Virginia Commonwealth University
VCU Scholars Compass

Theses and Dissertations

Graduate School

2022

Disparities between Native Americans and Whites in Trajectories of Functional Independence and Life Satisfaction over the 5 Years after Traumatic Brain Injury

Jack Watson

Follow this and additional works at: https://scholarscompass.vcu.edu/etd

Part of the Other Psychiatry and Psychology Commons

Jack D. Watson

Downloaded from
https://scholarscompass.vcu.edu/etd/7179

This Thesis is brought to you for free and open access by the Graduate School at VCU Scholars Compass. It has been accepted for inclusion in Theses and Dissertations by an authorized administrator of VCU Scholars Compass. For more information, please contact libcompass@vcu.edu.

Disparities between Native Americans and Whites in Trajectories of Functional Independence and Life Satisfaction over the 5 Years after Traumatic Brain Injury

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at Virginia Commonwealth University

Jack Watson, B.A.

Bachelors of Arts, University of Virginia, May 2012

Director: Paul B. Perrin, Ph.D.

Professor of Psychology

Department of Psychology

Virginia Commonwealth University

Richmond, Virginia

December 2022

Jack D. Watson 2022
All Rights Reserved

Acknowledgment

The Traumatic Brain Injury (TBI) Model Systems National Database is a multicenter study of the TBI Model Systems Centers Program, and is supported by the National Institute on Disability, Independent Living and Rehabilitation Research (NIDILRR) a center within the Administration for Community Living (ACL), Department of Health and Human Services (HHS). However, these contents do not necessarily reflect the opinions or views of the TBI Model Systems Centers, NIDILRR, ACL or HHS.

ABSTRACT

A traumatic brain injury (TBI) occurs when trauma to the head interrupts typical brain function and is caused by an external force like a blow to the head, fall, or concussive blast that results in functional impairment or loss of consciousness. TBI can have a host of negative consequences including impairments to motor and cognitive function and can be accompanied by comorbid psychological symptoms which often result in a decrease in quality of life (i.e., life satisfaction) for the person living with TBI. TBI is one of the leading causes of death and disability worldwide and disproportionately affects Native Americans, who have the highest rates of TBI among all races in the U.S. and elevated likelihood for fatality and severe complications. The current study used a subsample of the national TBI Model Systems Database of 80 demographically and injury severity matched Native American and White individuals (total $n = 160$) to investigate whether disparities in functional and life satisfaction outcomes exist over the 5 years after injury, and if so, whether demographic and injury-related covariates account for them. A series of hierarchical linear models found that Native Americans demonstrated significantly lower Functional Independence Measure (FIM) Cognitive and Motor trajectories than did Whites; however, life satisfaction was comparable. Further, FIM cognitive trajectories changed differentially over time, with Native Americans demonstrating declining cognitive function over time relative to a slight increase in White individuals; however, this differential movement dissipated with the addition of employment status at the time of injury and type of health insurance held by the person with TBI. These results demonstrate a profound need to further investigate the cultural and contextual variables unique to Native Americans that underlie these differences and highlight the importance of culturally responsive treatment and rehabilitation in bridging the gap in recovery.

Vita

Jack Watson was born on November 5th, 1989 in Henrico, Virginia. He received his bachelor's degree in medieval studies and English from the University of Virginia in May, 2012. Shortly thereafter, he worked as a law enforcement officer and air rescue fire fighter serving his local community in Charlottesville, Virginia for four years before pursuing a post-baccalaureate in psychology at VCU while working as a research coordinator for Dr. Paul B. Perrin at Virginia Commonwealth University. For Dr. Perrin, Jack worked on a number of studies, but his primary responsibility was coordinating Dr. Perrin's grant-funded *Randomized clinical trial of a telehealth transition assistance program for SCI caregivers*. He currently attends Virginia Commonwealth University in the counseling psychology doctoral program as part of the Distinguished Doctoral Scholars Program funded by the Southern Regional Education Board.

Disparities between Native Americans and Whites in Trajectories of Functional Independence and Life Satisfaction over the 5 Years after Traumatic Brain Injury

Overview of the Literature Review

This literature review will begin by discussing the epidemiology of traumatic brain injury (TBI) including incidence and prevalence followed by a description of common TBI impairments. The review will discuss impairments in functional independence, centered on reductions in motor and cognitive function, then review common mental health issues after TBI including depression, anxiety, and reduced life satisfaction. The review will then address TBI epidemiology in racial/ethnic minorities with a particular focus on Native Americans and discuss disparities in outcomes for Native Americans with TBI. Finally, the review will describe the purpose of this study which is to examine possible race-based disparities in functional independence and life satisfaction over the first five years after TBI between Native Americans and White individuals.

Epidemiology of TBI

A TBI occurs when trauma to the head interrupts typical brain function and is caused by an external force like a blow to the head, fall, or concussive blast that results in functional impairment or loss of consciousness (BIA, 2011; NDSC, March, 2017). To be considered a TBI, according to the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; *DSM-5*; American Psychiatric Association [APA], 2013), the head injury must result in loss of consciousness, evidence of neurological defects, amnesia, or disorientation and confusion. Individuals with TBI are classified by clinical severity, structural change, or mechanism of injury (Baalen et al., 2003). TBI severity ranges from mild (i.e., brief) to severe (i.e., extend period of impairment following injury), with the majority being mild. Typically, clinical severity is determined by the presence and duration of post traumatic amnesia (PTA) with greater days in PTA indicating a more severe TBI (Baalen et al., 2003).

TBI is one of the leading causes of death and disability worldwide and has been described as a global health crisis (Maas et al., 2017). TBI continues to impose a public health burden to patients, caregivers, healthcare providers, and healthcare systems (Chen et al., 2012; Humphreys et al., 2013). Approximately 69 million people sustain a new TBI each year (Dewan et al., 2018), often resulting in death, severe disability, and a host of other health complications (Roozenbeek et al., 2013). While the global incidence of TBI worldwide is rising, compared to the rest of the world, North America has the highest reported incidence of TBI per 100,000 people, though this could reflect disparities in reporting and healthcare access rather than real TBIs experienced (Dewan et al., 2018).

According to the Centers for Disease Control and Prevention (CDC), Americans experienced 206,570 TBI-related hospitalizations in 2018, and 58,135 TBI-related deaths in 2019; however, these estimates do not include untreated TBIs or TBIs treated exclusively in primary care, urgent care, or the emergency department (CDC, 2021a). The CDC estimates the total number of TBI-related hospitalizations, emergency room visits, and deaths in the U.S. at 2.88 million in 2014, indicating that the number of TBIs each year approaches or exceeds 2 million (CDC, 2019). Age, especially greater than 75, is a risk factor for TBI and, according to the CDC (2019), TBI is a leading cause of mortality and morbidity in the U.S. Falls (47.9%), collision with an object (17.1%), and motor vehicle accidents (13.2%) are the leading causes of TBI within the U.S. (CDC, 2019; Roozenbeek et al., 2013).

Common TBI Impairments and Negative Effects

Short-term and long-lasting effects often accompany a TBI and include but are not limited to: impaired movements, problems with short- and long-term memory, emotional distress, bowel and bladder difficulties, and impaired sensations (Centers for Disease Control, 2014). Individuals with TBI tend to score lower on health-related quality of life and life satisfaction measures than the general population (Jacobsson et al., 2010). Reduced involvement in activities, greater emotional distress, and reduced community integration all predict lower life satisfaction for individuals with TBI (Mailhan et al., 2005; Pierce & Hanks, 2006; Williams et al., 2014). Greater levels of disability have also been closely associated with reduced levels of life satisfaction and decreased mental and physical health (Fuhrer et al., 1992). In particular, lower physical function has been shown to reduce health-related quality of life, increase the presence and severity of symptoms of anxiety and depression, and reduce satisfaction with life (Rivers et al., 2018). Functional independence has been especially helpful in predicting life satisfaction among individuals with disabilities (Fuhrer et al., 1992; Rivers et al., 2018; Hartman-Maeir et al., 2007) and also demonstrates good predictive capability for minutes of assistance or supervision needed by the individual with TBI from a caregiver (Corrigan et al., 1997).

Individuals who experience a TBI are at a significantly higher risk for suicide than the average person without TBI (Centers for Disease Control, 2021b). They are also less likely to be employed and if employed are less likely to have stable, long-term employment (Catalano et al., 2006; Hoofien et al., 2001), and they are more likely to be unmarried or divorced (Hoofien et al., 2001; Stevens et al., 2017). Each of the aforementioned categories represents significant deviation from the reported national averages (Hoofien et al., 2001). Additionally, individuals living with a TBI are more likely to perceive of themselves as a burden to loved ones and endorse lower social functioning and higher loneliness (Hoofien et al., 2001). This indicates that a TBI often interferes with normal lifespan development and achievements (e.g., marriage, family, employment, etc.).

Functional Independence after TBI

Functional independence is the ability to regularly and independently perform basic tasks associated with daily living (Curzel et al., 2013; Heinemann et al., 1993), and it can be affected by a host of factors: cognitive and motor function, TBI severity, premorbid condition, sex, race/ethnicity, socioeconomic status (SES), access to healthcare and rehabilitation, social support, community integration, age, and intrinsic characteristics like resilience and grit (Arcinegas et al., 2002; Carpuso & Levin, 1992; Cowen et al., 1995; Erler et al., 2018; Levin et al., 1988). Not surprisingly, individuals with TBI demonstrate significantly lower cognitive and motor function than the general population; cognitive impairments are usually the most disabling consequence of TBI, particularly information processing speed and memory (Carpuso & Levin, 1992). While both retrograde and anterograde memory issues are common, long-term memory appears to be one of the most affected areas of cognition following TBI (Arcinegas et al., 2002; Levin et al., 1988), but many people also commonly experience deficits in attention, language, and perceptual skills (Capruso & Levin, 1992). Greater injury severity is linked to greater cognitive deficits both at admission to the hospital as well as post-discharge (Cowen et al., 1995).

Similarly, greater injury severity also predicts worse motor function at admission and post-discharge with worse motor function scores predicting longer length of stay and higher medical cost (Cowen et al., 1995). Individuals with TBI can experience a host of limiting motor troubles including difficulty with fine motor tasks (e.g., eating, writing), self-care tasks (e.g., grooming, bathing, dressing), bladder and bowel management, and locomotion (Centers for

Disease Control, 2014; Erler et al., 2018). Additionally, poor motor function is especially predictive of an individual's ability to return to pre-injury roles, routines, and engagement (Erler et al., 2018). Most cognitive and motor recovery is made between the time of admission to inpatient rehabilitation and hospital discharge, though some recovery can continue over three months after discharge or longer (Zarshenas et al., 2019). Further, comorbid conditions (e.g., obesity, diabetes, etc.), particularly for individuals with two or greater adverse health conditions in addition to TBI, can prevent recovery and exacerbate both cognitive and motor deficits (Zarshenas et al., 2019). Similarly, living alone and being referred to the emergency department multiple times after discharge also predicted worse cognitive and motor function (Zarshenas et al., 2019).

Mental Health, Life Satisfaction, and TBI

TBI is one of the leading causes of physical-trauma-related psychological disorders with generalized anxiety disorder and depression being the most common psychiatric sequelae of TBI (CDC, 2019; Bryant et al., 2010). Individuals with TBI may experience more intense and frequent mood changes accompanied by heightened anxiety and irritability (Holsinger et al., 2002). This can often lead to a sense of confusion and frustration for individuals with TBI who may notice a change in personality, increased impulsivity, and social disconnection (Holsinger et al., 2002; CDC, 2015; Milders et al., 2003). While TBI is often accompanied by depression, research indicates that TBI may be a unique risk factor for depression (Jean-Bay, 2000), with estimates of over 50% of individuals with moderate-to-severe TBI qualifying for a diagnosis of major depressive disorder (MDD) generally during the first year after their injury (Bombardier et al., 2010). However, rates of depression for individuals with TBI vary widely and differentially across time (Albrecht et al., 2019; Bombardier et al., 2016; Jorge et al., 2004).

Like depression, anxiety has a high comorbid prevalence with TBI. A systematic review found a pooled prevalence rate of 36% for anxiety in individuals with TBI (Scholten et al., 2016). In fact, anxiety and depression are so common in individuals with TBI that a large portion of people who meet criteria for a diagnosis of major depressive disorder are also likely to meet criteria for a diagnosis of generalized anxiety disorder (GAD; Hart et al., 2016; Jorge et al., 2004; Jorge et al., 1993) with estimates ranging from 24%-70% of individuals with MDD also meeting criteria for GAD (Rao & Lyketsos, 2002; Fann et al. 1995). Common anxiety disorders accompanying TBI include: social anxiety disorder, GAD, specific phobia, obsessive-compulsive disorder, post-traumatic stress disorder, and panic disorder (Mailya et al., 2015). The development of an anxiety disorder post-TBI is a strong predictor of negative personal, social, and work outcomes (Mailya et al., 2015).

Life satisfaction is a global construct referring to an individual's subjective perception of their well-being or quality of life (Diener et al., 1985), with the terms "life satisfaction," "quality of life", and "subjective well-being" often being used interchangeably to assess the same construct (Berger et al., 1999; Mailhan et al., 2005). For individuals with TBI, the degree to which a person is able to achieve and maintain a healthy and productive lifestyle is a strong indicator of their life satisfaction (Corrigan et al., 2001).

Since life satisfaction is a global measure of a person's subjective well-being (Diener et al., 1985), a host of factors can contribute to the perception. For individuals with TBI, not having a history of substance use, being able to attain gainful employment following TBI, having greater motor independence, achieving greater social integration, and not having depressed mood were all associated with higher life satisfaction (Corrigan et al., 2001; Underhill et al., 2003). More complete social integration is also a strong predictor of greater life satisfaction (Burleigh et al., 1998). Cicerone and Azulay (2007) highlighted the importance of perceived self-efficacy in predicting life satisfaction; they found self-efficacy to manage cognitive symptoms to be a significant contributor to life satisfaction and that it mediated the relation between community integration and life satisfaction.

Given the close relations among individuals with TBI between life satisfaction and depression (Corrigan et al., 2001; Underhill et al., 2003), anxiety (Hart et al., 2016), social integration (Burleigh et al., 1998; Williams et al., 2014), emotional distress (Williams et al., 2014), self-efficacy (Cicerone and Azulay, 2007), post-traumatic stress (Stålnacke, 2007), post-concussive symptoms (Stålnacke, 2007, Anke et al., 2015), and functional independence (Fuhrer et al., 1992; Rivers et al., 2018; Hartman-Maeir et al., 2007), it makes good sense to examine life satisfaction as a key outcome.

TBI in Native Americans

Little research has been conducted on TBI in Native Americans. In fact, a systematic review of TBI among indigenous people found only 26 studies meeting criteria for inclusion, and it is important to note that this systematic review surveyed *all* indigenous people, not just Native Americans, and included indigenous people from other countries than the U.S. (Lakhani et al., 2017). Of the studies included, only 8 mentioned Native Americans (Lakhani et al., 2017). Contrast this with a systematic review of TBI and olfaction which found 25 studies published in English (Schofield et al., 2014) or a systematic review examining health-related quality of life after TBI which found 58 studies meeting inclusion criteria (Polinder et al., 2015).

Mild TBI incidence in Native Americans is roughly 1,000/100,000 (Bazarian et al., 2003); studies suggest the incidence of TBI requiring hospitalization and rehabilitation for Native Americans is around 75/100,000 people (Langlois et al., 2003; Rutland-Brown et al., 2005). Nelson et al. (2007) found that lifetime TBI prevalence was higher for Native American males (22%-26%) than for females (8%-26%); however, prevalence rates varied by geographical location and Native American tribe. Additionally, both substance use and violence as a cause of injury are significant factors for TBI in Native American populations (Blackmer & Marshall, 1999; Linton & Kim, 2014; Linton et al., 2016).

Native Americans with TBI are significantly more likely to experience a mood or anxiety disorder than individuals without a TBI (Nelson et al., 2007). Native Americans also face difficulties with functional independence, employment, and healthcare access following TBI (Fuentes et al., 2016; Whitfield & Lloyd, 2008). Researchers focusing on TBI in non-Whites (Arango-Lasprilla & Niemeier, 2007), and especially in Native American populations (Nelson et al., 2007), have called for additional research highlighting the importance of cultural differences. Linton et al. (2016) highlighted race specifically as an important factor for future research in TBI that attempts to consider cultural and contextual factors specific to the disabled community.

Native American Health Disparities

Native Americans are a chronically underserved group within the U.S. health care system and experience a number of health disparities across many diseases, injuries, and age groups (Sarche & Spicer, 2008). Native Americans face disparities in poverty, education, employment, violence, trauma, and physical health (Sarche & Spicer, 2008). All of these disparities can be exacerbated by the experience of a TBI.

Assault is one of the leading causes of TBI and TBI-related deaths (Centers for Disease Control, 2021b), with Native Americans being three times as likely to experience a violent TBI as Whites (Linton & Kim, 2014). There is an association between intimate partner violence (IPV) and TBI, and Native American women experience high rates of IPV (Luna-Firebaugh et al., 2002), with as many as 31.1% of women who reported IPV also receiving a head injury (Evans-Campbell et al., 2006).

Rutland-Brown and colleagues (2005) discovered that Native Americans experienced a 30% higher rate of TBI than Whites while Langlois et al. (2003) reported Native Americans had the highest incidence of TBI among all races in the U.S. While TBI is potentially disabling and fatal for all groups, ethnic minorities, like Native Americans, are more likely to experience a more severe and fatal TBI than Whites (Shiho, 2018). Additionally, research demonstrates increased rates of in-hospital mortality and decreased likelihood of discharge to a rehabilitation center for Blacks and Hispanics when compared to Whites (Bowman et al., 2007). It is not unreasonable to hypothesize that similar disparities might also exist for Native Americans, though due to the dearth of research on Native Americans with TBI, this is unknown at present.

Native Americans are more than twice as likely to have substance use as a factor contributing to their TBI than Whites (Linton et al., 2016), and following discharge are significantly less likely to engage with healthcare services (Whitfield & Lloyd, 2008) and less likely to receive additional resources post-discharge than other races (Blackmer & Marshall, 1999). Additionally, despite no significant difference in injury severity, one study found that Native Americans were significantly more likely to receive surgical treatment and had a significantly lower number of family conferences prior to discharge than other races (Blackmer & Marshall, 1999).

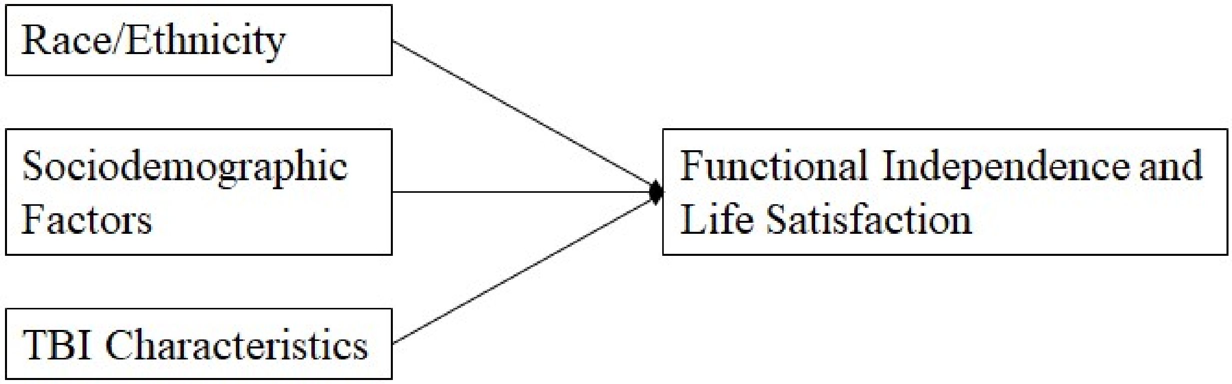
While some research has been conducted on racial/ethnic disparities in TBI, little has attempted to understand and highlight the experiences of Native Americans. This is partly due to a lack of adequate data and the relatively isolated, small, and culturally distinct nature of Native American tribes (Sarche & Spicer, 2008). It is particularly important that rehabilitation medicine further elucidate the unique challenges and needs of Native Americans with TBI and investigate the factors that may underly and predict functional outcomes (Arango-Lasprilla & Niemeier, 2007; Linton et al., 2016; Nelson et al., 2007).

Study Purpose

Meade and colleagues (2015) highlighted the lack of an appropriate medical conceptual framework for healthcare disparities within the disabled community. The authors noted that many of the previously existing conceptual models had failed to account adequately for cultural and contextual factors specific to the disabled community, had made inaccurate assumptions surrounding access to resources and healthcare, and largely had ignored concerns around structural accessibility (Meade et al., 2015). In response, the authors proposed the Model of Healthcare Disparities and Disability (MHDD) which encourages consideration of personal and environmental factors that might impact functional outcome. In essence, Meade and colleagues (2015) propose that functional outcome is the result of a complex interaction of intrinsic personal characteristics (e.g., race/ethnicity, age), sociodemographic characteristics (e.g., education, income), and disability characteristics (e.g., type of disability, severity). Coupled with the knowledge that the majority of functional recovery is made between inpatient rehabilitation and discharge (Zarshenas et al., 2019), this indicates that baseline demographic and injury characteristics may be important in helping predict functional outcome after discharge.

A related framework was used by Pugh (2021) to investigate longitudinal arrest probability following TBI. In the resulting theoretical model, race/ethnicity, sociodemographic confounds, and TBI characteristics combine with legal system factors and systemic racism to predict longitudinal arrest probability. The current study incorporated the theoretical underpinnings of the MHDD by modifying and applying Pugh's framework to functional independence and life satisfaction.

Figure 1.
Current Study Theoretical Model.



Thus, the purpose of this study was to evaluate the degree to which disparities in functional independence and life satisfaction outcomes exist between Native Americans and White individuals with TBI at 1, 2, and 5 years after injury. The study then examined whether demographic or injury related characteristics accounted for some of these disparities.

Hypotheses

Hypothesis 1. Given that previous research has documented that non-White groups with TBI report lower functional and mental health outcomes (Blackmer & Marshall, 1999; Bowman et al., 2007; Shiho, 2018; Whitfield & Lloyd, 2008) than Whites, it was hypothesized that Native Americans with TBI would show lower functional independence and life satisfaction trajectories compared to Whites.

Hypothesis 2. Previous studies have demonstrated that racial disparities in functional and mental health outcomes remain even after accounting for a number of socio-demographic variables (Blackmer & Marshall, 1999; Linton et al., 2016; Whitfield & Lloyd, 2008). Thus, differences in functional independence and life satisfaction between Native Americans and Whites would be partially accounted for by sociodemographic variables that differ between the two groups; however, these disparities would still exist even after adding the relevant covariates due to culturally and contextually specific variables that were not measured in the current study (Linton et al., 2016; Meade et al., 2015; Pugh, 2021).

Method

Procedure

The current study conducted secondary analyses of data collected as part of the Traumatic Brain Injury Model Systems (TBIMS) U.S. National Database. With 16 multidisciplinary rehabilitation medical centers, 3 follow-up centers nationwide, and data ranging as far back as 1987, the TBIMS database is the largest longitudinal study of TBI in the world. The database currently has information covering pre-injury, acute care, rehabilitation, and longitudinal outcomes on over 15,000 individuals with TBI.

Each TBIMS center received local institutional review board approval. All participants or a legal proxy completed informed consent during inpatient rehabilitation prior to enrollment. Demographic and injury-related characteristics were collected via medical record review, patient examination, data collection forms, or interview. Follow-up interviews were attempted at 1, 2, 5, 10, and every 5 years thereafter after discharge and were conducted in person, via telephone, or by mail with the participant or another person familiar with the participant (e.g., family member or caregiver). The U.S. Department of Health and Human Services funds the TBIMS program through the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR; MSKTC, 2020; NDSC, March 2017).

Participants

Individuals were enrolled in the study only if they sustained a TBI caused by an external mechanical force meeting one of the following criteria: (a) loss of consciousness >30 minutes,

(b) Glasgow Coma Scale (GCS) score < 13 on emergency admission, (c) trauma-related intracranial abnormality on neuroimaging, or (d) posttraumatic amnesia (PTA) > 24 hours. All participants were enrolled while undergoing inpatient rehabilitation at a TBIMS site. To be eligible for enrollment, individuals had to be 16 years of age or older, received medical care within 72 hours of injury, and received subsequent inpatient rehabilitation at a TBIMS site.

This study included 80 Native Americans and 80 White individuals who were demographically matched from the TBIMS database (Table 1).

Table 1

Participant Characteristics

Variable	Native American	White	*p-value*
Age at Injury, M (*SD*)	37.91 (15.49)	37.92 (15.46)	*p* = .996
Sex, n (%)			*p* = 1.000
Male	54 (67.50)	54 (67.50)	
Female	26 (32.50)	26 (32.50)	
Years of Education Pre-Injury, M (*SD*)	12.11 (2.55)	12.96 (3.02)	*p* = .059
Employment at Injury, n (%)			*p* = .003
Employed	35 (48.60)	54 (73.00)	
Not Employed	37 (51.40)	20 (27.00)	
Annual Earning, n (%)			*p* = .558
<9,999	7 (17.50)	11 (20.00)	
10,000-19,999	9 (22.50)	7 (12.70)	
20,000-29,999	11 (27.50)	12 (21.80)	
30,000-39,999	4 (10.00)	9 (16.40)	
40,000-49,999	3 (7.50)	2 (3.60)	
50,000-59,999	1 (2.50)	3 (5.50)	
60,000-69,999	-	2 (3.60)	
70,000-79,999	2 (5.00)	2 (3.60)	
80,00- 89,999	1 (2.50)	-	
90,000-99,999	1 (2.50)	1 (1.80)	
> 100,000	1 (2.50)	6 (10.90)	
Type of Work, n (%)			*p* = .347
Blue Collar	31 (81.60)	41 (73.20)	
White Collar	7 (18.40)	15 (26.80)	
Cause of Injury, n (%)			*p* = .058

Non-Violent	69 (86.30)	76 (95.00)	
Violent	11 (13.80)	4 (5.00)	
Insurance Type, n (%)			*p* = .011
Private	31 (39.20)	47 (59.50)	
Non-Private	48 (60.80)	32 (40.50)	
Marital Status, n (%)			*p* = .235
Married	51 (63.7)	58 (72.50)	
Not Married	29 (36.3)	22 (27.50)	
Language Spoken at Home, n (%)			*p* = .149
English	57 (93.40)	64 (98.50)	
Other than English	4 (6.60)	1 (1.50)	
Illicit/Non-Prescription Drug Use, n (%)			*p* = .116
Reported Problematic Use	45 (60.80)	37 (48.10)	
Did Not Report Problematic Use	29 (39.20)	40 (51.90)	
Cigarette Use, n (%)			*p* = .682
Smoked Prior to Injury	9 (42.90)	1 (25.00)	
Did Not Smoke Prior to Injury	12 (57.10)	3 (75.00)	
Alcohol Use, n (%)			*p* = .067
Reported Problematic Use	38 (74.50)	24 (46.15)	
Did Not Report Problematic Use	13 (25.50)	28 (53.85)	
Days Spent in PTA, M (*SD*)	23.32 (25.42)	23.67 (22.68)	*p* = 1.000

Note. Not all categories have *n* = 80 due to missing or refused data.

This number was chosen because at the time of data analysis, 80 Native Americans in the TBIMS database had follow-up data on the variables of interest. The 80 White individuals were chosen by the researcher with the following criteria: (a) gender must match, (b) injury severity must match (defined by time in posttraumatic amnesia category), and (c) the individual meeting both criteria (a) and (b) must have at least one completed data point for Functional Independence Measure (FIM) Cognitive and FIM Motor or Satisfaction with Life Scale (SWLS), and (d) age must be withing 1 year. In the event that multiple people fit these criteria, the White person appearing first in the database was selected to ensure consistency.

There was initially a total of 90 Native American identifying individuals in the original dataset; however, this number was reduced to 80 as participants were included in the current study only if they had at least one complete FIM Cognitive, one complete FIM Motor, or one complete life satisfaction score at any time point (years 1, 2, or 5). (However, predictive models were only run on participants with at least one follow-up data point for that particular outcome measure.) The number of individuals with complete data and percent of missing data appears in Table 2 separated by race.

Table 2
Data Missingness

Variable	Native American		White	
	# With Data	% Missing	# With Data	% Missing
One-Year FIM Cog, M *(SD)*	70	10.30	69	11.50
Two-Year FIM Cog, M *(SD)*	67	14.10	68	12.80
Five-Year FIM Cog, M (*SD*)	43	44.90	65	16.70
One-Year FIM Motor, M *(SD)*	70	10.30	69	11.50
Two-Year FIM Motor, M *(SD)*	66	15.40	68	12.80
Five-Year FIM Motor, M (*SD*)	43	44.90	64	17.90
One-Year SWLS, M *(SD)*	56	17.60	61	10.30
Two-Year SWLS, M *(SD)*	53	22.10	58	14.70
Five-Year SWLS, M (*SD*)	38	44.10	54	20.60

Missing data could occur for many reasons such as: refusal to participate, not available at time of collection, incorrect contact information at follow-up, not being physically or cognitively able to participate, and death.

Measures

Functional Independence.

Functional independence can be measured by an assessment of cognitive and motor function via the Functional Independence Measure (FIM; Heinemann et al., 1993), one of the most widely used measures of functional independence (Dodds et al., 1993). The FIM helps quantify functional independence and can be used to track progress, differentiate between cognitive and physical (i.e., motor) impairments, and help determine targeted rehabilitation programs (Linacre et al., 1994; Stineman et al., 1996). The FIM is an 18-item measure of functional independence with Cognitive and Motor subscales (Heinemann et al., 1993).

There are five cognitive items which assess functional independence in memory, problem solving, expression, comprehension, and social interaction. Thirteen items are used to assess stair climbing, locomotion, toileting, showering/bathing, dressing, grooming, and eating. Responses are Likert-type ranging from 1 (cannot do the item at all) to 7 (can do the item completely independently). Higher scores indicated greater functional independence. The five cognitive items and the 13 motor items are summed to obtain FIM Cognitive and FIM Motor subscores. The total FIM score is a summation of the two subscales; however, for the purposes of the current study, the subscales will be used separately. The FIM has been a staple in rehabilitation research (Stineman et al., 1996) has demonstrated good predictive validity (Corrigan et al., 1997) and reliability (Bogner et al., 2017).

Life Satisfaction.

The Satisfaction with Life Scale is a five-item, self-report global measure of a person’s satisfaction with their life (Diener et al., 1985). The five questions are: (1) In most ways my life is close to my ideal; (2) The conditions of my life are excellent; (3) I am satisfied with my life; (4) So far, I have gotten the important things I want in life; and (5) If I could live my life over, I would change almost nothing. Responses are scored on 7-point Likert-type scale from 1 (strongly disagree) to 7 (strongly agree). Items are then summed for a total satisfaction with life score ranging from 5 to 35, with higher scores indicating greater satisfaction with life; scores from 26 to 30 indicate extreme satisfaction while scores 5 to 9 indicate extreme dissatisfaction

(Pavot & Diener, 1993). The scale is closely associated with other measures of subjective well-being and has demonstrated good psychometric properties (Diener et al., 1985).

Data Analysis Plan

Preliminary Analyses.

All analyses were conducted using IBM SPSS Statistics version 28. Means, standard deviations, and frequencies were computed for sample sociodemographic and injury severity characteristics differentially as a function of race/ethnicity (Table 1). Further, descriptive statistics were run to assess statistically significant differences between Native Americans and Whites in demographics and injury characteristics using analysis of variance (ANOVAs) or chi-squared analyses as appropriate (Table 1).

Normality tests were performed to assess distributions of the outcome variables (FIM Cognitive, FIM Motor, and Life Satisfaction). For skewness and kurtosis, a value of 2.0 was used as the critical score to identify skewed or kurtotic data. Multicollinearity was also checked to assess whether the correlations were $r < .70$ among all predictor variables. To address missingness in the data, the current study calculated the percentage of missing variable data at 1-, 2-, and 5-years post-injury. Little's Missing Completely at Random (MCAR) test assessed the degree to which FIM and SWLS scores were missing at random. Because of the potential for missing data in longitudinal data collection, hierarchical linear model's (HLM's) full information maximum likelihood (FIML) estimation procedure was used to include participants with missing data (as long as they had at least one outcome variable for a particular analysis).

Primary Analyses.

A common approach to health disparities research is to (1) document the existence of disparities then (2) attempt to account for them with demographic or injury-related variables that differ between the participant groups entered as covariates. The current study used this method in addressing disparities in FIM Cognitive, FIM Motor, and life satisfaction between Native Americans and White individuals. A series of longitudinal HLMs was performed to test the study hypotheses.

Preliminary Curvature Analyses.

An initial set of three HLMs was run with the primary variable of interest and only the intercept and (a) time and (b) time*time as fixed effects predictors to determine whether a linear (e.g., straight line) or quadradic (e.g., U-shaped) model most accurately reflected the curvature trajectories of the variables of interest (i.e., two sets of HLMs, run for each outcome). -2Log likelihood (-2LL) values were compared for each successive model with a critical χ^2 value for significant difference at $\alpha = .05$ and a ≥ 3.841 drop from the previous model (at 1 degree of freedom).

Primary Set 1. The next set of HLMs assessed differences in functional independence and life satisfaction over time in the Native American and White groups. Follow-up HLMs incorporated interaction terms between time and race/ethnicity to determine if these differences in functional and life satisfaction outcomes occurred differentially as a function of time.

Primary Set 2. For the second primary set, this same series of analyses was conducted with the inclusion of the significantly different demographic and injury-related variables as covariates to determine whether these variables accounted for the effects of race/ethnicity in the first analyses. Potential covariates included: marital status, years of education, annual earnings, employment status at the time of injury, type of employment (blue vs. white collar), violence as a cause of injury, language spoken at home, type of health insurance, and substance use (alcohol, drugs, and tobacco).

Results

Descriptive and Normality Analyses

Means and standard deviations (*SD*s) for FIM Cognitive, FIM Motor, and SWLS at each time point are shown in Table 2.

Table 3

FIM and SWLS Means and SDs by Race

Variable	Native American	White
One-Year FIM Cog, M *(SD)*	28.94 (6.74)	31.35 (3.81)
Two-Year FIM Cog, M *(SD)*	30.18 (4.43)	32.13 (2.93)
Five-Year FIM Cog, M (*SD*)	28.33 (6.28)	32.34 (2.72)
One-Year FIM Motor, M *(SD)*	79.17 (18.33)	85.75 (10.22)
Two-Year FIM Motor, M *(SD)*	81.79 (15.11)	87.13 (6.21)
Five-Year FIM Motor, M (*SD*)	78.91 (17.77)	87.75 (5.12)
One-Year SWLS, M *(SD)*	21.09 (7.71)	19.44 (8.50)
Two-Year SWLS, M *(SD)*	19.79 (9.74)	22.53 (8.17)
Five-Year SWLS, M (*SD*)	20.84 (9.26)	22.02 (8.68)

Normality tests on satisfaction with life found that it was normally distributed, with skewness and kurtosis values below the cutoff of 2.0 for all three time points; however, FIM Cognitive and FIM Motor variables both demonstrated some varying degrees of non-normality (Table 3).

Table 4

Skew and Kurtosis of Study FIM and SWLS

Variable	Skew	Kurtosis
One-Year FIM Cog, M *(SD)*	-2.253	6.401
Two-Year FIM Cog, M *(SD)*	-1.400	1.960
Five-Year FIM Cog, M (*SD*)	-2.197	6.698
One-Year FIM Motor, M *(SD)*	-2.790	7.752
Two-Year FIM Motor, M *(SD)*	-3.348	13.156
Five-Year FIM Motor, M (*SD*)	-2.863	8.236

One-Year SWLS, M *(SD)*	-0.068	-1.025
Two-Year SWLS, M *(SD)*	-0.161	-1.167
Five-Year SWLS, M (*SD*)	-0.197	-1.153

Inspections of the histograms (Figures 1- 5) revealed that the distributions for FIM Cognitive and FIM Motor scores demonstrated an expected pattern of response, with values bunched up at the top of the scale (i.e., ceiling effects).

Figure 1. *One-year FIM Cognitive histogram.*

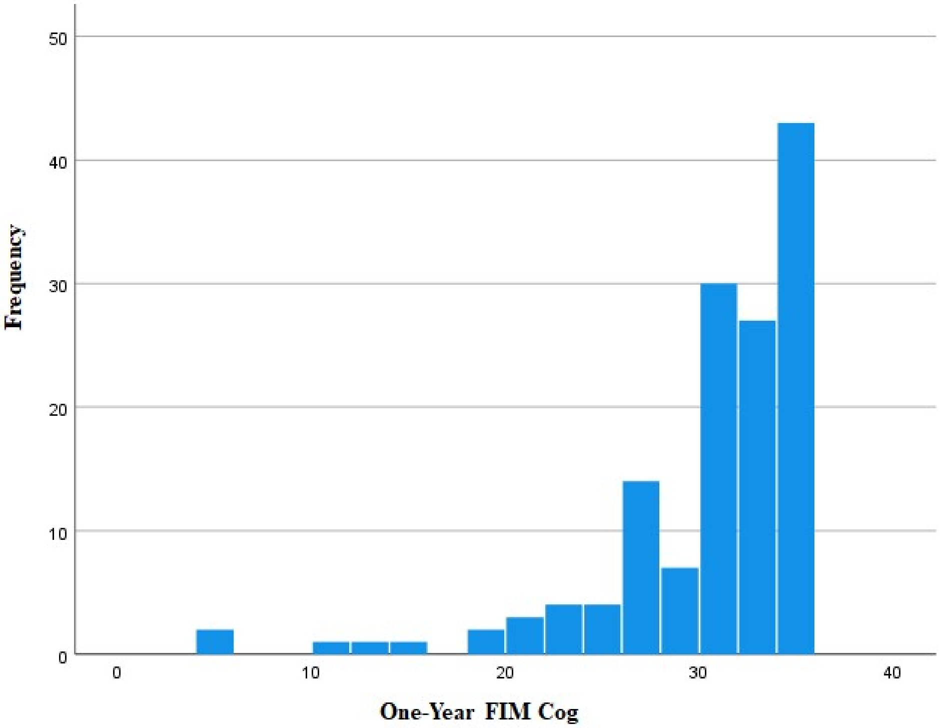


Figure 2. *Five-year FIM Cognitive histogram.*

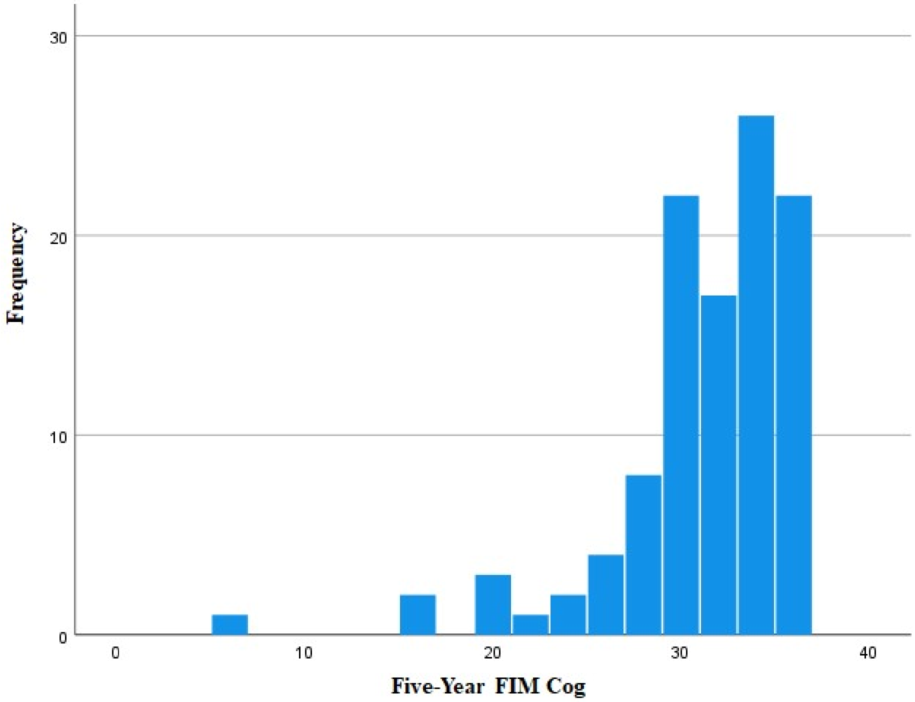


Figure 3. *One-year FIM Motor histogram.*

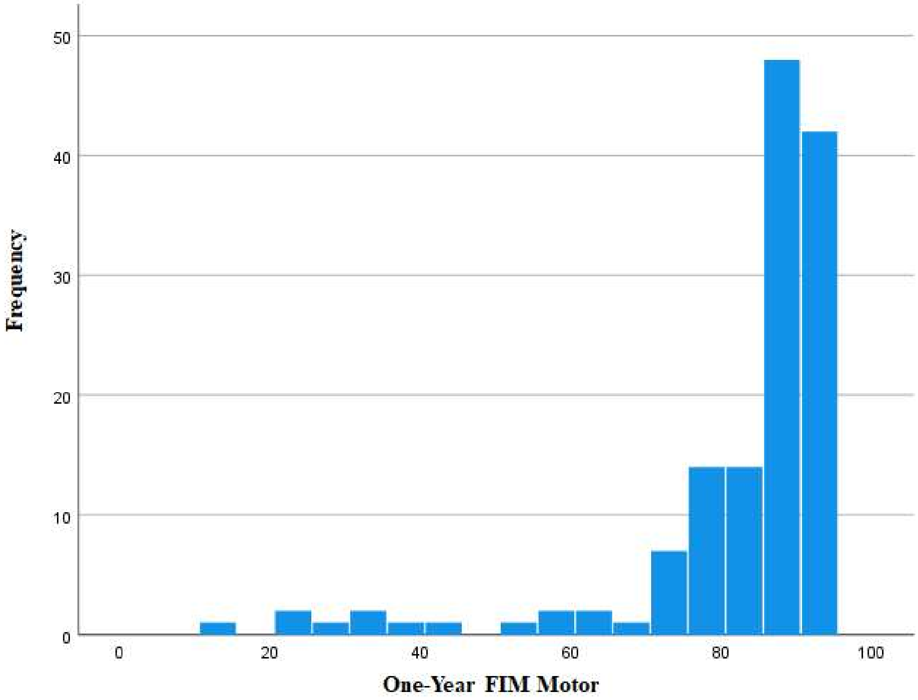


Figure 4. *Two-year FIM Motor histogram.*

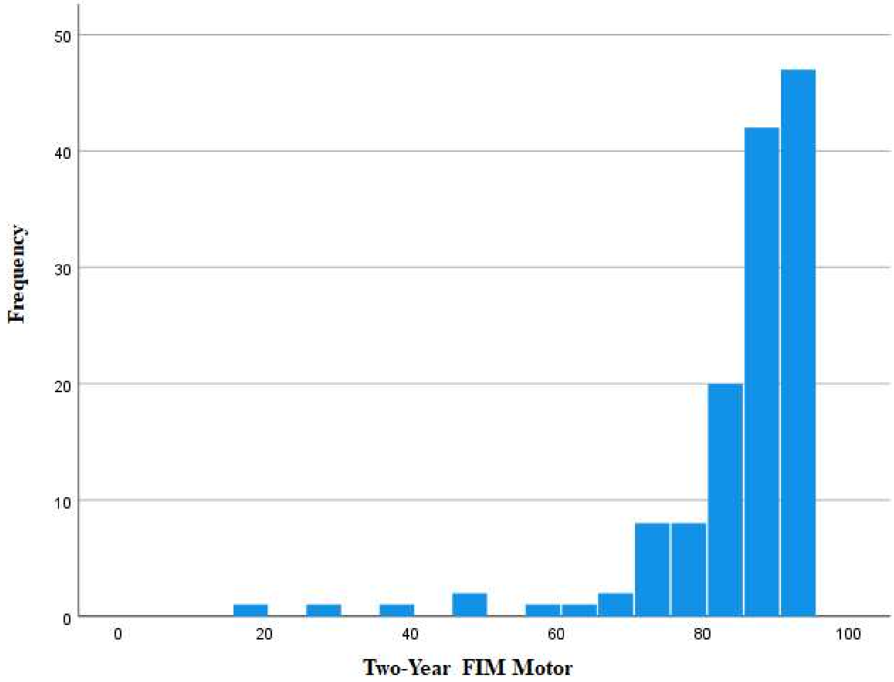
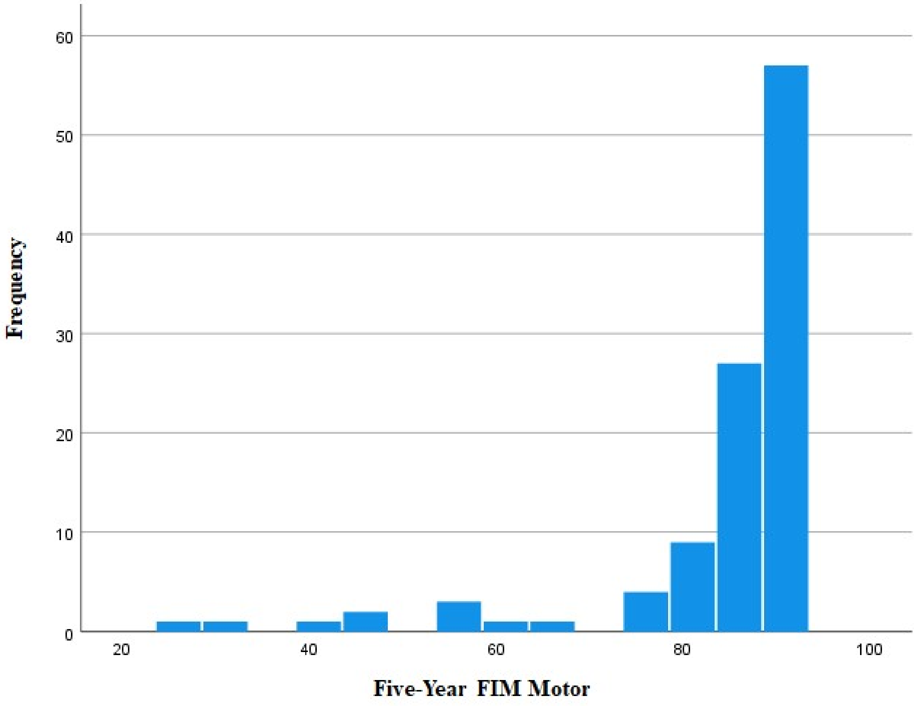


Figure 5. *Five-year FIM Motor histogram.*



Because statistical transformations of variables with ceiling effects still retain those ceilings, the data were not transformed and results should be interpreted in light of the potential limitations of highly clustered data.

Multicollinearity of all possible covariates for the model were examined via correlation coefficients (all $r < .70$) and revealed no problematic multicollinearity. Possible covariates were examined for statistically significant differences between Native Americans and White individuals with TBI via ANOVA or chi-squared tests where necessary (Table 1). Only employment status at the time of injury (employed vs. unemployed) and type of health insurance (private vs. other) were significant ($p = .003$ and $p = .011$ respectively) with White individuals being more likely to be employed at the time of injury and to have private insurance than Native Americans.

Preliminary Curvature Analysis and Missing at Random

For FIM Cognitive and FIM Motor, the Little's MCAR test indicated that the data were missing completely at random (χ^2 [9] = 14.70, $p = .100$); similarly, for SWLS, the Little's MCAR test indicated that the data were also missing completely at random (χ^2 [28] = 26.26, $p = .559$). As noted above, in order to avoid a biased sample from using listwise deletion, FIML was used to account for missing data and to retain all participants despite missingness. A comparison of curvature models suggested that a linear trend, or straight line, best fit FIM Cognitive, FIM Motor, and SWLS trajectories (Table 4).

Table 5
Curvature model comparisons for FIM COG, FIM Motor, and SWLS trajectories

Model	-2 Log Likelihood
FIM COG	
Linear	**2166.69**
Quadratic	2163.24
FIM Motor	

Linear	**2875.54**
Quadratic	2873.72
SWLS	
Linear	**2218.05**
Quadratic	2217.03

Note. Critical χ^2 value for significant difference at α = .05 is a > 3.841 drop from the previous model. No models surpassed this threshold. Bolded values represent the best model fit.

FIM Cognitive

Primary Set 1.

The first set of HLMs examined whether linear trajectories of FIM Cognitive scores could be predicted by race. All statistically significant and non-significant fixed effects from the first HLM within this set and their b-weights and *p*-values appear in Table 5.

Table 6

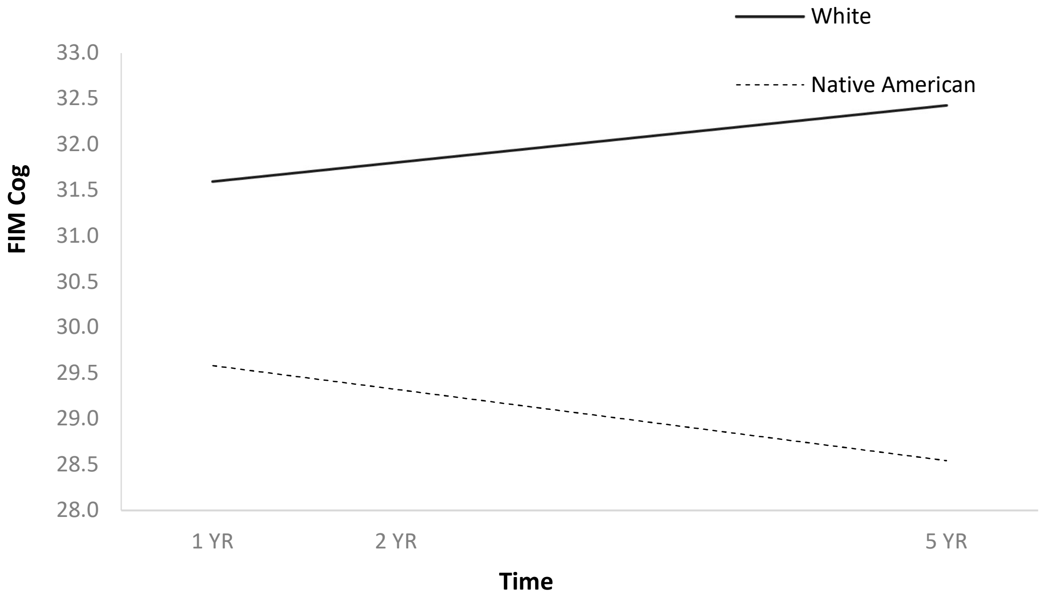
Predictors of FIM Cog, FIM Motor, and SWLS trajectories

	FIM Cog		FIM Motor		SWLS	
Predictor	*b-weight*	*p-value*	*b-weight*	*p-value*	*b-weight*	*p-value*
Set 1: Race						
Intercept	31.76	< .001	86.53	< .001	20.82	< .001
Time	.01	0.954	.08	.738	.33	.127
Native American vs. White	-2.64	< .001	-6.70	< .001	-.69	.588
Set 1: Race Interactions with Time						
Intercept	31.44	< .001	86.15	< .001	20.52	< .001
Time	.20	.107	.34	.311	.52	.064
Native American vs. White	-1.97	.009	-5.90	.004	-.02	.991
Time*Race	-.48	.014	-.57	.239	-.47	.286
Set 2: Race with Covariates						
Intercept	29.99	< .001	80.20	< .001	-	-
Time	.10	.317	.35	.159	-	-
Native American vs. White	-2.23	.004	-4.93	.021	-	-
Employment at Time of Injury	1.80	.025	5.63	.011	-	-
Type of Health Insurance	.38	.617	2.97	.162	-	-
Set 2: Race with Covariates and Time Interactions						
Intercept	29.87	< .001	-	-	-	-
Time	.18	.154	-	-	-	-

Native American vs. White	-1.95	.018	-	-	-	-
Employment at Time of Injury	1.80	.025	-	-	-	-
Type of Health Insurance	.38	.624	-	-	-	-
Time*Race	-.21	.302	-	-	-	-

There was a significant main effect of race on FIM Cognitive trajectories (*p* < .001), suggesting that Native Americans with TBI had lower FIM Cognitive trajectories over time than White individuals with TBI (Figure 6).

Figure 6. *Main effect of race on FIM Cognitive trajectories.*



There was also a significant time*race effect (Table 5; *p* = .014), suggesting that FIM Cognitive trajectories changed differentially over time as a function of race. That is, over time, White individuals' cognitive function tended to improve while the cognitive function of Native Americans decreased (Figure 6).

Primary Set 2.

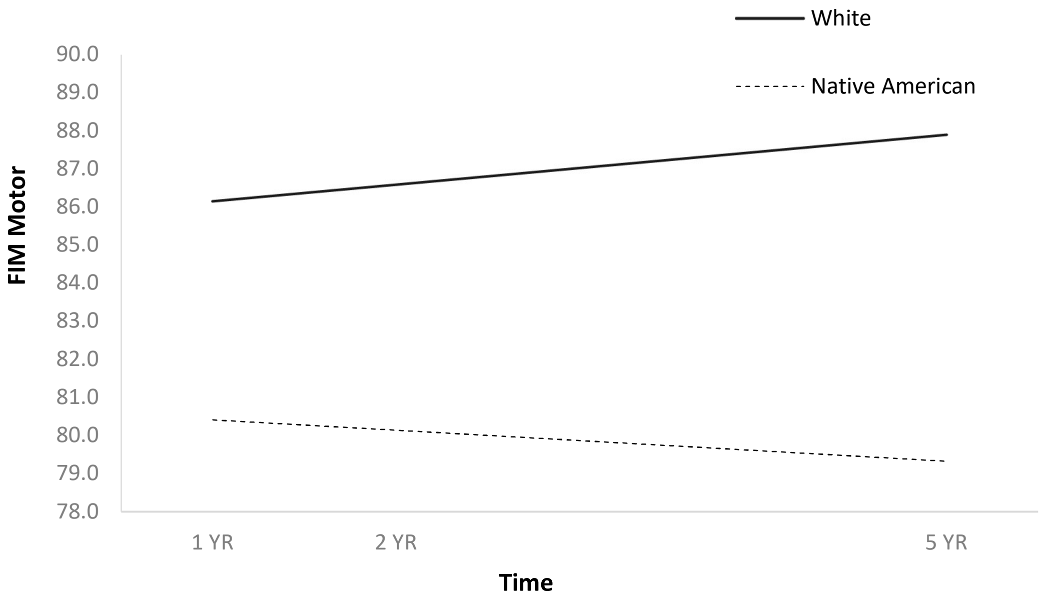
The HLM with demographic and injury-related covariates added to the model found that the effect of race on FIM Cognitive trajectories remained (*p* = .004) even after controlling for possible confounds (employment status at the time of injury and type of health insurance; Table 5). Given that the previous time*race effect was significant, an additional HLM was conducted with the addition of the covariates. There was no significant time*race effect after controlling for the addition of covariates (*p* = .624), suggesting these covariates accounted for the differential effect of race on FIM Cognitive trajectories over time.

FIM Motor

Primary Set 1.

The first set of FIM Motor HLMs examined whether linear trajectories of FIM Motor could be predicted by race. Again, all statistically significant and non-significant fixed effects from the HLM and their b-weights and *p*-values appear in Table 5. There was a significant main effect of race on FIM Motor trajectories (*p* < .001), suggesting that Native Americans with TBI had lower FIM Motor scores over time than White individuals with TBI (Figure 7).

Figure 7. *Main effect of race on FIM Motor trajectories.*



However, there was no significant time*race effect (*p* = .239; Table 5), suggesting that FIM Motor trajectories did not change differentially over time as a function of race.

Primary Set 2.

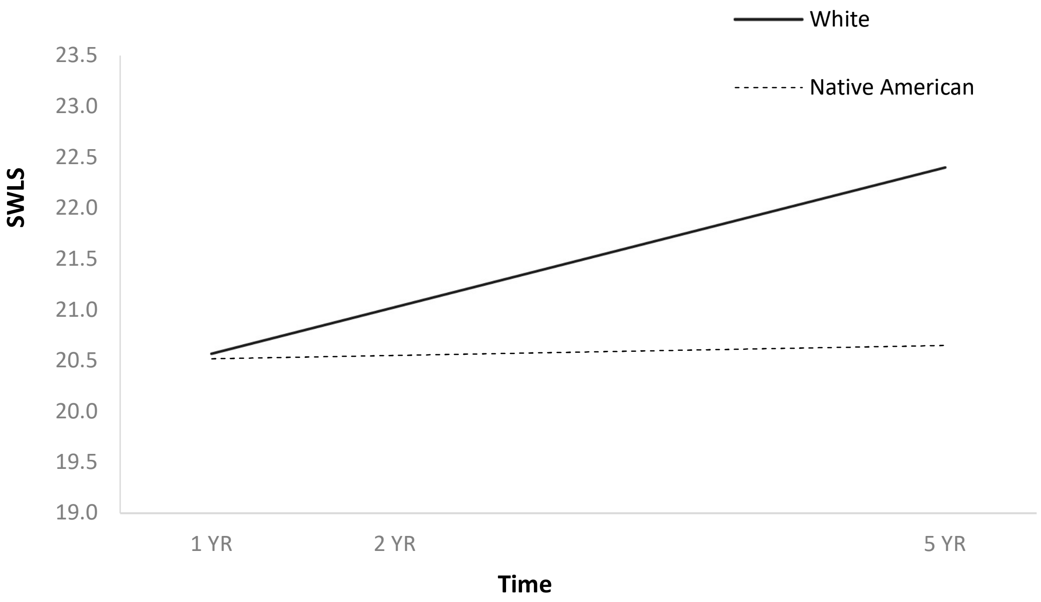
The FIM Motor HLM with employment status at the time of injury and type of health insurance added to the model found that the effect of race on FIM Motor trajectories remained (*p* = .021), even after controlling for possible confounds (Table 5). Because the time*race effect was not significant, no respective follow-up model was run with the addition of covariates.

SWLS

Primary Set 1.

There was no significant main effect of race on SWLS trajectories (*p* = .588; Table 5), suggesting that Native Americans with TBI had statistically equivalent life satisfaction scores over time relative to White individuals (Figure 3).

Figure 3. *Main effect of race on SWLS trajectories.*



Furthermore, there was no interaction effect of time*race, suggesting that trajectories of life satisfaction did not change differentially over time as a function of race. As a result, no additional SWLS models were run attempting to account for effects that were not found.

Discussion

The purpose of this study was to identify whether disparities in cognitive and motor function and life satisfaction existed between Native Americans and White individuals with TBI over the 5 years after injury, and if so, whether they were explained by sociodemographic and injury related characteristics that differed between the two groups. Native Americans exhibited lower cognitive and motor functional independence than White individuals even after controlling for significantly different sociodemographic and injury-related covariates; however, life satisfaction was comparable between the two groups. For cognitive functional independence, Native Americans worsened linearly over time while White individuals improved linearly over time; however, this difference over time dissipated with the addition of the significantly different sociodemographic covariates (employment status at the time of injury and type of health insurance). Native Americans with TBI exhibited significantly worse motor functional independence than White individuals with TBI, even after controlling for sociodemographic and injury related characteristics; however, there was no differential effect over time.

Functional Independence

Cognitive Functional Independence.

As hypothesized, the current study found Native Americans with TBI had worse cognitive function than White individuals with TBI even after accounting for significantly different sociodemographic characteristics (employment status at the time of injury and type of health insurance). This difference increased over time but dissipated after controlling for employment status at the time of injury and type of health insurance. Previous research suggests the majority of functional recovery following a TBI occurs within three months of discharge from the hospital (Zarshenas et al., 2019) and that greater time post-injury predicts further cognitive and motor decline (Sendroy-Terrill et al., 2010). In fact, some studies suggest the majority of individuals with TBI make no meaningful cognitive or physical improvement or even worsen over the first five years following a TBI (CDC, 2021). Further, what little research that does exist on TBI in Native Americans indicates they typically have lower physical and cognitive function following a TBI than White individuals (Fuentes et al., 2016; Whitfield & Lloyd, 2008).

Thus, based on previous research, the expected results were that Native Americans would report significantly worse cognitive function than White individuals but that both groups would show stable or decreasing cognitive function over time. The expected difference in cognitive function—that Native Americans would endorse lower cognitive function than

Whites—(Fuentes et al., 2016; Whitfield & Lloyd, 2008) reinforces the limited literature on TBI in Native Americans by bolstering the claim that a disparity exists in cognitive function between Native Americans and White individuals with TBI. Contrary to previous research, however, White individuals demonstrated a slight increase in cognitive function while Native Americans decreased over time.

While the gap in cognitive function between the two groups grew over time, this differential effect was explained by the significant differences in employment status at the time of injury (i.e., Native Americans were significantly less likely to be employed at the time of injury) and insurance type (i.e., Native Americans were significantly less likely to have private health insurance). It is possible that gainful employment at the time of injury may have been a buffer to cognitive decline in a similar fashion to education. That is, an active mind is less likely to show cognitive decline. Further, employment can bring a host of ancillary benefits like sense of purpose, increased social connection, and money—all of which might play a role in limiting cognitive decline. The current study did not assess the way in which employment status at the time of injury accounts for the differential movement of cognitive functional trajectories.

Access to private insurance also has a number of benefits. Research suggests that following hospital discharge, Native Americans are significantly less likely to engage with healthcare services (Whitfield & Lloyd, 2008) and less likely to receive additional resources post-discharge than other races (Blackmer & Marshall, 1999). This might be explained, in part, by the type of health insurance held by a Native American with TBI. Private insurance often affords better access to care, more options for healthcare providers, and less fear of medical bills. The current study did not assess the way in which type of health insurance held might account for the differential movement of cognitive functional trajectories.

The reason for the significant difference in cognitive function between Native Americans and White individuals with TBI is unclear given the limited scope of the current study and the dearth of research on TBI in Native Americans. The difference in cognitive outcomes is unlikely to be due to differences in sociodemographic or injury related characteristics as the current study examined a host of possible covariates (marital status, years of education, annual earnings, employment status at the time of injury, type of employment [blue vs white collar], violence as a cause of injury, language spoken at home, type of health insurance, and substance use [alcohol, drugs, and tobacco]) while also matching participants on sex, age, and injury severity (time spent in PTA). The theoretical framework of the MHDD (Meade et al., 2015) would suggest there are a plethora of unique cultural and contextual factors underlying this difference that were not assessed in the current study. Examples of some of these characteristics might include barriers to healthcare access, engagement with healthcare services, geographical location, ethnic identity, social support, caregiver relationship, community engagement, and a host of personal factors (like grit, resilience, and coping habits). Without a proper accounting of these important variables, it is impossible to draw specific conclusions as to the origin of the significant difference in cognitive function between Native Americans and White individuals with TBI as any one of these factors or a combination of them may be impacting the difference in cognitive outcomes. Further, given the disparity in cognitive function between Native Americans and White individuals with TBI, it is vital that we investigate and understand the unique cultural and contextual factors involved in creating this disparity to help inform treatment, support, and rehabilitation for Native Americans with TBI.

Physical Functional Independence.

As hypothesized, the current study found Native Americans with TBI had worse physical function than White individuals with TBI even after accounting for significantly different sociodemographic characteristics; however, there was no differential movement over time in FIM Motor trajectories. As noted earlier, previous research suggests FIM Motor trajectories should remain stable or decrease over time (CDC, 2021; Sendroy-Terrill et al., 2010; Zarshenas et al., 2019), and this pattern was discovered in the current study.

As noted in the discussion on the difference in cognitive function, it is impossible to draw specific conclusions within the current study as to the origin of the significant difference in physical function between Native Americans and White individuals with TBI. Knowing the cultural preferences and contextual factors of individuals with TBI is vital to understanding the origins of health and outcome disparities and mechanisms for change. Culture often plays an important role in determining how one views their condition, how they chose to engage with healthcare, and how they view rehabilitation and healing (Wolinksy, 1994).

Possible Explanations of Functional Disparities.

The limited research on TBI in Native Americans suggests some possible contributors to functional disparities. One possible explanation that has been highlighted more than most in the limited research is healthcare access and engagement. Native Americans are far less likely to engage with healthcare services (Whitfield & Lloyd, 2008) and less likely to receive necessary resources post-discharge (Blackmer & Marshall, 1999). Further, despite no significant difference in injury severity, Native Americans are significantly more likely to receive surgical treatment and have a significantly lower number of family conferences prior to discharge (Blackmer & Marshall, 1999). These sorts of healthcare disparities indicate problems at a systemic level with how Native Americans interact with and are treated by the healthcare system.

Native Americans already face significant disparities in poverty, education, employment, violence, trauma, and physical health (Sarche & Spicer, 2008), and a TBI can exacerbate these disparities even further (Erler et al., 2018). It is highly possible that some of the decrease in cognitive and motor function and the stagnancy of life satisfaction within the Native American group that is not reflected in the White group is the result of the compounding nature of both preexisting disparities and a new TBI. The possible compounding effects of on-going disparities in poverty, education, employment, etc. was not assessed in the current study.

Research also suggests that comorbid conditions (e.g., obesity, diabetes, etc.), particularly in the presence of two or more adverse health conditions in addition to TBI, can prevent recovery and exacerbate functional deficits (Zarshenas et al., 2019). Native Americans are chronically underserved within the U.S. health care system and experience a number of health disparities across many diseases (Sarche & Spicer, 2008), making the presence of multiple comorbidities highly likely. Being referred to the emergency department multiple times after discharge is highly associated with worse cognitive and motor function (Zarshenas et al., 2019). Given that the presence of comorbidities is likely and that those comorbidities may interfere with recovery or lead to more emergency room visits, this might be a possible explanation for why the disparities in functional outcome exist; however, this was beyond the scope of the current study.

Life Satisfaction

The average participant score on the SWLS for the full sample fell within the slightly satisfied range (Pavot and Diener, 1993) with a slight visual upward movement for White individuals with TBI while scores for Native Americans with TBI remained stable over time. However, this differential movement was not statistically significant. Contrary to the current study's hypothesis, the overall difference in life satisfaction between the two groups was not significant either, indicating comparable scores. Previous research suggests that life satisfaction should be lowest in the first year after the injury with general improvement thereafter (Brown et el., 2011; Dijkers, 2004) and that racial/ethnic minorities with TBI exhibit significantly lower mental health outcomes (e.g., life satisfaction) than White individuals (Arango-Lasprilla et al., 2007; Perrin et al., 2014). With so little research on mental health outcomes following TBI in Native Americans (Lakhani et al., 2017; Nelson et al., 2007), one is left to draw comparisons to other marginalized groups in order to link the current study's results to previous research.

Based on previous research, the expected results were that Native Americans with TBI would have lower life satisfaction than White individuals with TBI, but both groups would show a general increase in life satisfaction over time. Thus, the visual upward trend for White individuals is expected, but the Native American life satisfaction scores are somewhat contrary to the expected pattern of improving over time. Also contrary to existing research, Native Americans actually endorsed comparable life satisfaction to Whites, despite having lower levels of cognitive and motor functional independence.

There are three possible explanations for this unexpected trend. First, it is possible that life satisfaction is a strength of the Native American community. Cultural and contextual characteristics unique to the Native American community may help buffer possible detractors of life satisfaction that occur following a TBI (Linton et al., 2016; Meade et al., 2015). While no research has been conducted to examine what these factors might be (Lakhani et al., 2017; Nelson et al., 2007), one might reasonably hypothesize that cultural/ethnic identity, social support, and familial bond (just to name a few) might be unique aspects of the Native American culture that might prevent significant reduction in life satisfaction following a TBI relative to White individuals.

Second, given the trend of the life satisfaction scores within the current study, it is possible that, if the trend held, a longer-term study (10-15 years post injury) may reveal significant differences in life satisfaction between Native Americans and White individuals with TBI. In this conceptualization, the expected pattern (i.e., that Native Americans with TBI would have lower life satisfaction over time than White individuals) might exist but cannot be known due to the limited time of the current study (only five years).

And finally, it is possible that the concept of life satisfaction might be different across cultures, both between Whites and Native Americans as well as among Native American tribes. Thus, the results from the current study might be reflective of both qualitative and quantitative differences. The Satisfaction with Life Scale was not normed on Native Americans. It is possible that a culturally specific measure of life satisfaction might uncover different findings.

While the current study did not show a significant difference in life satisfaction between the two groups, it is still important to understand the cultural and contextual characteristics that underpin these results. As noted earlier, it is necessary to understand these factors to help inform treatment, support, and rehabilitation, and doing so may help elucidate key strength- and resilience-based factors upon which to build a culturally informed method of treatment and support for Native Americans with TBI.

Clinical Implications

Native Americans are a chronically underserved group in the United States (Sarche & Spicer, 2008), and the dearth of research on TBI in Native Americans (Lakhani et al., 2017; Nelson et al., 2007) makes it impossible to understand the specific cultural and contextual factors important in both healing and rehabilitation as well as the definitive origin of health disparities. By ignoring these important and unique characteristics, rehabilitation clinicians are missing key factors that can improve outcomes for Native Americans with TBI. Previous research indicates rehabilitation clinicians often do not provide appropriately culturally sensitive care (Meade et al., 2015; Niemeier & Arango-Lasprilla, 2007). Particularly as research has noted that Native American families are often not as included in medical decisions as White families of a person with TBI (Blackmer & Marshall, 1999), one simple way to improve the cultural sensitivity of healthcare provided to Native Americans with TBI would be to make a concerted effort to include the family in medical conferences.

Given that Native Americans are significantly less likely to engage with healthcare services (Whitfield & Lloyd, 2008) and to have appropriate resources following hospital discharge (Blackmer & Marshall, 1999), clinicians should assess the patient’s level of health literacy and provide intervention or advocacy support when appropriate. Especially as Native Americans have been shown to be more likely to undergo surgery despite no difference in injury severity (Blackmer & Marshall, 1999), it is probable that Native American patients and their families are not being given an adequate voice in their treatment. Further, due to the isolated nature of many Native American tribes (Sarche & Spicer, 2008), a concerted effort should be taken by rehabilitation clinicians to assess barriers to healthcare access, particularly as this study found that type of health insurance was a key factor in FIM Cognitive trajectories. Again, it is probable that some of the reticence to engage with healthcare services post-discharge may be due to geographic isolation from services or fear of incurring expensive medical bills.

The culturally distinct nature of Native Americans tribes (Sarche & Spicer, 2008) might indicate that rehabilitation programs need to be specifically tailored to Native Americans. That is, most of the research on TBI and rehabilitation has been Eurocentric with little research conducted for Native Americans alone (Lakhani et al., 2017). It is possible that rehabilitation programs may need to be broader in scope, intensified, longer in duration, or more culturally sensitive/specific (e.g., employing Native American clinicians).

Study Limitations and Future Directions

The current study has several limitations, and thus future directions, which should be considered when interpreting these findings. The sample size of only 80 Native Americans and 80 White individuals with TBI is rather small and makes generalizing to the larger population difficult, especially when considering the culturally distinct nature of Native American tribes throughout the U.S. (Sarche & Spicer, 2008). Further, given the already small sample size, advanced statistical methods (FIML) were used to retain as many participants as possible despite missing data. It is quite possible that some of the significant differences uncovered in the current study may be due to differential attrition. For instance, White individuals had 2.7x more complete data for FIM Cognitive at year 5 than Native Americans. Similar patterns were found for FIM Motor at year 5, with Whites having 2.5x the amount of complete data, and again for life satisfaction at a little more than double the complete data points. This differential attrition may be due to a plethora of issues like barriers to healthcare access, comorbid conditions, death, geographical isolation, etc. Future studies should incorporate a larger sample with less missing data. It is possible that as the TBIMS study continues to gain more participants that this study might be replicated with a larger and more complete sample.

As noted earlier, a host of constructs that might account for the difference in functional outcomes and the visual difference (though non-significant) in the pattern of responses for satisfaction with life were not investigated in the current study. Previous disability research (Linton et al., 2016; Meade et al., 2015) has called for as full an examination of culturally and contextually relevant factors as possible. While the TBIMS database contains a large number of important sociodemographic and injury related characteristics, it is by no means exhaustive. For instance, the TBIMS database does not assess how far the nearest rehabilitation clinic is for a person with TBI, a particularly important variable for assessing healthcare access in isolated Native American communities.

Native Americans are more than twice as likely to have substance use as a factor contributing to their TBI than Whites (Linton et al., 2016), and while substance use was considered as a possible covariate for the current study, data on tobacco use was only available for 21 Native Americans. Similarly, data on alcohol use was only available for 51 Native Americans. Even with this small amount of data, problematic alcohol use was marginally significant ($p = .067$). It is quite possible that with a large, more complete sample size, that substance use would have proved highly relevant. Additionally, the current study only assessed substance use prior to the injury. Future research should pay close attention to the possible role of substance use both before and after TBI.

Native Americans are at significant risk for health disparities across a number of diseases (Sarche & Spicer, 2008), and comorbidities are likely to hamper functional recovery (Zarshenas et al., 2019). The current study did not examine the presence of comorbid conditions. Future research may wish to investigate the presence of comorbid conditions, possible disparities in their presence, and how comorbid conditions might impact outcomes for Native Americans with TBI.

Given that Native Americans endorsed similar levels of life satisfaction as White individuals with TBI, future research may wish to take a strengths-based approach to the study of TBI in Native Americans and attempt to uncover factors, especially those unique to the Native American community, that assist in rehabilitation and healing or buffer the negative effects of

TBI. Doing so might help highlight areas for targeted scaffolding to further improve recovery following a TBI.

Given that the current study highlights the importance of culturally and contextually specific variables to Native Americans in predicting functional outcomes, it is vital to assess potential variables unique to Native Americans in future studies. In addition to the variables listed above (geographic isolation, substance use, and comorbid conditions) future research may wish to consider the role of intimate partner violence in TBI for Native American women (Evans-Campbell et al., 2006; Luna-Firebaugh et al., 2002). A host of interpersonal variables may also be worth investigating like social support, community engagement, caregiver relationship, and family systems. Similarly, personal characteristics like grit, resilience, coping habits, and especially tribal/ethnic identity may prove to be influential.

Conclusion

Few studies have examined TBI in Native Americans; even fewer studies have examined health disparities following TBI in Native Americans, and, prior to the current study, no research had been conducted examining health disparities following TBI in Native Americans with demographically matched White individuals with TBI. While some studies have demonstrated health disparities following TBI in Native Americans, the current study highlighted a significant difference in FIM Cognitive and FIM Motor trajectories between Native Americans and White individuals. Further, the current study found that the differential movement of FIM Cognitive trajectories over time was accounted for by baseline differences in employment status and type of health insurance held. These novel findings demonstrate that culturally and contextually specific characteristics of Native Americans drastically impact functional outcomes and that pre-injury disparities in employment status and insurance type have important implications for cognitive recovery in the 5 years after discharge from the hospital. This study highlights the great need for investigation of the factors unique to Native Americans that may impact functional outcome.

References

Albrecht, J. S., Barbour, L., Abariga, S. A., Rao, V., & Perfetto, E. M. (2019). Risk of depression after traumatic brain injury in a large national sample. *Journal of Neurotrauma, 36*, 300-307. http://dx.doi.org/10.1089/neu.2017.5608

American Psychiatric Association. (2013). Neurocognitive disorders. In *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

Anke, A., Andelic, N., Skandsen, T., Knoph, R., Ader, T., Manskow, U., ... & Røe, C. (2015). Functional recovery and life satisfaction in the first year after severe traumatic brain injury: A prospective multicenter study of a Norwegian national cohort. *Journal of Head Trauma Rehabilitation*, *30*(4), E38-E49. http://dx.doi.org/10.1097/HTR.0000000000000080

Arango-Lasprilla, J. C., & Niemeier, J. (2007). Cultural issues in the rehabilitation of TBI survivors: Recent research and new frontiers. *The Journal of Head Trauma Rehabilitation*, *22*(2), 73-74. http://dx.doi.org/10.1097/01.HTR.0000265094.98940.e0

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

Baalen, B. V., Odding, E., Maas, A. I., Ribbers, G. M., Bergen, M. P., & Stam, H. J. (2003). Traumatic brain injury: Classification of initial severity and determination of functional outcome. *Disability and Rehabilitation*, *25*(1), 9-18. http://dx.doi.org/10.1080/713813430

Bazarian, J. J., Pope, C., McClung, J., Cheng, Y. T., & Flesher, W. (2003). Ethnic and racial disparities in emergency department care for mild traumatic brain injury. *Academic*

Emergency Medicine, *10*(11), 1209-1217. http://dx.doi.org/10.1197/S1069-6563(03)00491-3

Berger, E., Leven, F., Pirente, N., Bouillon, B., & Neugebauer, E. (1999). Quality of life after traumatic brain injury: A systematic review of the literature. *Restorative Neurology & Neuroscience, 14*, 93-102.

Blackmer, J.& Marshall, S. C. (1999). A comparison of traumatic brain injury in the Saskatchewan native North American and non-native North American populations. *Brain Injury*, *13*(8), 627-635. https://doi.org/10.1080/026990599121359

Bogner, J. A. , Whiteneck, G. G. , MacDonald, J. , Juengst, S. B. , Brown, A. W. , Philippus, A. M., Marwitz, J. H. , Lengenfelder, J. , Mellick, D. , Arenth, P. & Corrigan, J. D. (2017). Test-Retest reliability of traumatic brain injury outcome measures: A Traumatic Brain Injury Model Systems study. *Journal of Head Trauma Rehabilitation, 32* (5), E1-E16. http://dx.doi.org/10.1097/HTR.0000000000000291

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. http://dx.doi.org/10.1001/jama.2010.599

Bombardier, C. H., Hoekstra, T., Dikmen, S., & Fann, J. R. (2016). Depression trajectories during the first year after traumatic brain injury. *Journal of Neurotrauma, 33*, 2115–2124. http://dx.doi.org/10.1089/neu.2015.4349

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*, 686-690. http://dx.doi.org/10.1097/MLR.0b013e31803dcdf3

Brown, A. W., Moessner, A. M., Mandrekar, J., Diehl, N. N., Leibson, C. L., & Malec, J. F. (2011). A survey of very-long-term outcomes after traumatic brain injury among members of a population-based incident cohort. *Journal of Neurotrauma*, *28*(2), 167–176. https://doi.org/10.1089/neu.2010.1400

Bryant, R. A., O'donnell, M. L., Creamer, M., McFarlane, A. C., Clark, C. R., & Silove, D. (2010). The psychiatric sequelae of traumatic injury. *American Journal of Psychiatry*, *167*, 312-320. http://doi.org/10.1176/appi.ajp.2009.09050617

Burleigh, S. A., Farber, R. S., & Gillard, M. (1998). Community integration and life satisfaction after traumatic brain injury: Long-term findings. *The American Journal of Occupational Therapy*, *52*(1), 45-52. http://dx.doi.org/10.5014/ajot.52.1.45

Capruso, D. X., & Levin, H. S. (1992). Cognitive impairment following closed head injury. *Neurologic Clinics*, *10*(4), 879-893. http://dx.doi.org/10.1016/S0733-8619(18)30185-3

Catalano, D., Pereira, A. P., Wu, M. Y., Ho, H., & Chan, F. (2006). Service patterns related to successful employment outcomes of persons with traumatic brain injury in vocational rehabilitation. *NeuroRehabilitation*, *21*(4), 279-293. http://dx.doi.org/10.3233/NRE-2006-21403

Centers for Disease Control and Prevention. (2014). Traumatic brain injury in the United States: Fact sheet. Centers for Disease Control and Prevention, U.S. Department of Health and Human Services. Retrieved October 31, 2021, from https://www.cdc.gov/traumaticbraininjury/get_the_facts.html

Centers for Disease Control and Prevention. (2019). Surveillance report of traumatic brain injury-related emergency department visits, hospitalizations, and deaths—United States,

2014. Centers for Disease Control and Prevention, U.S. Department of Health and Human Services. Retrieved October 31, 2021, from https://www.cdc.gov/traumaticbraininjury/data/tbi-edhd.html

Centers for Disease Control and Prevention (2021a). National Center for Health Statistics: Mortality Data on CDC WONDER. Retrieved December 11, 2021, from https://wonder.cdc.gov/mcd.html.

Centers for Disease Control and Prevention (2021b). Surveillance report of traumatic brain injury-related hospitalizations and deaths by age group, sex, and mechanism of injury—United States, 2016 and 2017. Centers for Disease Control and Prevention, U.S. Department of Health and Human Services. Retrieved October 31, 2021, from Surveillance Report (cdc.gov)

Centers for Disease Control and Prevention, National Center for Injury Prevention and Control. (2021c). *Moderate to severe traumatic brain injury is a lifelong condition.* Retrieved October 10, 2022, from: www.cdc.gov/TraumaticBrainInjury

Chen, A., Bushmeneva, K., Zagorski, B., Colantonio, A., Parsons, D., & Wodchis, W. P. (2012). Direct cost associated with acquired brain injury in Ontario. *BMC Neurology*, *12*(1), 1-12. http://dx.doi.org/10.1186/1471-2377-12-76

Cicerone, K. D., & Azulay, J. (2007). Perceived self-efficacy and life satisfaction after traumatic brain injury. *The Journal of Head Trauma Rehabilitation*, *22*(5), 257-266. http://dx.doi.org/10.1097/01.HTR.0000290970.56130.81

Corrigan, J. D., Bogner, J. A., Mysiw, W. J., Clinchot, D., & Fugate, L. (2001). Life satisfaction after traumatic brain injury. *The Journal of Head Trauma Rehabilitation*, *16*(6), 543-555. http://dx.doi.org/10.1097/00001199-200112000-00003

Corrigan, J. D., Smith-Knapp, K., & Granger, C. V. (1997). Validity of the functional independence measure for persons with traumatic brain injury. *Archives of Physical Medicine and Rehabilitation*, *78*(8), 828-834. http://dx.doi.org/10.1016/S0003-9993(97)90195-7

Cowen, T. D., Meythaler, J. M., DeVivo, M. J., Ivie III, C. S., Lebow, J., & Novack, T. A. (1995). Influence of early variables in traumatic brain injury on functional independence measure scores and rehabilitation length of stay and charges. *Archives of Physical Medicine and Rehabilitation*, *76*(9), 797-803. http://dx.doi.org/10.1016/S0003-9993(95)80542-7

Curzel, J., Forgiarini Junior, L. A., & Rieder, M. de M. (2013). Evaluation of functional independence after discharge from the intensive care unit. *Revista Brasileira de Terapia Intensiva*, *25*(2), 93–98. https://doi.org/10.5935/0103-507X.20130019

Dewan, M. C., Rattani, A., Gupta, S., Baticulon, R. E., Hung, Y. C., Punchak, M., ... & Rosenfeld, J. V. (2018). Estimating the global incidence of traumatic brain injury. *Journal of Neurosurgery*, *1*30(4), 1080-1097. http://dx.doi.org/10.3171/2017.10.JNS17352

Diener, E. D., Emmons, R. A., Larsen, R. J., & Griffin, S. (1985). The satisfaction with life scale. *Journal of Personality Assessment*, *49*(1), 71-75. http://dx.doi.org/10.1207/s15327752jpa4901_13

Dijkers M. P. (2004). Quality of life after traumatic brain injury: a review of research approaches and findings. *Archives of physical medicine and rehabilitation*, *85*(4 Suppl 2), S21–S35. https://doi.org/10.1016/j.apmr.2003.08.119

Erler, K. S., Whiteneck, G. G., Juengst, S. B., Locascio, J. J., Bogner, J. A., Kaminski, J., & Giacino, J. T. (2018). Predicting the trajectory of participation after traumatic brain injury: A longitudinal analysis. *The Journal of Head Trauma Rehabilitation*, *33*(4), 257-265. http://dx.doi.org/10.1097/HTR.0000000000000383

Evans-Campbell, T., Lindhorst, T., Huang, B., & Walters, K. L. (2006). Interpersonal violence in the lives of urban American Indian and Alaska Native women: Implications for health, mental health, and help-seeking. *American Journal of Public Health*, *96*(8), 1416-1422. http://dx.doi.org/10.2105/AJPH.2004.054213

Fann J. R., Katon W. J., Uomoto J. M., & Esselman P.C. (1995). Psychiatric disorders and functional disability in outpatients with traumatic brain injuries. *American Journal of Psychiatry,* 152:1493–1499. http://dx.doi.org/10.1097/00001199-199608000-00013

Fuentes, M. M., Jimenez, N., Apkon, S. D., & Rivara, F. P. (2016). Functional outcomes during inpatient rehabilitation for American Indian and Alaska Native children with traumatic brain injury. *Journal of Pediatric Rehabilitation Medicine*, *9*(2), 133-141. http://dx.doi.org/10.3233/PRM-160376

Fuhrer, M. J., Rintala, D. H., Hart, K. A., Clearman, R., & Young, M. E. (1992). Relationship of life satisfaction to impairment, disability, and handicap among persons with spinal cord injury living in the community. *Archives of Physical Medicine and Rehabilitation*, *73*(6), 552-557. https://doi.org/10.5555/uri:pii:0003999392901908

Hart, T., Fann, J. R., Chervoneva, I., Juengst, S. B., Rosenthal, J. A., Krellman, J. W., ... & Kroenke, K. (2016). Prevalence, risk factors, and correlates of anxiety at 1 year after moderate to severe traumatic brain injury. *Archives of Physical Medicine and Rehabilitation*, *97*(5), 701-707. http://dx.doi.org/10.1016/j.apmr.2015.08.436

Hartman-Maeir, A., Soroker, N., Ring, H., Avni, N., & Katz, N. (2007). Activities, participation and satisfaction one-year post stroke. *Disability and Rehabilitation*, *29*(7), 559-566. http://dx.doi.org/10.1080/09638280600924996

Heinemann, A. W., Linacre, J. M., Wright, B. D., Hamilton, B. B., & Granger, C. (1993). Relationships between impairment and physical disability as measured by the functional independence measure. *Archives of Physical Medicine and Rehabilitation*, *74*(6), 566-573. http://dx.doi.org/10.1016/0003-9993(93)90153-2

Hoofien, D., Gilboa, A., Vakil, E., & Donovick, P. J. (2001). Traumatic brain injury (TBI) 10-20 years later: A comprehensive outcome study of psychiatric symptomatology, cognitive abilities and psychosocial functioning. *Brain Injury*, *15*(3), 189-209.

Holsinger, T., Steffens, D. C., Phillips, C., Helms, M. J., Havlik, R. J., Breitner, J. C. S., Guralnik, J. M., & Plassman, B. L. (2002). Head injury in early adulthood and the lifetime risk of depression. *Archives of General Psychiatry*, *59*(1), 17–22. https://doi.org/10.1001/archpsyc.59.1.17

Humphreys, I., Wood, R. L., Phillips, C. J., & Macey, S. (2013). The costs of traumatic brain injury: A literature review. *ClinicoEconomics and Outcomes Research: CEOR*, *5*, 281. https://doi.org/10.2147/CEOR.S44625

Jacobsson, L. J., Westerberg, M., & Lexell, J. (2010). Health-related quality-of-life and life satisfaction 6–15 years after traumatic brain injuries in northern Sweden. *Brain Injury*, *24*(9), 1075-1086. http://dx.doi.org/10.3109/02699052.2010.494590

Jorge, R. E., Robinson, R. G., Moser, D., Tateno, A., Crespo-Facorro, B., & Arndt, S. (2004). Major depression following traumatic brain injury. *Archives of General Psychiatry*, *61*(1), 42-50. http://dx.doi.org/10.1001/archpsyc.61.1.42

Jorge, R. E, Robinson, R. G., Starkstein S. E., & Arndt, S.V. (1993). Depression and anxiety following traumatic brain injury. *Journal of Neuropsychiatry,* 5:369–374. https://psycnet.apa.org/doi/10.1176/jnp.5.4.369

Lakhani, A., Townsend, C., & Bishara, J. (2017). Traumatic brain injury amongst indigenous people: A systematic review. *Brain Injury*, *31*(13-14), 1718-1730. http://dx.doi.org/10.1080/02699052.2017.1374468

Langlois, J. A., Kegler, S. R., Butler, J. A., Gotsch, K. E., Johnson, R. L., Reichard, A. A., ... & Summ, M. S. (2003). Traumatic brain injury-related hospital discharges. Results from a 14-state surveillance system 1997. Morbidity and mortality weekly report. *Surveillance Summaries*, Washington, D.C.

Levin, H. S., Goldstein, F. C., High, W. M., & Eisenberg, H. M. (1988). Disproportionately severe memory deficit in relation to normal intellectual functioning after closed head injury. *Journal of Neurology, Neurosurgery & Psychiatry*, *51*(10), 1294-1301. http://dx.doi.org/10.1136/jnnp.51.10.1294

Linacre, J. M., Heinemann, A. W., Wright, B. D., Granger, C. V., & Hamilton, B. B. (1994). The structure and stability of the functional independence measure. *Archives of Physical Medicine and Rehabilitation*, *75*(2), 127–132. https://doi.org/10.1016/0003-9993(94)90384-0

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. http://dx.doi.org/10.3109/02699052.2014.901558

Linton, K. F., Jung Kim, B. & Kim, B. J. (2016). The Moderation of blood alcohol levels on higher odds of survival among American Indians with violent, blunt-force traumatic brain injuries. *Social Work in Public Health*, *31*(3), 168-174. http://dx.doi.org/10.1080/19371918.2015.1087920

Luna-Firebaugh, E. M., Lobo, S., Hailer, J. Barragan, D., Mortensen, M., & Pearson, D. (2002). Impact evaluation of STOP grant program for reducing violence against women among Indian tribes, Final Report. National Institute of Justice. Washington, D.C. Retrieved on October 31, 2021, from https://www.ojp.gov/pdffiles1/nij/grants/195174.pdf

Maas, A. I., Menon, D. K., Adelson, P. D., Andelic, N., Bell, M. J., Belli, A., ... & Francony, G. (2017). Traumatic brain injury: Integrated approaches to improve prevention, clinical care, and research. *The Lancet Neurology*, *16*(12), 987-1048. http://dx.doi.org/10.1016/S1474-4422(17)30371-X

Mailhan, L., Azouvi, P., & Dazord, A. (2005). Life satisfaction and disability after severe traumatic brain injury. *Brain Injury*, *19*(4), 227-238. http://dx.doi.org/10.1080/02699050410001720149

Mallya, S., Sutherland, J., Pongracic, S., Mainland, B., & Ornstein, T. J. (2015). The manifestation of anxiety disorders after traumatic brain injury: A review. *Journal of Neurotrauma*, *32*(7), 411-421. http://dx.doi.org/10.1089/neu.2014.3504

Meade, M. A., Mahmoudi, E., & Lee, S. Y. (2015). The intersection of disability and healthcare disparities: A conceptual framework. *Disability and Rehabilitation*, *37*(7), 632-641. http://dx.doi.org/10.3109/09638288.2014.938176

Milders, M., Fuchs, S., & Crawford, J. R. (2003). Neuropsychological Impairments and Changes in Emotional and Social Behavior Following Severe Traumatic Brain Injury. *Journal of Clinical and Experimental Neuropsychology*, *25*(2), 157–172. http://dx.doi.org/10.1076/jcen.25.2.157.13642

Model Systems Knowledge Translation Center. (2020). The Traumatic Brain Injury Model Systems. Retrieved from https://msktc.org/sites/default/files/2021-DRAFT-TBIMS-Slides-508.pdf

National Data and Statistical Center (NDSC). (2017, March). *The traumatic brain injury model systems*: *National Institute on Disability, Independent Living, and Rehabilitation Research.* Model Systems Knowledge Translation Center. https://www.tbindsc.org/StaticFiles/Documents/2017_TBIMS_InfoSheet_Brochure.pdf

Nelson, L. A., Rhoades, D. A., Noonan, C., Manson, S. M., & AI-SUPERPFP Team. (2007). Traumatic brain injury and mental health among two American Indian populations. *The Journal of Head Trauma Rehabilitation*, *22*(2), 105-112. http://dx.doi.org/10.1097/01.HTR.0000265098.52306.a9

Niemeier, J., & Arango-Lasprilla, J. C. (2007). Toward improved rehabilitation services for ethnically diverse survivors of traumatic brain injury. *The Journal of Head Trauma Rehabilitation*, *22*(2), 75-84. http://dx.doi.org/10.1097/01.HTR.0000265095.06565.7b

Pavot, W., & Diener, E. (1993). Review of the Satisfaction with Life Scale. *Psychological Assessment,* 5, 164-172. http://dx.doi.org/10.1037/1040-3590.5.2.164

Perrin, P. B., Krch, D., Sutter, M., Snipes, D. J., Arango-Lasprilla, J. C., Kolakowsky-Hayner, S. A., Wright, J., & Lequerica, A. (2014). Racial/ethnic disparities in mental health over the first two years after traumatic brain injury: A model systems study. *Archives of Physical Medicine & Rehabilitation, 95*, 2288-2295. http://dx.doi.org/10.1016/j.apmr.2014.07.409

Pierce, C. A., & Hanks, R. A. (2006). Life satisfaction after traumatic brain injury and the World Health Organization model of disability. *American Journal of Physical Medicine & Rehabilitation*, *85*(11), 889-898. http://dx.doi.org/10.1097/01.phm.0000242615.43129.ae

Polinder, S., Haagsma, J. A., van Klaveren, D., Steyerberg, E. W., & Van Beeck, E. F. (2015). Health-related quality of life after TBI: A systematic review of study design, instruments, measurement properties, and outcome. *Population Health Metrics*, *13*(1), 1-12. http://dx.doi.org/10.1186/s12963-015-0037-1

Pugh, M. (2021). Racial/ethnic disparities in longitudinal trajectories of arrest probability after traumatic brain injury. Virginia Commonwealth University.

Rao, V., & Lyketsos, C. (2002). Psychiatric aspects of traumatic brain injury. *The Psychiatric Clinics of North American,* 25:43–69. http://dx.doi.org/10.1016/S0193-953X(03)00052-2

Rivers, C. S., Fallah, N., Noonan, V. K., Whitehurst, D. G., Schwartz, C. E., Finkelstein, J. A., ... & Ho, C. (2018). Health conditions: Effect on function, health-related quality of life, and life satisfaction after traumatic spinal cord injury. A prospective observational registry cohort study. *Archives of Physical Medicine and Rehabilitation*, *99*(3), 443-451. http://dx.doi.org/10.1016/j.apmr.2017.06.012

Roozenbeek, B., Maas, A. I., & Menon, D. K. (2013). Changing patterns in the epidemiology of traumatic brain injury. *Nature Reviews Neurology*, *9*(4), 231–236. https://doi.org/10.1038/nrneurol.2013.22

Rutland-Brown, W., Wallace, L. D., Faul, M. D., & Langlois, J. A. (2005). Traumatic brain injury hospitalizations among American Indians/Alaska natives. *The Journal of Head Trauma Rehabilitation*, *20*(3), 205-214. http://dx.doi.org/10.1097/00001199-200505000-00004

Sarche, M., & Spicer, P. (2008). Poverty and health disparities for American Indian and Alaska Native children: Current knowledge and future prospects. *Annals of the New York Academy of Sciences*, *1136*, 126. http://dx.doi.org/10.1196/annals.1425.017

Schofield, P. W., Moore, T. M., & Gardner, A. (2014). Traumatic brain injury and olfaction: A systematic review. *Frontiers in Neurology*, *5*, 5. http://dx.doi.org/10.3389/fneur.2014.00005

Scholten, A. C., Haagsma, J. A., Cnossen, M. C., Olff, M., Van Beeck, E. F., & Polinder, S. (2016). Prevalence of and risk factors for anxiety and depressive disorders after traumatic brain injury: A systematic review. *Journal of Neurotrauma*, *33*(22), 1969-1994. http://dx.doi.org/10.1089/neu.2015.4252

Shiho, F. (2018). The burden of traumatic brain injury in children. *Lancet (London, England)*, *391*, 813. https://doi.org/10.1016/S0140-6736(18)30547-6

Stålnacke, B. M. (2007). Community integration, social support and life satisfaction in relation to symptoms 3 years after mild traumatic brain injury. *Brain Injury*, *21*(9), 933-942. http://dx.doi.org/10.1080/02699050701553189

Stineman, M. G., Shea, J. A., Jette, A., Tassoni, C. J., Ottenbacher, K. J., Fiedler, R., & Granger, C. V. (1996). The functional independence measure: Tests of scaling assumptions, structure, and reliability across 20 diverse impairment categories. *Archives of Physical Medicine and Rehabilitation*, *77*(11), 1101–1108. https://doi.org/10.1016/S0003-9993(96)90130-6

Stevens, L. F., Lapis, Y., Tang, X., Sander, A. M., Dreer, L. E., Hammond, F. M., ... & Nakase-Richardson, R. (2017). Relationship stability after traumatic brain injury among veterans and service members: A VA TBI Model Systems study. *The Journal of Head Trauma Rehabilitation*, *32*(4), 234. http://dx.doi.org/10.1097/HTR.0000000000000324

Whitfield, H. W., & Lloyd, R. (2008). American Indians/Native Alaskans with traumatic brain injury: Examining the impairments of traumatic brain injury, disparities in service provision, and employment outcomes. *Rehabilitation Counseling Bulletin*, *51*(3), 190-192. http://dx.doi.org/10.1177/0034355207311316

Williams, M. W., Rapport, L. J., Millis, S. R., & Hanks, R. A. (2014). Psychosocial outcomes after traumatic brain injury: Life satisfaction, community integration, and distress. *Rehabilitation Psychology*, *59*(3), 298-305. http://dx.doi.org/10.1037/a0037164

Wolinsky F. D. (1994). Health services utilization among older adults: Conceptual, measurement, and modeling issues in secondary analysis. *The Gerontologist*, *34*(4), 470–475. https://doi.org/10.1093/geront/34.4.470

Zarshenas, S., Colantonio, A., Horn, S. D., Jaglal, S., & Cullen, N. (2019). Cognitive and motor recovery and predictors of long-term outcome in patients with traumatic brain injury. *Archives of Physical Medicine and Rehabilitation*, *100*(7), 1274-1282. http://dx.doi.org/10.1016/j.apmr.2018.11.023