic brain injury in the general adult population: A Meta-Analysis. *Neuroepidemiology*, *40*(3), 154–159. https://doi.org/10.1159/000343275

Gary, K. W., Arango-Lasprilla, J. C., & Stevens, L. F. (2009). Do racial/ethnic differences exist in post-injury outcomes after TBI? A comprehensive review of the literature. *Brain Injury*, *23*(10), 775–789. https://doi.org/10.1080/02699050903200563

Ghajar, J. (2000). Traumatic brain injury. *The Lancet*, *356*(9233), 923–929. https://doi.org/10.1016/s0140-6736(00)02689-1

Global Burden of Disease Study 2016 Traumatic Brain Injury and Spinal Cord Injury Collaborators. (2019). Global, regional, and national burden of traumatic brain injury and spinal cord injury, 1990–2016: A Systematic analysis for the Global Burden of Disease Study 2016. *The Lancet Neurology*, *18*(1), 56-87. https://doi.org/10.1016/S1474-4422(18)30415-0

Goetz, C. G., & Pappert, E. J. (1999). *Textbook of clinical neurology*. https://doi.org/10.1016/b978-1-4160-3618-0.x1000-4

Gordon, W. A., Zafonte, R., Cicerone, K., Cantor, J., Brown, M., Lombard, L., Goldsmith, R., & Chandna, T. (2006). Traumatic brain injury rehabilitation. *American Journal of Physical Medicine & Rehabilitation*, *85*(4), 343–382. https://doi.org/10.1097/01.phm.0000202106.01654.61

Graham, D. I., Ford, I., Adams, J. H., Doyle, D., Teasdale, G. M., Lawrence, A. E., & McLellan, D. R. (1989). Ischaemic brain damage is still common in fatal non-missile head injury. *Journal of Neurology, Neurosurgery & Psychiatry*, *52*(3), 346–350. https://doi.org/10.1136/jnnp.52.3.346

Greenfield, B. L., & Venner, K. L. (2012). Review of substance use disorder treatment research in Indian Country: Future directions to strive toward health equity. *American Journal of Drug and Alcohol Abuse, 38*,483–492.http://dx.doi.org/10.3109/00952990.2012.702170

Greenspan, A. I., Stringer, A. Y., Phillips, V. L., Hammond, F. M., & Goldstein, F. C. (2006). Symptoms of post-traumatic stress: Intrusion and avoidance 6 and 12 months after TBI. *Brain Injury*, *20*(7), 733–742. https://doi.org/10.1080/02699050600773276

Greve, K. W., Love, J., Sherwin, E., Stanford, M. S., Mathias, C., & Houston, R. (2002). Cognitive strategy usage in long-term survivors of severe traumatic brain injury with persisting impulsive aggression. *Personality and Individual Differences, 32*(4), 639–647. https://doi.org/10.1016/s0191-8869(01)00066-6

Halbauer, J. D., Ashford, J. W., Zeitzer, J. M., Adamson, M. M., Lew, H. L., & Yesavage, J. A. (2009). Neuropsychiatric diagnosis and management of chronic sequelae of war-related mild to moderate traumatic brain injury. *The Journal of Rehabilitation Research and Development*, *46*(6), 757. https://doi.org10.1682/jrrd.2008.08.0119

Hart, T., O'Neil-Pirozzi, T. M., Williams, K. D., Rapport, L. J., Hammond, F., & Kreutzer, J. (2007). Racial differences in caregiving patterns, caregiver emotional function, and sources of emotional support following traumatic brain injury. *Journal of Head Trauma Rehabilitation*, *22*(2), 122–131. https://doi.org/10.1097/01.htr.0000265100.37059.44

Hart, T., Whyte, J., Polansky, M., Kersey-Matusiak, G., & Fidler-Sheppard, R. (2005). Community outcomes following traumatic brain injury. J*ournal of Head Trauma Rehabilitation*, *20*(2), 158–172. https://doi.org/10.1097/00001199-200503000-00004

Hill-Jarrett, T. G., Gravano, J. T., Sozda, C. N., & Perlstein, W. M. (2015). Visuospatial attention after traumatic brain injury: The role of hemispheric specialization. *Brain Injury*, *29*(13-14), 1617–1629. https://doi.org/10.3109/02699052.2015.1075155

Hoptman, M. J., D'Angelo, D., Catalano, D., Mauro, C. J., Shehzad, Z. E., Kelly, A. M. C., … Milham, M. P. (2009). Amygdalofrontal functional disconnectivity and aggression in schizophrenia. *Schizophrenia Bulletin, 36*(5), 1020–1028. https://doi.org/10.1093/schbul/sbp012

Institute of Medicine [IOM]. (2011). Cognitive rehabilitation therapy for traumatic brain injury: Evaluating the evidence. Washington, DC: National Academies Press. Retrieved from http://www.nap.edu/ openbook.php?record_id=13220&page=R1

Jackson W. T., Novack T. A., & Dowler, R. N. (1998). Effective serial measurement of cognitive orientation in rehabilitation: the Orientation Log. *Archives of Physical Medicine and Rehabilitation*, *79*:718–720.

Johnstone, B., Price, T., Bounds, T., Schopp, L. H., Schootman, M., & Schumate, D. (2003). Rural/urban differences in vocational outcomes for state vocational rehabilitation clients with TBI. *NeuroRehabilitation*, *18*(3), 197–203. https://doi.org/10.3233/nre-2003-18303

Kennepohl, S., Shore, D., Nabors, N., & Hanks, R. (2004). African American acculturation and neuropsychological test performance following traumatic brain injury. *Journal of the International Neuropsychological Society*, *10*(4), 566–577. https://doi.org/10.1017/s1355617704104128

Kolakowsky-Hayner, S. A., & Kreutzer, J. S. (2001). Pre-injury crime, substance abuse, and neurobehavioural functioning after traumatic brain injury. *Brain Injury*, *15*(1), 53–63. http://doi.org/10.1080/02699050150209138

Koponen, S., Taiminen, T., Portin, R., Himanen, L., Isoniemi, H., Heinonen, H., Hinkka, S., & Tenovuo, O. (2002). Axis I and ii psychiatric disorders after traumatic brain injury: A 30-year follow-up study. *American Journal of Psychiatry*, *159*(8), 1315–1321. https://doi.org/10.1176/appi.ajp.159.8.1315

Kou, Z., Gattu, R., Kobeissy, F., Welch, R. D., O'Neil, B. J., Woodard, J. L., Ayaz, S. I., Kulek, A., Kas-Shamoun, R., Mika, V., Zuk, C., Tomasello, F., & Mondello, S. (2013). Combining biochemical and imaging markers to improve diagnosis and characterization of mild traumatic brain injury in the acute setting: Results from a pilot study. *PLoS ONE*, *8*(11), e80296. https://doi.org/10.1371/journal.pone.0080296

Kreutzer, J. S., Marwitz, J. H., Walker, W., Sander, A., Sherer, M., Bogner, J., Fraser, R., & Bushnik, T. (2003). Moderating factors in return to work and job stability after traumatic brain injury. *Journal of Head Trauma Rehabilitation*, *18*(2), 128–138. https://doi.org/10.1097/00001199-200303000-00004

Kubrin, C. E., & Stewart, E. A. (2006). Predicting who reoffends: The neglected role of neighborhood context in recidivism studies*. *Criminology*, *44*(1), 165–197. https://doi.org/10.1111/j.1745-9125.2006.00046.x

Laforce, R., & Martin-MaCleod, L. (2001). Symptom cluster associated with mild traumatic brain injury in university students. *Perceptual and Motor Skills*, *93*(1), 281–288. http://doi.org/10.2466/pms.2001.93.1.281

Laker, S. R. (2011). Epidemiology of concussion and mild traumatic brain injury. *PM&R*, *3*, S354–S358. https://doi.org/10.1016/j.pmrj.2011.07.017

Langlois, J. A., Kegler, S. R., Butler, J. A., Gotsch, K. E., Johnson, R. L., Reichard, A. A., Webb., K. W., Coronado, V. G., Selassie., A., & Thurman, D. J. (2003). Traumatic brain injury-related hospital discharges. *MMWR Surveillance Summary*, *52*(4), 1-20.

Langlois, J. A., Rutland-Brown, W., & Wald, M. M. (2006). The epidemiology and impact of traumatic brain injury. *Journal of Head Trauma Rehabilitation*, *21*(5), 375–378. https://doi.org/10.1097/00001199-200609000-00001

Larkins, B. (2007). The application of the ICF in cognitive-communication disorders following traumatic brain injury. *Seminars in Speech and Language*, *28*(4), 334–342. https://doi.org/10.1055/s-2007-986530

Lee, S. Y., Amatya, B., Judson, R., Truesdale, M., Reinhardt, J. D., Uddin, T., Xiong, X., & Khan, F. (2019). Clinical practice guidelines for rehabilitation in traumatic brain injury: A Critical appraisal. *Brain Injury, 33*(10), 1263–1271. https://doi.org/10.1080/02699052.2019.1641747

Levin, H. S. (1990). Memory deficit after closed-head injury. *Journal of Clinical and Experimental Neuropsychology*, *12*(1), 129–153. https://doi.org/10.1080/01688639008400960

Levin, H. S., O'donnell, V. M., & Grossman, R. G. (1979). The Galveston Orientation and Amnesia Test. *The Journal of Nervous and Mental Disease*, *167*(11), 675–684. https://doi.org/10.1097/00005053-197911000-00004

Lezak, M. D., Howieson, D. B., Loring, D. W., & Fischer, J. S. (2004). Neuropsychological assessment. Oxford University Press, USA. https://doi.org/ 10.1007/s00415-005-0003-0

Linton, K. F., & Kim, B. J. (2014). Traumatic brain injury as a result of violence in Native American and Black communities spanning from childhood to older adulthood. *Brain Injury*, *28*(8), 1076–1081. https://doi.org/10.3109/02699052.2014.901558

Lukow, H. R., Godwin, E. E., Marwitz, J. H., Mills, A., Hsu, N. H., & Kreutzer, J. S. (2015). Relationship between resilience, adjustment, and psychological functioning after traumatic brain injury. *Journal of Head Trauma Rehabilitation*, *30*(4), 241–248. https://doi.org/10.1097/htr.0000000000000137

Luukkainen, S., Riala, K., Laukkanen, M., Hakko, H., & Räsänen, P. (2012). Association of traumatic brain injury with criminality in adolescent psychiatric inpatients from Northern Finland. *Psychiatry Research*, *200*(2-3), 767–772. https://doi.org/10.1016/j.psychres.2012.04.018

Mapou, R. (2013). *Handbook of Head Trauma–Early-Recovery Care to Recovery*. (C. J. Long & L. K. Ross). Springer.

Marmarou, A., Lu, J., Butcher, I., McHugh, G. S., Murray, G. D., Steyerberg, E. W., Mushkudiani, N. A., Choi, S., & Maas, A. I. R. (2007). Prognostic value of the Glasgow

Coma Scale and pupil reactivity in traumatic brain injury assessed pre-hospital and on enrollment: An IMPACT analysis. *Journal of Neurotrauma*, *24*(2), 270–280. https://doi.org/10.1089/neu.2006.0029

Marschark, M., Richtsmeier, L. M., Richardson, J. T. E., Crovitz, H. F., & Henry, J. (2000). Intellectual and emotional functioning in college students following mild traumatic brain injury in childhood and adolescence. *Journal of Head Trauma Rehabilitation*, *15*(6), 1227–1245. https://doi.org/10.1097/00001199-200012000-00004

Marshall, L. F., Gautille, T., Klauber, M. R., Eisenberg, H. M., Jane, J. A., Luerssen, T. G., Marmarou, A., & Foulkes, M. A. (1991). The outcome of severe closed head injury. *Journal of Neurosurgery*, *75*(Supplement), S28–S36. https://doi.org/10.3171/sup.1991.75.1s.0s28

Matheson, F. I., McIsaac, K. E., Fung, K., Stewart, L. A., Wilton, G., Keown, L. A., Nathens, A. B., Colantonio, A., & Moineddin, R. (2020). Association between traumatic brain injury and prison charges: A population-based cohort study. *Brain Injury*, *34*(6), 757–765. https://doi.org/10.1080/02699052.2020.1753114

McCauley, S. R., Wilde, E. A., Barnes, A., Hanten, G., Hunter, J. V., Levin, H. S., & Smith, D. H. (2014). Patterns of early emotional and neuropsychological sequelae after mild traumatic brain injury. *Journal of Neurotrauma*, *31*(10), 914–925. https://doi.org/10.1089/neu.2012.2826

McKenna, K., Cooke, D. M., Fleming, J., Jefferson, A., & Ogden, S. (2006). The incidence of visual perceptual impairment in patients with severe traumatic brain injury. *Brain Injury*, *20*(5), 507–518. https://doi.org/10.1080/02699050600664368

McMilla, A., Baer, G., Beattie, A., Carson, A., Edwards, M., Evans, J., Harrison, A., Hogg, S., Holden, R., & Jack, R. Brain injury rehabilitation in adults: A National clinical guideline [Internet]. Edinburgh: SIGN guidelines, 2013. http://www.sign.ac.uk.

Menon, D. K., Schwab, K., Wright, D. W., & Maas, A. I. (2010). Position statement: Definition of traumatic brain injury. *Archives of Physical Medicine and Rehabilitation*, *91*(11), 1637–1640. https://doi.org/10.1016/j.apmr.2010.05.017

Meythaler, J. M., Peduzzi, J. D., Eleftheriou, E., & Novack, T. A. (2001). Current concepts: Diffuse axonal injury–associated traumatic brain injury. *Archives of Physical Medicine and Rehabilitation*, *82*(10), 1461–1471. https://doi.org/10.1053/apmr.2001.25137

Miles, S. R., Brenner, L. A., Neumann, D., Hammond, F. M., Ropacki, S., Tang, X., Eapen, B. C., Smith, A., & Nakase-Richardson, R. (2020). Posttraumatic stress disorder symptoms contribute to staff perceived irritability, anger, and aggression after tbi in a longitudinal veteran cohort: A VA TBI Model Systems study. *Archives of Physical Medicine and Rehabilitation*, *101*(1), 81–88. https://doi.org/10.1016/j.apmr.2019.07.018

Miles, S. R., Harik, J. M., Hundt, N. E., Mignogna, J., Pastorek, N. J., Thompson, K. E., Freshour, J. S., Hong., J. Y., & Cully, J. A. (2017). Delivery of mental health treatment to combat veterans with psychiatric diagnoses and TBI histories. *PLOS ONE*, *12*(9), e0184265. https://doi.org/10.1371/journal.pone.0184265

Mitchell, T., Theadom, A., & du Preez, E. (2017). Prevalence of traumatic brain injury in a male adult prison population and its association with the offence type. *Neuroepidemiology*, *48*(3-4), 164–170. https://doi.org/10.1159/000479520

Moore, E., Indig, D., & Haysom, L. (2014). Traumatic brain injury, mental health, substance use, and offending among incarcerated young people. *Journal of Head Trauma Rehabilitation*, *29*(3), 239–247. https://doi.org/10.1097/htr.0b013e31828f9876

Morgan, A. T., Mageandran, S.-D., & Mei, C. (2010). Incidence and clinical presentation of dysarthria and dysphagia in the acute setting following paediatric traumatic brain injury. *Child: Care, Health and Development*, *36*(1), 44–53. https://doi.org/10.1111/j.1365-2214.2009.00961.x

Murakawa, N., & Beckett, K. (2010). The penology of racial innocence: The erasure of racism in the study and practice of punishment. *Law & Society Review*, *44*(3-4), 695–730. https://doi.org/10.1111/j.1540-5893.2010.00420.x

Novack, T. A., Dowler, R. N., Bush, B. A., Glen, T., & Schneider, J. J. (2000). Validity of the Orientation Log, relative to the Galveston Orientation and Amnesia Test. *Journal of Head Trauma Rehabilitation*, *15*(3), 957–961. https://doi.org/10.1097/00001199-200006000-00008

Office of Juvenile Justice and Delinquency Prevention Statistical Briefing Book (2020). Arrest rates by offense and race, 2019 (rates are per 100,000 in age group). Available at https://www.ojjdp.gov/ojstatbb/crime/ucr.asp?table_in=2.

Oliver, P. (2017). Percent Black: Regionalism, urbanism and group threat as explanations for racial disparities in imprisonment 1985-2001. https://doi.org/10.31235/osf.io/cypme

Ommaya, A. K., Salazar, A. M., Dannenberg, A. L., Ommaya, A. K., Chervinsky, A. B., & Schwab, K. (1996). Outcome after traumatic brain injury in the U.S. military medical system. *The Journal of Trauma: Injury, Infection, and Critical Care*, *41*(6), 972–975. https://doi.org/10.1097/00005373-199612000-00005

Ozbudak, Görgülü, & Köseoglu. (2006). Comparison of rehabilitation outcome in patients with aphasic and non-aphasic traumatic brain injury. *Journal of Rehabilitation Medicine*, *38*(1), 68–71. https://doi.org/10.1080/16501970510041262

Perkinson, R. (2010). *Texas tough: The rise of America's prison empire*. Metropolitan Books.

Perron, B. E., & Howard, M. O. (2008). Prevalence and correlates of traumatic brain injury among delinquent youths. *Criminal Behaviour and Mental Health*, *18*(4), 243–255. https://doi.org/10.1002/cbm.702

Piccolino, A. L., & Solberg, K. B. (2014). The impact of traumatic brain injury on prison health services and offender management. *Journal of Correctional Health Care*, *20*(3), 203–212. https://doi.org/10.1177/1078345814530871

Ponsford, J. L., Downing, M. G., Olver, J., Ponsford, M., Acher, R., Carty, M., & Spitz, G. (2014). Longitudinal follow-up of patients with traumatic brain injury: Outcome at two, five, and ten years post-injury. *Journal of Neurotrauma*, *31*(1), 64–77. https://doi.org/10.1089/neu.2013.2997

Raine, A. (2002). Biosocial studies of antisocial and violent behavior in children and adults: A review. *Journal of Abnormal Child Psychology*, *30*(4), 311–326. https://doi.org/10.1023/a:1015754122318

Rao, V., Rosenberg, P., Bertrand, M., Salehinia, S., Spiro, J., Vaishnavi, S., Rastogi P., Noll, K., Schretlen, D. J., Brandt, J., Cornwell, E., Makley, M., & Miles, Q. S. (2009). Aggression after traumatic brain injury: Prevalence and correlates. *The Journal of Neuropsychiatry and Clinical Neurosciences*, *21*(4), 420–429. https://doi.org/10.1176/jnp.2009.21.4.420

Rapoport, M., McCauley, S., Levin, H., Song, J., & Feinstein, A. (2002). The role of injury severity in neurobehavioral outcome 3 months after traumatic brain injury. *Cognitive and Behavioral Neurology, 15*(2), 123-132.

Rees, L., Marshall, S., Hartridge, C., Mackie, D., & Weiser, M. (2007). Cognitive interventions post acquired brain injury. *Brain Injury*, *21*(2), 161–200. https://doi.org/10.1080/02699050701201813

Reisig, M. D., Bales, W. D., Hay, C., & Wang, X. (2007). The effect of racial inequality on Black male recidivism. Justice Quarterly, 24(3), 408–434. https://doi.org/10.1080/07418820701485387

Rohling, M. L., Binder, L. M., Demakis, G. J., Larrabee, G. J., Ploetz, D. M., & Langhinrichsen-Rohling, J. (2011). A meta-analysis of neuropsychological outcome after mild traumatic brain injury: Re-analyses and reconsiderations of Binder et al. (1997), Frencham et al. (2005), and Pertab et al. (2009). *The Clinical Neuropsychologist*, *25*(4), 608–623. https://doi.org/10.1080/13854046.2011.565076

Rosell, D. R., & Siever, L. J. (2015). The neurobiology of aggression and violence. *CNS Spectrums, 20*(3), 254–279. https://doi.org/10.1017/s109285291500019x

Rosenthal, M., & Ricker, J. (2000). Traumatic brain injury. *Handbook of Rehabilitation Psychology*, 49–74. https://doi.org/10.1037/10361-003

Roy, D., Vaishnavi, S., Han, D., & Rao, V. (2017). Correlates and prevalence of aggression at six months and one year after first-time traumatic brain injury. *The Journal of Neuropsychiatry and Clinical Neurosciences*, *29*(4), 334–342. https://doi.org/10.1176/appi.neuropsych.16050088

Rudebeck, P. H., & Murray, E. A. (2014). The Orbitofrontal oracle: Cortical mechanisms for the prediction and evaluation of specific behavioral outcomes. *Neuron, 84*(6), 1143–1156. https://doi.org/10.1016/j.neuron.2014.10.049

Rutland-Brown, W., Wallace, L. J. D., Faul, M. D., & Langlois, J. A. (2005). Traumatic Brain injury hospitalizations among American Indians/Alaska Natives. J*ournal of Head Trauma Rehabilitation*, *20*(3), 205–214. https://doi.org/10.1097/00001199-200505000-00004

Sabaz, M., Simpson, G. K., Walker, A. J., Rogers, J. M., Gillis, I., & Strettles, B. (2014). Prevalence, Comorbidities, and Correlates of Challenging Behavior Among Community-Dwelling Adults With Severe Traumatic Brain Injury. *Journal of Head Trauma Rehabilitation, 29*(2), E19–E30. https://doi.org/10.1097/htr.0b013e31828dc590

Sah, P., Faber, E. S. L., Lopez De Armentia, M., & Power, J. (2003). The amygdaloid complex: Anatomy and physiology. *Physiological Reviews, 83*(3), 803–834. https://doi.org/10.1152/physrev.00002.2003

Salzman, C. D., & Fusi, S. (2010). Emotion, cognition, and mental state representation in amygdala and prefrontal cortex. *Annual Review of Neuroscience, 33*(1), 173–202. https://doi.org/10.1146/annurev.neuro.051508.135256

Sander, A. M., Lequerica, A. H., Ketchum, J. M., Hammond, F. M., Gary, K. W., Pappadis, M. R., Felix, E. R., Johnson-Greene, D., & Bushnik, T. (2018). Race/Ethnicity and retention in traumatic brain injury outcomes research. *Journal of Head Trauma Rehabilitation*, *33*(4), 219–227. https://doi.org/10.1097/htr.0000000000000395

Scheid, R., Walther, K., Guthke, T., Preul, C., & von Cramon, D. Y. (2006). Cognitive sequelae of diffuse axonal injury. *Archives of Neurology*, *63*(3), 418. https://doi.org/10.1001/archneur.63.3.418

Seel, R. T., Kreutzer, J. S., Rosenthal, M., Hammond, F. M., Corrigan, J. D., & Black, K. (2003). Depression after traumatic brain injury: A national institute on disability and rehabilitation research model systems multicenter investigation. *Archives of Physical Medicine and Rehabilitation*, *84*(2), 177–184. https://doi.org/10.1053/apmr.2003.50106

Sherer, M., Katz, D. I., Bodien, Y. G., Arciniegas, D. B., Block, C., Blum, S., … Yablon, S. A. (2020). Post-traumatic Confusional State: A Case Definition and Diagnostic Criteria. Archives of Physical Medicine and Rehabilitation, 101(11), 2041–2050. https://doi.org/10.1016/j.apmr.2020.06.021

Sherer, M., Nick, T. G., Sander, A. M., Hart, T., Hanks, R., Rosenthal, M., Walter Jr., W. M., & Yablon, S. A. (2003). Race and productivity outcome after traumatic brain injury: Influence of confounding factors. *The Journal of head trauma rehabilitation*, *18*(5), 408-424.

Sherer, M., Struchen, M. A., Yablon, S. A., Wang, Y., & Nick, T. G. (2007). Comparison of indices of traumatic brain injury severity: Glasgow Coma Scale, length of coma and post-traumatic amnesia. *Journal of Neurology, Neurosurgery & Psychiatry*, *79*(6), 678–685. https://doi.org/10.1136/jnnp.2006.111187

Shiroma, E. J., Ferguson, P. L., & Pickelsimer, E. E. (2012). Prevalence of traumatic brain injury in an offender population. *Journal of Head Trauma Rehabilitation*, *27*(3), E1–E10. https://doi.org/10.1097/htr.0b013e3182571c14

Shores, E. A., Marosszeky, J. E., Sandanam, J., & Batchelor, J. (1986). Preliminary validation of a clinical scale for measuring the duration of post-traumatic amnesia. *Medical Journal of Australia*, *144*(11), 569–572. https://doi.org/10.5694/j.1326-5377.1986.tb112311.x

Sivák, Š., Bittšanský, M., Grossmann, J., Nosál', V., Kantorová, E., Siváková, J., Demková, H. P., & Kurča, E. (2013). Clinical correlations of proton magnetic resonance spectroscopy findings in acute phase after mild traumatic brain injury. *Brain Injury*, *28*(3), 341–346. https://doi.org/10.3109/02699052.2013.865270

Slaughter, B., Fann, J. R., & Ehde, D. (2003). Traumatic brain injury in a county jail population: prevalence, neuropsychological functioning and psychiatric disorders. Brain Injury, 17(9), 731–741. https://doi.org/10.1080/0269905031000088649

Stuss, D. T. (2007). New approaches to prefrontal lobe testing.

Stuss, D. T., Binns, M. A., Carruth, F. G., Levine, B., Brandys, C. E., Moulton, R. J., … Schwartz, M. L. (1999). The acute period of recovery from traumatic brain injury: Posttraumatic amnesia or posttraumatic confusional state? *Journal of Neurosurgery, 90*(4), 635–643. https://doi.org/10.3171/jns.1999.90.4.0635

Substance Abuse and Mental Health Services Administration, Office of Applied Studies. National Household Survey on Drug Abuse: Population Estimates, 1997. Rockville, MD: US Department of Health and Human Services, 1998

Substance Abuse and Mental Health Services Administration. (2016). NSDUH: Latest national survey on drug use and health. Retrieved March 14, 2021, from oas.samhsa.gov/nsduhLatest.htm

Tateno, A., Jorge, R. E., & Robinson, R. G. (2003). Clinical correlates of aggressive behavior after traumatic brain injury. *The Journal of Neuropsychiatry and Clinical Neurosciences*, *15*(2), 155–160. https://doi.org/10.1176/jnp.15.2.155

TBI-related Hospitalizations. (2019, March 29). Retrieved September 03, 2020, from https://www.cdc.gov/traumaticbraininjury/data/tbi-hospitalizations.html

Teasdale, G., & Jennett, B. (1974). Assessment of coma and impaired consciousness. *The Lancet*, *304*(7872), 81–84. https://doi.org/10.1016/s0140-6736(74)91639-0

The Management of Concussion-mild Traumatic Brain Injury, Working Group. VA/DoD clinical practice guideline for the management of concussion-mild traumatic brain injury [Internet]. 2016. https://www.healthquality.va.gov/guidelines/Rehab/mtbi/mTBICPGFullCPG50821816.pdf

The Sentencing Project. (2013). Report of the sentencing project to the United Nations human rights committee: Regarding racial disparities in the United States criminal justice system.

The Sentencing Project. (2016), The facts: state by state data. http://www.sentencingproject.org/map/map.cfm. Accessed September, 2020.

Theadom, A., Parag, V., Dowell, T., McPherson, K., Starkey, N., Barker-Collo, S., Jones, K., Ameratunga, S., Feigin, V. L., & BIONIC Research Group. (2016). Persistent problems 1 year after mild traumatic brain injury: a longitudinal population study in New Zealand. *British Journal of General Practice*, *66*(642), e16–e23. https://doi.org/10.3399/bjgp16x683161

Tsaousides, T., & Gordon, W. A. (2009). Cognitive rehabilitation following traumatic brain injury: Assessment to treatment. *Mount Sinai Journal of Medicine: A Journal of*

Translational and Personalized Medicine, *76*(2), 173–181. https://doi.org/10.1002/msj.20099

U.S. Census Bureau (2001). “Section 5: Law Enforcement, Courts, and Prisons,” Statistical Abstract of the United States. http://www.Census.Gov/Prod/2002pubs/01statab/Law.Pdf. Accessed: September, 2020.

US Department of Health and Human Services, Centers for Disease Control and Prevention. (1998). *Behavioral risk factor surveillance system user’s guide*. Atlanta, GA.

Vanderploeg, R. D., Curtiss, G., Duchnick, J. J., & Luis, C. A. (2003). Demographic, medical, and psychiatric factors in work and marital status after mild head injury. *Journal of Head Trauma Rehabilitation*, *18*(2), 148–163. https://doi.org/10.1097/00001199-200303000-00006

Vaughn, M. G., Salas-Wright, C. P., DeLisi, M., & Perron, B. (2014). Correlates of traumatic brain injury among juvenile offenders: A multi-site study. *Criminal Behaviour and Mental Health*, *24*(3), 188–203. https://doi.org/10.1002/cbm.1900

Veeramuthu, V., Narayanan, V., Kuo, T. L., Delano-Wood, L., Chinna, K., Bondi, M. W., Waran V., Ganesan, D., & Ramli, N. (2015). Diffusion tensor imaging parameters in mild traumatic brain injury and its correlation with early neuropsychological impairment: A longitudinal study. *Journal of Neurotrauma*, *32*(19), 1497–1509. https://doi.org/10.1089/neu.2014.3750

Virkkunen, M., Nuutila, A., & Huusko, S. (1976). Effect of brain injury on social adaptability. *Acta Psychiatrica Scandinavica*, *53*(3), 168–172. https://doi.org/10.1111/j.1600-0447.1976.tb00072.x

Visher, C. A., & Travis, J. (2003). Transitions from prison to community: Understanding individual pathways. *Annual Review of Sociology*, *29*(1), 89–113. https://doi.org/10.1146/annurev.soc.29.010202.095931

Wagner, A. K., Hammond, F. M., Sasser, H. C., Wiercisiewski, D., & Norton, H. J. (2000). Use of injury severity variables in determining disability and community integration after traumatic brain injury. *The Journal of Trauma: Injury, Infection, and Critical Care*, *49*(3), 411–419. https://doi.org/10.1097/00005373-200009000-00005

Walton, M. E., Croxson, P. L., Behrens, T. E. J., Kennerley, S. W., & Rushworth, M. F. S. (2007). Adaptive decision making and value in the anterior cingulate cortex. *NeuroImage, 36*, T142–T154. https://doi.org/10.1016/j.neuroimage.2007.03.029

Western, B., & Wildeman, C. (2009). The Black family and mass incarceration. *The ANNALS of the American Academy of Political and Social Science*, *621*(1), 221–242. https://doi.org/10.1177/0002716208324850

Whaley, A. L. (2002). Psychometric analysis of the cultural mistrust inventory with a Black psychiatric inpatient sample. *Journal of Clinical Psychology*, *58*(4), 383–396. https://doi.org/10.1002/jclp.1150

Wheeler, S., Acord-Vira, A., Arbesman, M., & Lieberman, D. (2017). Occupational therapy interventions for adults with traumatic brain injury. American journal of occupational therapy, 71(3), 7103395010p1-7103395010p3. https://doi.org/10.5014/ajot.2017.713005

Whyte, J., Hart, T., Laborde, A., & Rosenthal, M. (2005). Rehabilitation issues in traumatic brain injury. *Physical medicine and rehabilitation: principles and practice*, *2*, 1677-713.

Williams, W. H., Mewse, A. J., Tonks, J., Mills, S., Burgess, C. N. W., & Cordan, G. (2010a). Traumatic brain injury in a prison population: Prevalence and risk for re-offending. *Brain Injury*, *24*(10), 1184–1188. https://doi.org/10.3109/02699052.2010.495697

Williams, W., Cordan, G., Mewse, A. J., Tonks, J., & Burgess, C. N. W. (2010b). Self-reported traumatic brain injury in male young offenders: A risk factor for re-offending, poor mental health and violence? *Neuropsychological Rehabilitation*, *20*(6), 801–812. https://doi.org/10.1080/09602011.2010.519613

World Health Organization. (2019). *ICD-11: international statistical classification of diseases and related health problems*.

Wortzel, H. S., & Arciniegas, D. B. (2013). A forensic neuropsychiatric approach to traumatic brain injury, aggression, and suicide. *Journal of the American Academy of Psychiatry and the Law Online*, *41*(2), 274-286.

Zeiler, K. J., & Zeiler, F. A. (2017). Social Determinants of traumatic brain injury in the North American Indigenous population: A Review. *Canadian Journal of Neurological Sciences / Journal Canadien Des Sciences Neurologiques, 44*(5), 525–531. https://doi.org/10.1017/cjn.2017.49

Zuercher, M., Ummenhofer, W., Baltussen, A., & Walder, B. (2009). The use of Glasgow Coma Scale in injury assessment: A critical review. *Brain Injury*, *23*(5), 371–384. https://doi.org/10.1080/02699050902926267