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

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ABSTRACT

INFLUENCE OF IMMIGRATION STATUS ON THE 10-YEAR TRAJECTORIES OF PSYCHOSOCIAL FUNCTIONING IN INDIVIDUALS WITH TRAUMATIC BRAIN INJURY

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The population of racially/ethnically diverse groups within the U.S. is growing at an exponential rate. The U.S. Census Bureau estimated the number of foreign-born individuals in the U.S. to be nearly 40 million or 13% of the total population (Grieco et al., 2012). Racially/ethnically diverse groups in the U.S. have a higher incidence of traumatic brain injury (TBI; Gary et al., 2009). Although racial/ethnic disparities have been documented in numerous outcomes, research has yet to thoroughly explore differences in rehabilitation outcomes for immigrants relative to U.S.-born individuals. The purpose of this study was to compare the functional and mental health outcomes over the first 10 years after TBI for individuals born in the U.S. vs. those who had immigrated to the U.S. For the current analyses, a sample of 12,161 individuals in the TBI Model Systems database with a coding for Country of Birth = US (N=10,662) vs. Other than the US (N=1,507) was used. Findings suggested that immigrants with TBI exhibited higher life satisfaction trajectories than those born in the U.S., even after controlling for demographic and injury-related covariates, but comparable levels of depression and anxiety. Immigrants also exhibited lower motor functional independence trajectories than those born in the U.S., again even after controlling for demographic and injury-related covariates. However, immigrants generally showed a stronger upward quadratic trajectory in motor functional independence with the greatest gains between the 5- and 10-year time points, whereas those born in the U.S. improved more quickly but then plateaued between the 5- and 10-year time points; these differential effects over time dissipated with the addition of demographic and injury-related covariates. Immigrants exhibited lower cognitive functional independence trajectories, as well as greater supervision needs trajectories, than those born in the U.S., even after controlling for demographic and injury-related covariates. These findings support current literature suggesting that racially/ethnically diverse group exhibit lower functional independence on the FIM when compared to White American groups. They may also suggest potential systematic barriers such as healthcare access and language barriers that may influence the frequency, rate, and quality of care received. The results highlight the importance of uncovering cultural distinctions and can aid in facilitating research examining immigration-based disparities following TBI.

Overview of the Literature Review

This literature review will summarize the research on issues surrounding US born vs. immigrant individuals with traumatic brain injury (TBI) with a particular focus on functional and mental health outcomes. It will begin by discussing the epidemiology and prevalence of TBI, considering racial/ethnic disparities in rates of TBI. This will be followed by a description of common impairments and related needs following TBI. The review will discuss impairments in functional status, such as reductions in functional independence, and will provide contexts to the level of supervision needs based on one's functional ability. The review will then discuss common mental health issues after TBI, including depression, anxiety, and reduced life satisfaction. The review will then move on to describing findings within the context of racial/ethnic disparities and immigration disparities. Although TBI has a common etiological presentation that is consistent across persons with TBI, several factors may yield differential outcomes for racial/ethnic minority populations and foreign-born populations. Specific attention will be paid to disparities in services utilization, psychosocial outcomes, and potential culturally-based sources of these disparities. The literature review will finally describe the purpose of this study, which is to examine possible immigration-based disparities in functional and mental health outcomes over the first 10 years after TBI between individuals born in the US vs. immigrant individuals.

Epidemiology of TBI

Traumatic brain injury (TBI) is regarded as a critical public health problem and a major contributor to morbidity and mortality (Bonow et al., 2017). The global estimate of TBI is approximately 69 million people annually sustaining a new TBI (Dewan et al., 2019), which often results in lifelong disability and chronic illness for those who survive (Roozenbeek et al., 2013). In the literature, TBI is branded as the "silent epidemic" which is reflective of the lack of societal awareness regarding the magnitude of TBI prevalence, the invisible nature by which physical and psychosocial consequences manifest, and the global underreporting of TBI (Hyder et al., 2007). The global incidence of TBI worldwide is rising, with motor vehicle accidents as the primary cause of injury in lower and middle-income countries, and the greatest proportion of TBIs resulting from road traffic collisions was in Africa and Southeast Asia and lowest in North America (Dewan et al., 2018).

In the US, falls represent the primary cause of TBI in children age 0-17 and adults 55 and older (CDC, 2019; Roozenbeek et al., 2013). It is estimated that around 5.3 million people in the US are living with TBI-related disabilities (Roozenbeek et al., 2013), and approximately 500-800 new cases per 100,000 people are estimated each year (Dewan et al., 2018). Relative to the US, in low-to-middle-income countries (LMICs), rates of TBI are elevated and outcomes worse due to increased risk factors such as living below the poverty line, residing in a conflict zone (Collaborators MCT, 2008), a lack of preventative measures, and having less developed health systems to address physical and mental health outcomes (World Health Organization, 2009; Puvanachandra & Hyder, 2008).

According to the CDC, TBI is a major cause of morbidity and mortality in both children and adults, with unintentional falls as the principal mechanism of injury (47.9%), followed by collision with an object (17.1%), and motor vehicle accidents (13.2%) (CDC surveillance report, 2019). In 2014, about 2.87 million TBI-related emergency department (ED) visits, hospitalizations, and deaths occurred in the US (CDC, 2019). The number of TBI-related emergency department visits, hospitalizations, and deaths (EDHDs) in 2014 represents a 53% increase from 2006, in which there were approximately 1.88 million TBI-EDHDs. From 2006 to 2014, the number of TBI-related emergency department hospital visits increased by 63%, hospitalization increased by 3.5%, and the number of TBI-related deaths increased by 4.3% (CDC, 2019).

Diversity of US Population

The population of racially/ethnically diverse groups within the US is growing at an exponential rate. About two-thirds (62%) of the foreign-born population came to live in the US in 1990 or later, including over one-third (35%) who entered in 2000 or later (Grieco et al., 2012). The most growth occurred in Spanish-speaking and Latinx populations, and the majority (63.6%) of immigrants from Latin America currently living in the US came to the US in 1990 or later. Similarly, 78% of the foreign-born US population from Africa and 62.8% of the foreign-born US population from Asia entered the US in 1990 or later (Grieco et al., 2012).

It has been projected that by 2050, about 45% of the country's total population in 2050 will consist of racially/ethnically diverse groups (US Census Bureau, 2006). The influx of diverse racial/ethnic groups largely is attributed to immigration. Following the Immigration Act of 1965 that abolished the national origins quota system, there has been a shift in the racial/ethnic makeup of immigrants from predominantly European populations to predominantly Latin American, Asian, and African populations (US Census, 2020). In 2010, the US Census Bureau estimated the number of foreign-born individuals in the US to be nearly 40 million, or 13% of the total population (Grieco et al., 2012). Foreign-born individuals from Latin America were the largest group, accounting for 21.2 million individuals (over 53%) of all foreign-born groups, followed by individuals from Asia (28%) Europe (12 percent), and Africa (4%; Grieco et al., 2012).

Racial/Ethnic TBI Disparities in TBI Rates

Over the past decades, various studies have shown that racial/ethnic minorities in the US have a higher incidence of TBI, with rates of injuries for Black populations at 278 injuries per 100,000 people and Hispanics at 262 per 100,000, compared to Whites at 209 per 100,000 (Cooper et al., 1983). Race-specific annual incidence in US emergency departments showed that although the total frequency of TBI in the White population (921,580 per year) was five times that in the Black population (187,167), the proportion of TBIs among Blacks was 35% higher than among whites (582 vs. 429 per 100,000, respectively; Jager et al., 2000). Even after adjusting for covariates that are common among racial/ ethnic groups like injury severity, a number of pre-existing health conditions, and age, Black women with TBI are 21% less likely to be hospitalized than White women (Selassie et al., 2004), and the odds of racial/ethnic minorities with severe blunt TBI being placed in rehabilitation were 15% lower than for Whites (Shafi et al., 2007).

Common Impairments

TBI is defined as a “the disruption of brain function due to externally applied forces either causing acceleration or deceleration of the brain or direct physical contact of an object with the brain or head” (Bryan Young, 2013, p. 1). The external force, its nature, direction, intensity, and duration establish the extent and pattern of damage, which inform TBI classification (McCrory, et al., 2005). Traditionally, TBI has been classified by three main factors: mechanism (closed head injury or penetrating injury), severity, and assessment of structural damage through neuroimaging (Maas, Stockett, &Bullock, 2008). The Glasgow Coma Scale (GCS) is currently the most widely used classification system for TBI severity, with severity rated as mild (score between 13-15), moderate (9-12), or severe (3-8; Bruns & Hauser, 2003). TBI often result in physical impairments, although many of the most problematic consequences involve cognition, emotional functioning, and behavior (Corrigan, 1999).

Concussions are considered a mild TBI (mTBI) due to several factors, including minimal to no structural alterations to the brain (noted through neuroimaging scans) and neurologic functional impairments recovery occurring within 2 weeks of concussion (Young, 2013; McCrory, et al., 2005). Symptoms of mild TBI, like concussions, include alteration of consciousness, confusion, amnesia, lack of balance and coordination, difficulties with visuospatial processing, and various cognitive problems (Young, 2013). Cognitive deficits associated with mTBI resolve fully within 3 to 6 months without the presence of other intracranial complications (Rabinowitz & Levin, 2014). Multiple mTBIs can become cumulative where symptoms persist for a longer period of time and can result in long-term complications (Rabadi & Jordan, 2001).

The majority of individuals with moderate-to-severe TBI report long-term problems with cognitive functioning, as well as impairments impacting work, relationships, leisure, and activities of daily including driving, handling finances, and meal making (Rabinowitz & Levin, 2014). Executive functioning, defined as higher-order cognitive abilities predominantly at the prefrontal cortex of the brain, is typically the cognitive domain most impacted by TBI. Impairments to executive functioning are associated with difficulties with organization, problem-solving, decision-making, multitasking, and difficulties beginning and completing tasks; other cognitive impairments include difficulties with attention, concentration, learning, and memory (Mayo Clinic, 2019). Cognitive recovery after moderate-to-severe TBI is often the most prevalent during the first year, followed by more gradual improvements during the years after (Rabinowitz & Levin, 2014).

Communication Impairments. Other closely related impairments to cognitive impairments include communication, social, functioning, and emotional impairments (Milders, Fuchs, & Crawford 2010). Cognitive impairments have been shown to directly affect communication after TBI (Beauchamp & Anderson, 2010; Douglas, 2010). Communication deficits are often regarded as a hallmark symptom of TBI and are a result of the interplay among various dimensions of cognition and language; communication difficulties include tangential communication, as well as impaired interpretation of social cues and emotions, and verbal reasoning, expression, and response speed (McDonald et al., 2014; VanSolkema et al., 2020). Communication impairments are idiosyncratic among persons with TBI, depending on severity level, and often play out in an individual's level of interactive appropriateness, social functioning, and overall understanding of pragmatics within a conversation (VanSolkema et al., 2020).

Social Impairments. The cognitive and communication impairments associated with TBI often result in problems with social interactions (Skirving 1999). Social interaction is among one of the most fundamental aspects of human existence and relies on the abilities to tend to others, inhibit inappropriate behaviors, understand and use verbal and nonverbal language to convey or interoperate messages, and respond appropriately given the social contexts (Anderson et al., 2013; Skirving 1999). Impairments in social functioning across the lifespan have negative implications for mental health, educational attainment, career, and quality of life (Anderson et al., 2013). Milders et al. (2003) found that individuals with TBI had impaired ability to recognize facial expressions and detect social faux paus, which was correlated with more social behavioral problems. Individuals with TBI often have difficulties creating and maintaining meaningful social relationships as a result of these changes (Brooks et al., 1987; Malia, et al., 1995). During the first few years, social impairments are not always apparent to persons with TBI, and often family members/significant others recognize the shifts in socialization more so than the person with TBI (VanSolkema et al., 2020). However, Thomsen (1984) found that 10-15 years after TBI, personality changes and a loss of social contact was still apparent in two-thirds of cases.

Rehabilitation Needs after TBI. TBI Rehabilitation services are integral during the first few years following injury. Research has shown that people with TBI have care needs that are often long-term (Hodgkinson et al., 2000). Difficulties with mobility and self-care, such as impaired ambulation, requires the need for physical assistance and verbal cueing to perform basic activities of daily living. Impairments following TBI impact an individual's capacity to resume educational or work pursuits, drive or use public transportation without assistance (NIH, 1998). Service delivery requires skilled professionals such as doctors, nurses, and various skills therapist to implement various service needs; Service needs includes social, personal care, and maintenance therapies and interventions that can to help them make the transition from rehab to community living, achieve, and improve the overall quality of life (Tate et al., 2004; O'Keeffe, 1994). Mellick et al., (2003) investigated factors that determine the pathways of care for people with TBI follow after acute care discharge. The study showed that almost two-thirds of survivors after TBI received no additional services after discharge from the acute care hospital. The study also showed that older white individuals and people whose care was funded by the government received the most community-based services and long-term care, while members of minority groups were received less care.

Functional Independence. Functional independence is the extent to which one is able to perform daily activities, and establish an independent, productive, and socially satisfying lifestyle. Functional independence is historically among the core rehabilitation goals for individuals with TBI, and the systematic assessment of an individual's capacity to function independently is integral in tailoring rehabilitation care following injury (Bamdad et al., 2003). Functional assessment measures developed over the past decades have made it so that researchers, as well as clinicians, can assess functional impairments and ability status to infer overall functional status (Hernandez-Cardenache, 2006). The development of measures to assess the functional impact of injury has been guided by the World Health Organization Classification of Impairments, Disabilities, and Handicaps (World Health Organization, 1990). Clinicians and researchers utilize functional assessments both for short- and long-term effects of treatment not only for clinical purposes, but also for program evaluation, marketing, and accreditation (Hall, 20001)**.**

Functional assessments consist of a series of tasks aimed to uncover an individual's proficiency in a skilled area. Functional assessments are intended to assess an individual's overall ability to perform activities of daily living. They are used as an index of change to gauge the effectiveness of acute or post-acute recovery following TBI (Kashluba et al., 2008). Functional impairments following TBI are determined by multiple factors, including location and extent of brain damage, course of recovery, comorbid conditions and medical complications, and preexisting history of neurologic and psychological functioning (World Health Organization, 1990). It should be noted that the presentation of an individual's functional ability differs across people, even when classified within the same brain injury severity level. Individuals who fall within the 'severe disability post-TBI' category could display vast differences in functional independence and supervision needs. For example, an individual with severe TBI may be in a skilled nursing care facility and only be able to perform basic motor commands. However, another individual in the same category may have the ability to engage in several activities of daily living (ADLs), yet be unable to engage in more skilled life activities such as accessing and utilizing public transportation independently (Hernandez-Cardenache, 2006). Thus, employing a systematic analysis to assess the idiosyncratic presentation of functional status is imperative not only in evaluating neurocognitive functioning following TBI, but to better inform the practical, financial, and environmental support needs of persons with TBI (Novack et al., 2001).

Supervision Needed. Because TBI affects numerous facets of functioning, the need for supervision of daily activities increases as well (Benge et al., 2010). Supervision within this context is referred to as any form of assistance that requires a caregiver (e.g., family member, paid attendant or facility staff member, friend, or any other person who takes responsibility for being with persons with TBI) to be within the physical vicinity of the person with TBI (Boake, 1996). It also implies the continuous or intermittent presence of a caregiver to provide physical care, instructions for or set-up of daily living tasks, problem-solving, or any combination of these facets (Hart et al., 2003). Assessing for the level of supervision is imperative because it not only informs practical consequences, such as financial costs of nursing care, but it is also highly reflective of the cumulative impact of all of a person’s cognitive, physical, social, and behavioral, impairments (Boake, 1996).

Those with high supervision needs may have more difficulties integrating into their communities (Benge et al., 2010). Hart et al. (2003) found that deficits in executive functioning were associated with greater supervision needs. Hawkins et al., (1996) examined the amount of supervision required for persons with TBI and showed although cognitive skills were diminished for most individuals, a greater proportion of TBI patients achieved a substantial reduction in disability within 18 months after TBI; 90% of the patients were living at home, 16% required full-time supervision, and 82% were independent of supervision throughout most of the day.

Mental Health Issues Following TBI

Depression. TBI is recognized as the leading cause of trauma-related psychological disorders, including the comorbid incidence of depression and generalized anxiety disorder as the most common symptoms associated with TBI impairment (CDC, 2019; Bryant et al., 2010). Studies have shown that post-TBI prevalence rates range greatly differ, ranging from 6.3% (Bombardier et al., 2016) to 79.5% (Albrecht et al., 2019). Jorge et al. (2004) investigated the presentation of depression with 91 individuals with an acute TBI enrolled in a longitudinal study; major depressive disorder was reported in 33% of the participants during the first year after TBI. The study also showed that participants with major depression had significantly greater impairment in executive functions than nondepressed participants. Seel et al. (2003) reported a prevalence rate of 27% of major depressive disorder among 666 individuals with TBI evaluated between 10 months to 10.5 years recruited from 17 outpatient clinics. Koponen et al. (2002) evaluated 60 patients with TBI 30 years after injury, finding a 26.7% lifetime prevalence of major depression. Holsinger et al. (2002) found an increased likelihood of lifetime prevalence of major depression in individuals with a history of TBI among a community sample, suggesting that persons with TBI have a higher frequency of recurrent depressive disorder throughout their lifetime compared to non-TBI patients. Variations in depression rates have been attributed to time since injury, TBI severity, differences in population groups (i.e., outpatient, inpatient, community), and differences in assessment tools (Uomoto, & Esselman, 1995).

Preexisting conditions and personality traits such as anxiety or alcohol abuse may further increase the chances of developing chronic depression post-TBI (Bombardier et al., 2016). Environmental factors such as lack of support could also increase the development of depression. Additional risk factors for depression following TBI include lower education levels (Bombardier, et al., 2010; Dikmen et al., 2004), younger age (Bombardier, et al., 2010; Rapoport et al., 2003), woman gender (Rutherford, Merrett, & Mcdonali, 1977; Whelan-Goodinson et al., 2010), and premorbid psychiatric problems (Whelan-Goodinson et al., Johnston, 2010). More acute forms of depression following TBI can be attributed to changes in neurochemistry, but late posttraumatic depression following TBI is often associated with comorbid psychological and psychosocial factors (Silver et al., 2009). Depression has also been linked with decreased motivation to engage in rehabilitation services, community integration, and poor functional outcomes (Bowen, et al., 1998; Pagulayan et al., 2008; Hibbard, et al., 2004).

Anxiety. Depression and anxiety are well known for their high degree of co-morbidity, with reported co-morbidity rates ranging from 33–65% (Stavarakaki & Vargo, 1986; Moore et al., 2006). Jorge et al. (2004; 1993) found major depressive disorder was strongly linked with anxiety disorders such that almost all TBI patients with major depressive disorder met the criteria for comorbid generalized anxiety disorder (GAD). GAD has been reported at rates as high as 70% in individuals with TBI (Rao & Lyketsos, 2002). Fann et al. (1995) examined the frequency of GAD in those with a TBI as well as its relationship to major depression and found that 24% of 50 consecutive outpatients with TBI were diagnosed as having GAD. The CDC (2019) reported that irritability, sadness, anxiety, and changes in emotional processing are often emotional consequences following TBI. Specific anxiety disorders that are common post-TBI include generalized anxiety disorder, obsessive-compulsive disorder, panic disorder, and phobic disorders. Rates of specific anxiety disorders post-TBI injury also vary: generalized anxiety disorder rates fall between 3-28%; obsessive-compulsive disorder in 2-15%; panic disorder in 4-13%; and phobic disorders in 1-10% (Hiott & Labbate, 2002; Moore et al., 2006, Koponen et al., 2002).

Anxiety disorders have been shown to be among the most frequently documented post-injury psychological changes in TBI patients and have been evident particularly in individuals with mild TBI, as compared to moderate and severe TBI (Moore et al., 2006; Bryant et al., 2010). Diagnosis of GAD requires 6 months or more of excessive anxiety and worry about a number of activities or events in one's daily life (APA, 2013). Muscle tension, restlessness, sleep disturbance, or concentration difficulties are additional symptoms that must be present for diagnosis. Given that well-supported research has shown that individuals with TBI often experience depression and anxiety post-injury, it is vital to consider how these mental health concerns may impact overall life satisfaction.

Satisfaction with Life. Life satisfaction, quality of life, and subjective well-being are terms often used interchangeably in previous TBI research. Life satisfaction is defined as the ability to subjectively judge one's current life situation in relation to one's expectations, life experiences, values, and goals (Mailhan et al., 2005; Berger et al., 1999). Physical health, mental health, productive employment, and other various facets of life that influence one's overall satisfaction with life are abruptly, and often permanently changed due to TBI. Research examining satisfaction with life across various physical and mental health domains varies. Depression has been shown to be significantly associated with lower life satisfaction among persons with TBI at 2, 4, and 5 years post-injury (Underhill et al., 2003). With regard to the relationship between functional impairment and life satisfaction, Corrigan et al. (2001) reported greater life satisfaction was associated with increased motor independence at 1-year post-injury. Similarly, other studies have shown that functional impairment was predictive of decreased life satisfaction following TBI (Johnson et al., 2010; Resch et al., 2009). Some studies report that gender plays a significant role in life satisfaction, with women having worse life satisfaction than men (Farace & Alves, 2000; Seibert et al. 2002) while other studies failed to detect significant gender differences (Resch et al., 2009). Research has not shown any significant correlations with age and life satisfaction among persons with TBI (Resch et al., 2009; Corrigan et al., 2001). The variation in reporting on life satisfaction could be attributed to several factors: the most common factors attributed to satisfaction with life are marriage, social participation (Jacobsson et al., 2013), participation in work and leisure activities, and the availability of emotional support (Steadman-pare et al., 2001).

Racial/Ethnic Disparities

Disparities in Rehabilitation Services. Although there is a robust literature regarding functional impairment and supervision needs, most of these studies do not incorporate cultural considerations or examine differential rehabilitation outcomes for various racial/ethnic groups. Racial/ethnic disparities manifest throughout the continuum of rehabilitation care and have surfaced in access to, the amount of, and the type of rehabilitation services received by individuals from racial/ethnic minority backgrounds compared to Whites. Bazarian et al. (2003) found that aspects of rehabilitation care, including the length of time to see a physician, number of referrals for services, number of therapy hours received, and functional outcomes attained were discrepant across racial/ethnic groups, typically with non-Hispanic Whites receiving better care. It has been documented that racial/ethnic minority groups in the US begin to experience disparities as soon as they are admitted to a hospital for treatment of their TBI; Arango-Lasprilla and Kreutzer's (2010) conducted a literature review examining the relationship between race/ethnicity and TBI outcomes. The results of the review consistently identified the existence of racial/ethnic disparities in the areas of hospitalization rates, emergency department care, and discharge placement. Sander et al. (2009) found that African Americans with TBI were significantly more disabled than Whites, spent significantly more time in direct caregiving, and overall reported less independence and productivity compared to Whites and Hispanics. Studies have also shown that when matched to Whites in TBI injury severity, minorities are less likely to receive rehabilitation services post-TBI; minorities who do receive rehabilitation, nevertheless, have been found to have poorer long-term functional outcomes after TBI relative to White samples (Shafi et al., 2007; Hart et al., 2007; Haider et al, 2007; Staudenmayer et al., 2007).

Disparities in Functional Outcomes. Several studies have identified racial/ethnic disparities in rehabilitation outcomes (Arango-Lasprilla et al., 2009, Hanks et. al., 2013; Hart et. al. 2007; Perrin et al., 2014), showing that individuals from racially/ethnically diverse groups report lower functional independence and greater disability than Whites (Wagner et al., 2000; Haider et al, 2007; Hanks et al., 2003). Arango-Lasprilla et al. (2007a) investigated demographic factors, injury, and rehabilitation characteristics of a large sample of White and Hispanic individuals with TBI. Results showed that there were no significant differences between Whites and Hispanics in functional outcomes at admission or discharge. However, at 1-year post-injury, Hispanics were approximately 2.5 times more likely than Whites to have worse outcomes across all functional outcome measures. In a study by some of the same authors examining Black and Latinx groups on demographic and functional outcomes at admission, discharge, and 1-year post-injury, Arango-Lasprilla et al. (2007b) reported that minorities had poorer functional outcomes compared with Whites on all measures of functional independence.

Gary et al. (2009) conducted a literature review highlighting studies examining numerous racial/ethnic differences in post-TBI outcomes. For example, Hart et al. (2007) reported that Blacks and Hispanics have worse functional outcomes (less independence and more severe disabilities). Other studies reported that Blacks and Hispanics fared worse in community integration outcomes (Rosenthal et al., 1996; Hanks et al., 2003; Hart et al., 2005) and were less likely to receive treatment and be employed than Whites post-TBI (Kreutzer et al., 2003). Similarly, Arango-Lasprilla and Kreutzer (2010) conducted a literature review, uncovering that racial/ethnic minority groups experience functional deficits at higher incidence rates than Whites. Staudenmayer et al. (2007) found that among a majority Black and Hispanic sample, at 6 and 12 months follow ups, patients scored worse on the functional status examinations scores in all domains and were more likely to be dependent on others, with the differences in standard of living, leisure, and work or school achieving statistical significance. Regarding neuropsychological test performance, Donders et al. (2004) found that White race was associated with better performance on verbal comprehension and perceptual organization.

Disparities in Mental Health. A number of studies have found that individuals with TBI from racial/ethnic minority backgrounds show higher levels and rates of mental health issues than Whites. For example, Seel et al. (2003) found that Black individuals with TBI reported greater depression symptoms when compared to Whites. Arango-Lasprilla and colleagues (2009) showed Black individuals with TBI reported lower overall satisfaction with life scores compared to White and Asian groups. Regarding other domains of mental health, Black patients reported a greater PTSD symptomatology at 12 months post-injury compared to White TBI patients (Greenspan et al., 2006). There have also been several studies documenting racial/ethnic disparities in life satisfaction. Jimenez et al. (2020) showed that Latinx children reported larger reductions in life satisfaction relative to White children three years post-injury. However, Hart et al. (2005) found that Black and White groups who had comparable pre-injury characteristics reported similar outcomes, with both groups showing increases in depression symptoms, and lower satisfaction with life, suggesting no significant differences over time in life satisfaction.

Immigration-Based Disparities. There is a gap in research examining cultural factors that can influence rehabilitation outcomes following TBI, but some studies have examined language and acculturation. Communication is a tool used to navigate cultural differences, and complexity in affective provisions for treatment may arise when service providers and patients do not share the same language (Grahame et al., 2000). According to the 2010 US Census, about 85% of the foreign-born population spoke a language other than English at home (Grieco et al., 2012). Lequerica et al. (2015) examined the effect of primary language on functional independence outcome measures. Results showed that individuals who did not speak English were rated worse on functional communication outcomes at inpatient rehabilitation discharge compared to individuals whose primary language was English. Research shows that racial/ethnic groups who have limited English proficiency are often misdiagnosed and incorrectly treated by the healthcare system (Flores, 2006).

Lequerica et al. (2019) examined the effect of foreign-born vs. US native status on productive activity (e.g., employment, community engagement) among Hispanics at 1 year after TBI. Among foreign-born individuals with TBI, those living in an area with a higher proportion of foreign-language speakers were 2.8 times more likely to engage in productive activity than those living in areas with a lower proportion of foreign language speakers. Saltapidas and Ponsford (2007) compared functional outcomes following 32 TBI in individuals from culturally and linguistically diverse (CALD) backgrounds (born in countries other than Australia, New Zealand, the United Kingdom, and the United States) with 38 individuals from non-CALD backgrounds. They found that poorer functional outcomes were evident in the CALD group on several functional domains (including post-injury employment status, cognitive independence, mobility, and social integration, and showed greater distress about changes in the ability to perform certain life roles). This finding suggests individuals from different cultural backgrounds were disadvantaged in terms of pre-injury education, reported greater reliance on others for assistance with mobility and with cognitive activities, and reported less social interaction. Individuals with English speaking backgrounds and individual from CALD groups differed significantly on all acculturation variables, including acculturation level, English proficiency, and the number of years lived in the country.

It was noted that the findings of this study were limited by the modest sample size; thus, Ponsford, Downing, and Pechlivanidis (2018) conducted a subsequent study also examining cultural backgrounds on psychosocial outcomes following TBI. The study was conducted with a larger sample of 206 individuals from CALD and non-CALD groups. CALD groups spoke less English at home and spent significantly less time in Australia than non-CALD groups. Participants who reported having greater acculturation to the Australian value system had higher functional outcomes compared to those whose value system aligned more with their culture of origin. The study also reported that individuals in the CALD group were significantly less independent in activities of daily living (light domestic duties, shopping, and financial management) and reported significantly lower cognitive independence, mobility, greater anxiety and depression symptoms, and lower participation in occupational and social activities than non-CALD participants post-injury. The results from these studies reveal that not only are there disparities in CALD groups based on sociodemographic characteristics, but disparities may also be attributed to being from a cultural background less acculturated to the dominant culture.

Possible Sources of Disparities. Examining potential underlying mechanisms that contribute to these disparities in rehabilitation outcomes post-TBI is paramount. In addition to demographic and socioeconomic contributors to racial/ethnic disparities, research has documented disparities concerning post-injury hospitalization (Burnett et al., 2002), rehabilitation referrals (Johnestone et al., 2003), and post-hospital discharge location (Chang et al., 2008). Given that current research has shown that racial/ethnic disparities are present after TBI, researchers believe that exploring cultural conceptions of TBI is integral in forwarding the literature (Brown et al., 2004). Efforts have been made to provide explanations related to cultural traditions, level of acculturation, cultural competencies, and prejudices.

Gary et al. (2009) purported that three interconnected factors must be taken into consideration: patient cultural traditions, level of acculturation, and language ability were identified factors that may affect the individual's willingness to engage in rehabilitation and treatment. Likewise, at the level of healthcare staff, cultural competency, biases, prejudices, stereotypes, and mannerisms all contribute to how rehabilitation providers interact and provide care for racially/ethnically diverse groups (Gary et al., 2009; Bowman et al., 2007). Every cross-cultural physician relationship interacts with four different cultures: the culture of the physician, the culture of the patient, the culture of the medical system the physician is operating under, and the patient's traditional medical culture (Fitzgerald et al., 1997; Simson et al., 2000).

Due to these four different cultures, many forms of communication can be hindered, including miscommunication in body language and actual differences in the language spoken. Misconceptions about TBI, its consequences, and strategies that could lead to improved participation have been documented as one of the likely sources of disparities. Pappadis et al. (2011) examined misconceptions about TBI (e.g., current knowledge about TBI etiology, impairments, recovery, and rehabilitation care) among Spanish-speaking individuals. The study showed that a greater endorsement of TBI misconceptions was associated with having lower education, cultural beliefs, speaking Spanish as the primary language, and immigration status.

Current neuropsychological assessment measures are also under scrutiny due to cultural biases (Donders & Nesbit-Green, 2004). Kennepohl et al. (2004) examined the effect of African Americans' acculturation on neuropsychological assessments and found that Black individuals who were less acculturated (i.e., ascribed to traditional African American religiosity, cultural values, and beliefs) showed lower overall neuropsychological performance. These underlying cultural influences often drive disparities in neuropsychological test performance which ultimately impacts rehabilitation service, care, and outcomes for racially/ethnically diverse groups.

Current Study Objectives

Although the literature examining racial/ethnic disparities following TBI is growing, there is still a notable gap in research that explores disparities in functional and mental health outcomes longitudinally in US-born vs. immigrant groups after TBI. Ponsford, Downing, and Pechlivanidis (2018) suggest that future studies should examine psychosocial trajectories of change over time after discharge from inpatient care in culturally and linguistically diverse groups to identify more specifically when and where group differences appear. Differences in spoken language are often a cultural identification marker for many immigrants, and previous studies have shown that individuals who do not speak English as their primary language show worse ratings in functional outcome scores at inpatient rehabilitation discharge (Lequerica et al., 2015). Previous research examining acculturation levels of immigrants also shows that less accultured individuals with TBI fare worse on functional outcomes measures (Ponsford, Downing & Pechlivanidis, 2018); these cultural differences can result in an increased risk of misdiagnosis and overall poor health outcomes (Judd et al., 2005; Meeuwesen et. al., 2012; Schouten et al., 2006). In addition, research has documented the racially/ethnically diverse groups exhibit lower satisfaction with life, and greater depression and anxiety (Lequerica et al., 2015; Shafti et al., 2007). As a result, the purpose of this study is to evaluate the degree to which disparities in functional and mental health outcomes exist between US-born vs. immigrant individuals with TBI at 1, 2, 5, and 10 years after injury. The study will then examine whether demographic, injury-related characteristics, and acculturation characteristics contribute to some of these disparities.

Hypotheses

Hypothesis 1. As the current makeup of immigrant groups in the US are extremely racially/ethnically diverse, and given that previous research has documented that racially/ethnically diverse groups with TBI report lower functional and mental health outcomes (Hank et al., 2013; Staudenmayer et al., 2010; Arango-Lasprilla et al., 2010, Perrin et al., 2014) than Whites, it is hypothesized that immigrant groups (those born outside of the US) with TBI will show lower functional and mental health outcomes longitudinally compared to US-born groups.

Hypothesis 2. Previous studies have documented the existence of racial/ethnic disparities in functional and mental health outcomes even after controlling for injury and demographic characteristics such as and individuals' sex, age, marital status, employment status, education, annual earning, and pre-injury history (Arango-Lasprilla et al., 2007; Perrin et al., 2014). It is therefore hypothesized that functional and mental health differences in the US-born vs. immigrant groups will be in part accounted for by socio-demographic variables, but that these disparities will still remain even after adding these covariates.

Method

Participants

Participants in this study were part of the National Database of the National Institute for Disability, Independent Living, and Rehabilitation Research (NIDILRR) Traumatic Brain Injury Model System (TBIMS) study. TBIMS is a multicenter longitudinal study that comprises 16 level 1 trauma centers and three longitudinal follow-up centers. TBIMS participants receive initial care in an emergency department, followed by management of acute neurotrauma, comprehensive inpatient rehabilitation, and often long-term outpatient services. To be included in the TBIMS database, participants must have acquired a TBI defined by "damage to brain tissue caused by an external mechanical force as evidenced by a medical documented loss of consciousness or posttraumatic amnesia due to brain trauma or by objective neurological findings that can be reasonably attributed to TBI on physical examination or mental status examination" (TBIMS, 2020).

The inclusion criteria for the TBIMS National Database was: (a) 16 years of age or older at the time of injury, (b) medically diagnosed TBI from the TBIMS center (e.g., mild complicated, moderate, or severe TBI), (c) either Glasgow Coma Scale score of ≤12 upon emergency admission, > 24-hour duration of posttraumatic amnesia (PTA), loss of consciousness (LOC) >30 minutes, or evidence of intracranial trauma on neuroimaging, (d) admission to the respective TBIMS acute care hospital within 72 hours of injury, and (e) enrollment and completion of inpatient rehabilitation services within the TBIMS center. "Country of birth" was the key variable used to observe US-born vs. immigrant groups. Individuals who refused to answer or were coded as unknown or system-related missing for this variable were not included in the study.

Participants who had recorded data of their country of birth from at least one follow-up data point were included in the current sample. Participants who had completed data for at least one time point for the outcome variables were also included. The inclusion of the independent variable (country of birth), functional outcome variables (Supervision Rating Scale and Functional Independence Measure) and mental health dependent variables (Patient Health Questionnaire-9 [PHQ-9], Satisfaction with Life Scale [SWLS] and Generalized Anxiety Disorder 7-item [GAD-7]) resulted in a final sample size of 12,169 participants. Of these participants, 10,662 identified as US-born, and 1,507 identified as born outside of the U.S. The two groups were compared on demographics using analyses of variance (ANOVAs) for continuous variables and chi-square tests for categorical variables. See Table 1 for participants' demographics and the respective *p*-values of each group comparison.

Table 1. *Sample characteristics.*

Demographics	US-Born *M* (*SD*) or *n* (%)	Immigrant *M* (*SD*) or *n* (%)	*p*-value
n	10,662	1,507	
Sex			$p = .014$
Male	7,778 (73.0%)	1,143 (76.0%)	
Female	2,878 (27.0%)	361 (24.0%)	
Age	44.75 (64.29)	50.85 (75.36)	
Race			$p < .001$
Black	1,975 (18.5%)	123 (8.2%)	
White	7,760 (72.8%)	356 (23.7%)	
Asian	99 (.9%)	226 (15.0%)	
Hispanic origin	667 (6.3%)	736 (48.9%)	
Native American	66 (.6%)	4 (.3%)	
Other	91 (.9%)	59 (3.9%)	
Marital status			$p < .001$
Married	3,310 (31.1%)	596 (39.7%)	
Not married	7,341 (68.9%)	906 (60.3%)	
Education	12.81 (2.64)	11.62 (4.26)	$p < .001$
Employment at Injury Discharge			$p < .001$
Employed	5,886 (62.7%)	892 (65.0%)	
Not employed	3,498 (37.3%)	480 (35.0 %)	
Annual Earning			$p < .001$
<9,999	1,000 (17.6%)	157 (18.7%)	

10,000-19,999	916 (16.1%)	195 (23.2%)	
20,000-29,999	912 (16.1%)	169 (20.1%)	
30,000-39,999	769 (13.5%)	98 (11.7%)	
40,000-49,999	576 (10.1%)	52 (6.2%)	
50,000-59,999	393 (6.9%)	46 (5.5%)	
60,000-69,999	294 (5.2%)	27 (3.2%)	
70,000-79,999	178 (3.1%)	22 (2.6%)	
80,00- 89,999	131 (2.3%)	16 (1.9%)	
90,000-99,999	116 (2.0%)	8 (1.0%)	
> 100,000	391 (6.9%)	49 (5.8%)	
Cause of Injury			*p* = .061
Non-Violent	9,511 (89.4%)	1,312 (87.8%)	
Violent	1,125 (10.6%)	182 (12.2%)	
GCS	11.00 (4.13)	10.74 (4.13)	*p* = .068
PTA	22.71 (22.51)	22.71 (23.53)	*p* = .992

In the table, and as a result for the statistical analyses, several variables were re-categorized. Marital status was dichotomized into married (single) and not married (divorced, separated, widowed, other, or unknown). Preinjury employment status was dichotomized into employed (competitively employed) and not employed (all other categories of employment). Cause of injury was dichotomized into violent (gunshot wound, assault with blunt instrument, and other violence) and nonviolent (air sports, other sports, water sports, track/field, motor vehicle accident, motorcycle, bicycle, other vehicle, and unclassified). Lastly, insurance was dichotomized into private insurance and other (Medicare, Medicaid, workers compensation, HMO, PPO, Tricare, Department of Rehabilitation, and state or county).

Procedure

Study procedures were approved by the individual institutional review boards for each funded TBIMS center. Informed consent was provided by either the TBIMS participant (or when appropriate their legal guardian or family member) or their proxy. Participants were recruited after admission to inpatient rehabilitation. Caregivers or family members provided data on demographic or pre-injury characteristics when participants were unable to provide the information themselves. All data collection was completed through the review of medical records and interviews with participants by highly trained research assistants. Follow-up data were collected via telephone interviews, and participants had the option to choose an in-person interview or complete a self-administered questionnaire.

Measures

Satisfaction with Life Scale (SWLS). The SWLS is a 5-item assessment developed to provide a global measure of life satisfaction (Diener et al., 1985). The level of life satisfaction is recorded on a 7-point Likert-type scale ranging from strongly disagree (1) to strongly agree (7). Scores range from 5 to 35 with higher scores representing greater life satisfaction. Extreme satisfaction and dissatisfaction with life are represented by scores ranging from 26 to 30 and 5 to 9, respectively (Pavot & Diener, 1993). The scale has good test-retest reliability and excellent internal consistency. The SWLS has good convergent validity with other measures of subjective well-being (Pavot & Diener, 1993). The SWLS is also well-validated and reliable among individuals with TBI (Cicerone & Azulay, 2007; Corrigan et al., 2001).

Patient Health Questionnaire-9 (PHQ-9). To assess depression, the PHQ-9 (Kroenke, Spitzer, & Williams, 2001) will be used. This scale contains nine items used to rate the frequency and severity of depressive symptoms that patients may have experienced over the last two weeks (DeJesus et al., 2007; Spitzer et al., 1999). The patient answers each item on a Likert-type scale from 0-3 where 0 indicates “not at all,” 1 indicates “several days,” 2 indicates “more than half the days,” and 3 indicates “nearly every day.” The total score can be used to represent symptom severity, with higher scores indicates higher levels of depression. The PHQ-9 has a sensitivity of 88% and a specificity of 88% in the diagnosis of major depression when the cut-off score of ≥10 is used (Kroenke, Spitzer & Williams, 2001). In two separate PHQ-9) studies, the reliability of the PHQ-9 was good (α = .89 & .86; Kroenke, Spitzer, & Williams, 2001).

Generalized Anxiety Disorder-7 (GAD-7). To assess anxiety, the GAD-7 will be used. This scale uses seven items to measure the severity of anxiety symptoms over the last two weeks (Spitzer, Kroenke, Williams, & Lowe, 2006). The GAD-7 assesses the most prominent diagnostic features (diagnostic criteria A, B, and C from the Diagnostic and Statistical Manual of Mental Disorders, fourth edition [DSM-IV]) for GAD (Lowe et al., 2008). The GAD-7 asks participants to rate how often they have been bothered by each the 7 core symptoms over the past 2 weeks. Response categories are "not at all," "several days," "more than half the days," and "nearly every day," scored as 0, 1, 2, and 3, respectively. The total score of the GAD-7 ranges from 0 to 21, in which a higher score indicates higher levels of anxiety. The GAD-7 scale has good test-retest reliability and excellent internal consistency (Spitzer et al., 2006). The GAD-7 scale has been used to assess anxiety symptoms among individuals with TBI (Fogelberg et al., 2012).

Functional Independence Measure (FIM). The FIM is an 18-item measure used to assess the patient's level of functional ability. It is comprised of 13 motor items and 5 cognitive items, each rated on a 7-point scale from (1) indicating complete functional dependence to (7) indicating complete functional independence (Fiedel & Granger, 1996). The FIM assesses problem-solving, memory, expression, comprehension, social interaction, eating, grooming, bathing, dressing–upper body, dressing–lower body, toileting, bowel management, bladder management, transfers to bed, chair, or wheelchair, transfers to toilet, and transfers to shower/tub, locomotion, and stair climbing (Pretz et al., 2016). The cognitive subscale of the FIM assesses expression, social interaction, problem-solving, comprehension, and memory. The

5 items of the motor subscale evaluate physical functioning such as eating, toileting, and transferring, and the cognitive describes communication, social interaction, and cognitive functioning (Stineman et al., 1996). Total scores range from 18 to 126, with higher scores reflecting greater independence. Clinically appropriate validity and interrater reliability have been well established for the FIM (Hamilton et al., 1991). Within the TBI literature, studies have shown that the FIM has strong internal consistency (Dodds, Martin, Stolov, & Dayo, 1993). There is consistent evidence of the utility of the FIM for inpatient rehabilitation and discharge planning, in addition to evaluations of long-term rehabilitation outcomes (Heinemann et al., 1997; Heinemann et al., 1994).

Supervision Rating Scale (SRS). The SRS assesses the level of supervision needed for persons with TBI. The SRS captures an individual's overall need for services and the functional significance of progress made in rehabilitation. The SRS was developed to overcome some of the limitations of other well-known brain injury measures such as the Disability Rating Scale (DRS) and the Glasgow Outcome Scale (GOS); The DRS and GOS rely partly on the rater's subjective judgment of the patient's ability, where the SRS is fully based on verifiable observations of the amount of supervision received by a patient (Boake, 1996). The level of supervision is ranked on a 13-point ordinal scale where scale points correspond to degrees of supervision ranked in order of both the intensity and duration of the supervision received by a patient. Responses range from 'The patient lives alone or independently' to 'The patient is in physical restraints.' Scoring is grouped into five categories (Independent, Overnight Supervision, Part-Time Supervision, Full-Time Indirect Supervision, and Full-Time Direct Supervision). A higher rating indicates greater dependence. In previous studies, the SRS has demonstrated good interrater reliability and is strongly associated with other similar commonly used measures of functional disability like the DRS and the Glasgow Coma Scale (GCS) (Boake, 1996).

Data Analysis Plan: Descriptive and Assumption-Focused Analyses

Descriptive statistics (i.e., means, standard deviations) of outcome variables were generated using SPSS version 27 in order to characterize the sample. Normality tests (i.e., skewness and kurtosis) were performed on each outcome to determine whether subscales or total scales were normally distributed. A value of 2.0 was used as the critical cutoff to identify values that were skewed or kurtotic. Data transformations were considered if they might improve non-normal distributions. To address missingness in the outcome data, the percentage of missing outcome data was calculated at 1-, 2-, 5-, and 10-years post-discharge. Little’s Missing Completely at Random (MCAR) test assessed the degree these data were missing at random. Because of the high potential of missing data in longitudinal data collection, hierarchical linear model’s (HLM’s) full information maximum likelihood (FIML) estimation procedure was conducted to include participants with missing data.

Data Analytic Plan: Primary Analyses

A traditional approach in disparities research is to (a) document the existence of health disparities and (b) try to account for those disparities with demographic or injury-related differences among the participant groups. Thus, these steps were incorporated in the present study. A series of HLMs was performed in this regard.

Preliminary Curvature Analyses. An initial set of three HLMs was run with only the intercept and (a) time, (b) addition of time*time, and (c) addition of time*time*time as fixed effects predictors in order to determine whether a linear (e.g., straight line), quadradic (e.g., U-shaped), or cubic (e.g., S-shaped) model, respectively, most accurately reflected each type of outcome data over time (i.e., six sets of HLMs, one for each outcome). -2Log likelihood values were compared for each successive model with a critical χ^2 value for significant difference at α = .05 being a ≥ 3.841 drop from the previous model (at 1 degree of freedom).

Primary Set 1. The next set of HLMs assessed differences in each of the six mental health and functional outcomes over time in the US-born and immigrant groups. Follow-up HLMs within each outcome incorporated interaction terms between time and immigration status to determine if these differences in functional and mental health outcomes occurred differentially as a function of time when main effects of immigration status had been found.

Primary Set 2. For the second primary set, this same series of analyses was conducted with the inclusion of the following demographic and injury-related variables as covariates to determine whether these variables accounted for effects of immigration status in the first analyses: violence as a cause of injury (1 = violent, 0 = not violent), GCS, PTA, age, sex, years of education, employment status at injury (1 = competitively employed, 0 = not competitively employed), marital status at injury (1 = married, 0 = not married), annual earnings, and health insurance status (1 = private insurance, 0 = public or no insurance). Similarly, follow-up HLMs incorporated interaction terms between time and immigration status, with the same covariates included, to determine if these differences in functional and mental health outcomes occurred differentially as a function of time even after co-varying for possible confounds.

Results

Satisfaction with Life Scale (SWLS)

Descriptive and Assumption-Focused Analyses. Means and standard deviations (SDs) for the SWLS at each time point were calculated (Table 2). The average participant score in the sample fell into the slightly satisfied range (Pavot & Diener, 1993), with a slight upward movement for the first five years, and scores remained relatively stable from the 5- to 10-year time point. Normality tests on the SWLS found that it was normally distributed, with skewness and kurtosis values below the cutoff of 2.0 for all four time points (Table 2). The Little's MCAR test indicated that the data were not missing completely at random (χ^2 [28] = 101.87, $p < .001$). As noted above, in order to avoid a biased sample from using listwise deletion, FIML was used to account for missing data and as a result include all participants.

Table 2. *Mental health variable skewness and kurtosis.*

	1 Year	2 Years	5 Years	10 Years
SWLS				
Mean (*SD*)	21.42 (8.26)	21.74 (8.38)	22.13 (8.27)	22.07 (8.30)
Skewness	-.23	-.27	-.34	-.31
Kurtosis	-1.00	-1.00	-.96	-.99
PHQ-9				
Mean (*SD*)	5.43 (5.78)	5.32 (5.80)	5.20 (5.75)	5.43 (5.89)
Skewness	1.24	1.25	1.30	1.26
Kurtosis	1.00	.92	1.13	.92
GAD-7				
Mean (*SD*)	4.09 (5.16)	4.25 (5.25)	4.20 (5.30)	4.03 (5.05)
Skewness	1.47	1.44	1.37	1.46
Kurtosis	1.37	1.32	.98	1.42

Preliminary Curvature Analyses. A comparison of curvature models suggested that a quadratic, or U-shaped, trend best fit SWLS trajectories over time (Table 3).

Table 3. *Curvature model comparisons for SWLS, PHQ-9, and GAD-7 trajectories*.

Model	-2 Log Likelihood
SWLS	
Linear	151,885.42
Quadratic	**151,868.98**
Cubic	151,867.25
PHQ-9	
Linear	**56,324.34**
Quadratic	56,322.66
Cubic	56,322.13
GAD-7	

Linear	**34,946.05**
Quadratic	34,943.91
Cubic	34,943.82

Note. Critical χ^2 value for significant difference at $\alpha = .05$ is > 3.841 drop from the previous model. Bolded values surpassed this threshold.

Primary Set 1. The first set of HLMs examined whether quadratic SWLS trajectories could be predicted by immigration status. All statistically significant and non-significant fixed effects from the HLM and their b-weights and *p*-values appear in Table 4.

Table 4. *Predictors of SWLS, PHQ-9, and GAD-7 trajectories*.

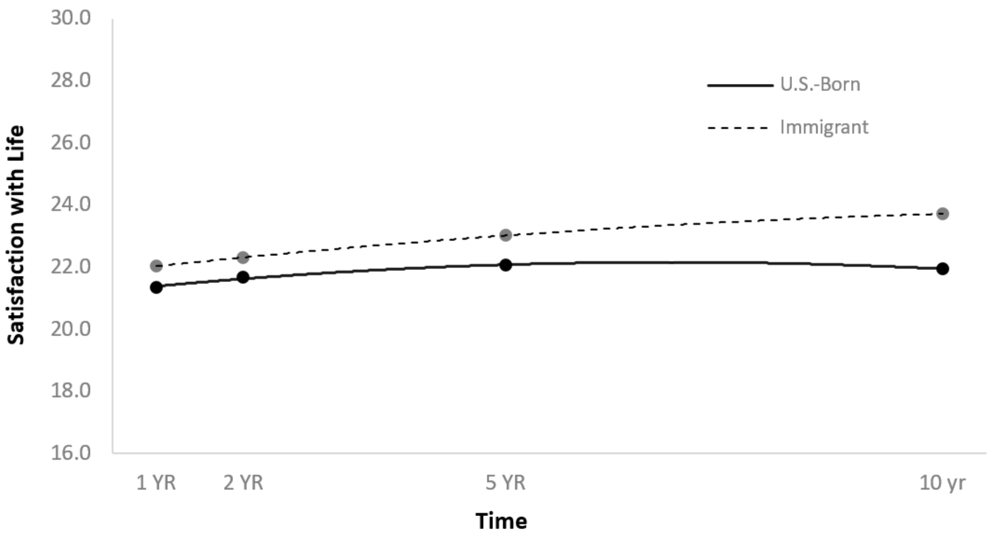
	SWLS		PHQ-9		GAD-7	
Predictor	*b*-weight	*p*-value	*b*-weight	*p*-value	*b*-weight	*p*-value
Set 1: Immigration Effects						
Intercept	21.20	< .001	5.43	< .001	4.20	< .001
Time	.27	< .001	-.01	.644	-.01	.695
Time^2	-.02	< .001	-	-	-	-
Immigrant vs. US-born	**.89**	**< .001**	**-.28**	**.295**	**-.36**	**.172**
Set 1: Immigration Interactions with Time						
Intercept	21.21	< .001	-	-	-	-
Time	.28	< .001	-	-	-	-
Time^2	-.02	< .001	-	-	-	-
Immigrant vs. US-born	.74	.011	-	-	-	-
Time*Immigration	-.07	.658	-	-	-	-
Time^2*Immigration	**.03**	**.156**	-	-	-	-
Set 2: Immigration with Covariates			-	-	-	-
Intercept	18.13	< .001	-	-	-	-
Time	.20	.019	-	-	-	-
Time^2	-.01	.293	-	-	-	-
Immigrant vs. US-born	**1.64**	**< .001**	-	-	-	-
Violent Cause	-2.67	< .001	-	-	-	-
GCS	.04	.379	-	-	-	-
PTA	-.04	< .001	-	-	-	-
Age	-.06	< .001	-	-	-	-
Male Sex	-.05	.885	-	-	-	-
Years of Education	.33	< .001	-	-	-	-
Employed at Injury	1.32	.048	-	-	-	-
Married at Injury	1.76	< .001	-	-	-	-
Annual Earnings	.18	.002	-	-	-	-
Private Insurance	1.19	< .001	-	-	-	-

Set 2: Immigration Interactions with Time and Covariates						
Time^2*Immigration	-	-	-	-	-	-

Note. Bolded predictors within each model were those focused on for interpretation based on the study's research aims.

There was a significant main effect of immigration status on SWLS trajectories, suggesting that immigrants with TBI had higher life satisfaction scores over time than individuals born in the US (Figure 1).

Figure 1. *Main effect of immigration status on SWLS trajectories*.



However, there was no significant time^2*immigration effect (Table 1), suggesting that SWLS trajectories did not change differentially over time.

Primary Set 2. The HLM with demographic and injury-related covariates added to the model found that the effect of immigration status on SWLS trajectories remained, even after controlling for possible confounds (Table 2). Because the original time^2*immigration effect had not been significant, no respective follow-up model was run with the addition of covariates.

Depressive Symptoms (PHQ-9)

Descriptive and Assumption-Focused Analyses. Means and standard deviations (*SD*s) for the PHQ-9 at each time point were calculated (Table 2). The average participant PHQ-9 score in the sample fell into the mild depressive symptom range over time (Kroenke, Spitzer, & Williams, 2001) which remained relatively stable at each successive time point. Normality tests on the PHQ-9 found that it was normally distributed, with skewness and kurtosis values below the cutoff of 2.0 for all four time points (Table 2). The Little's MCAR test indicated that the data were missing completely at random (χ^2 [23] = 27.60, $p = .231$), indicating that there was no systematic missingness in the data, and FIML was used to account for missing data.

Preliminary Curvature Analyses. A comparison of curvature models suggested that a linear, or straight-line, trend best fit PHQ-9 trajectories over time (Table 1).

Primary Set 1. There was no significant main effect of immigration status on PHQ-9 trajectories, suggesting that immigrants with TBI had statistically equivalent scores over time relative to individuals born in the US. As a result, no additional PHQ-9 models were comparing these two groups.

Generalized Anxiety Disorder (GAD-7)

Descriptive and Assumption-Focused Analyses. Means and standard deviations (*SD*s) for the GAD-7 at each time point were calculated (Table 2). The average participant GAD-7 score in the sample fell into the minimal anxiety symptom range over time (Spitzer, Kroenke, Williams, & Lowe, 2006) which remained relatively stable at each successive time point. Normality tests on the GAD-7 found that it was normally distributed, with skewness and kurtosis values below the cutoff of 2.0 for all four time points (Table 2). The Little's MCAR test indicated that the data were missing completely at random (χ^2 [15] = 23.72, $p = .070$), indicating that there was no systematic missingness in the data, and FIML was used to account for missing data.

Preliminary Curvature Analyses. A comparison of curvature models suggested that a linear, or straight-line, trend best fit GAD-7 trajectories over time (Table 3).

Primary Set 1. There was no significant main effect of immigration status on GAD-7 trajectories, suggesting that immigrants with TBI had statistically equivalent scores over time relative to individuals born in the US. As a result, no additional GAD-7 models were run comparing these two groups.

Functional Independence Measure – Motor (FIM Motor)

Descriptive and Assumption-Focused Analyses. Means and standard deviations (*SD*s) for the FIM motor at each time point were calculated (Table 5). The average participant FIM motor score in the sample was generally in line with motor independence in previous research (Stineman et al., 1996; Dehnadi-Moghadamet al., 2017) with a slight upward movement for the first five years, and then scores remained relatively stable from the 5- to 10-year time points (Table 5). Normality tests on the FIM Motor suggested that it was not normally distributed, with skewness and kurtosis values above the cutoff of 2.0 for all four time points (Table 5). Square root, log, and inverse square root transformations were performed but did not improve skewness and kurtosis, likely because of the FIM's ceiling effects with many participants scoring the scale's highest value (91); therefore, the original variables were used. The Little's MCAR test indicated that the data were not missing completely at random (χ^2 [28] = 242.10, p < .001). As above, in order to avoid a biased sample from using listwise deletion, FIML was used to account for missing data.

Table 5. *Functional independence variable skewness and kurtosis.*

	1 Year	2 Years	5 Years	10 Years

FIM Motor				
Mean (*SD*)	80.65 (20.45)	81.38 (20.57)	82.45 (19.82)	82.42(20.01)
Skewness	-2.59	-2.72	-2.95	-2.94
Kurtosis	5.74	6.29	7.62	7.50
FIM Cognitive				
Mean (*SD*)	29.92 (6.46)	30.17 (6.46)	30.58(6.10)	30.46 (6.26)
Skewness	-2.04	-2.15	-2.39	-2.34
Kurtosis	3.82	4.24	5.59	5.17
SRS				
Mean (*SD*)	3.55 (2.74)	3.21 (2.48)	2.95 (2.22)	2.83 (2.19)
Skewness	1.79	2.21	2.55	2.86
Kurtosis	2.17	4.02	5.84	7.50

Preliminary Curvature Analyses. A comparison of curvature models suggested that a quadratic, or U-shaped, trend best fit FIM Motor trajectories over time (Table 6).

Table 6. *Curvature model comparisons for FIM Motor, FIM Cognitive, and SRS trajectories*.

Model	-2 Log Likelihood
FIM Motor	
Linear	231,913.54
Quadratic	**231,894.92**
Cubic	231,894.84
FIM Cognitive	
Linear	179,102.56
Quadratic	**179,078.48**
Cubic	179,078.41
SRS	
Linear	113,193.32
Quadratic	113,050.68
Cubic	**113,005.10**

Note. Critical χ^2 value for significant difference at $\alpha = .05$ is > 3.841 drop from the previous model. Bolded values surpassed this threshold.

Primary Set 1. The first set of HLMs examined whether quadratic FIM motor trajectories could be predicted by immigration status. All statistically significant and non-significant fixed effects from the HLM and their b-weights and *p*-values appear in Table 7.

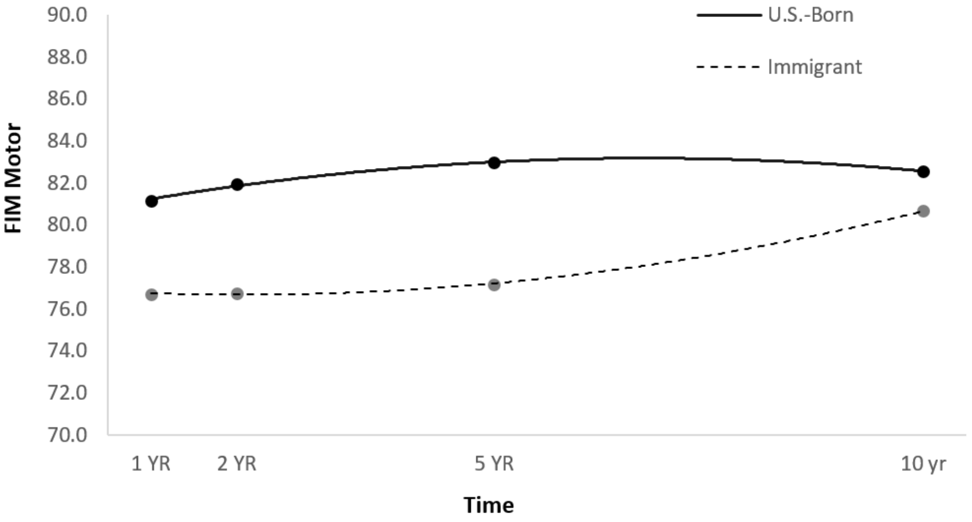
Table 7. *Predictors of FIM motor, FIM cognitive, and SRS trajectories*.

	FIM motor		FIM cognitive		SRS	
Predictor	*b*-weight	*p*-value	*b*-weight	*p*-value	*b*-weight	*p*-value
Set 1: Immigration Effects						
Intercept	81.15	< .001	30.05	< .001	3.48	< .001
Time	.44	< .001	.16	< .001	-.39	< .001
Time^2	-.05	< .001	-.02	< .001	.09	< .001
Time^3	-	-	-	-	-.01	< .001
Immigrant vs. US-born	**-4.67**	**< .001**	**-1.26**	**< .001**	**.49**	**< .001**
Set 1: Immigration Interactions with Time						
Intercept	81.12	< .001	30.05	< .001	3.47	< .001
Time	.50	< .001	.17	< .001	-.39	< .001
Time^2	-.06	< .001	-.02	< .001	.09	< .001
Time^3	-	-	-	-	-.01	< .001
Immigrant vs. US-born	-4.46	< .001	-1.25	< .001	.51	< .001
Time*Immigration	-.69	.069	-.10	.383	-.00	.973
Time^2*Immigration	**.10**	**.020**	**.02**	**.215**	-.00	.999
Time^3*Immigration	**-**	**-**	**-**	**-**	**-.00**	**.930**
Set 2: Immigration with Covariates						
Intercept	81.18	< .001	29.64	< .001	3.50	< .001
Time	-.12	.557	-.04	.489	-.34	< .001
Time^2	-.01	.831	-.00	.836	.09	< .001
Time^3	-	-	-	-	-.01	< .001
Immigrant vs. US-born	**-2.77**	**< .001**	**-.53**	**.035**	**.19**	**.038**
Violent Cause	-1.33	.112	-.74	.005	.43	< .001
GCS	-.11	.124	-.04	.071	.02	.011
PTA	-.08	< .001	-.03	< .001	.02	< .001
Age	-.15	< .001	-.03	< .001	.01	< .001
Sex	1.18	.050	.45	.020	-.06	.356
Years of Education	.44	< .001	.24	< .001	-.07	< .001
Employed at Injury	1.45	.200	1.16	.001	-.29	.029
Married at Injury	1.39	.018	.44	.020	-.03	.670
Annual Earnings	-.04	.688	-.01	.772	-.03	.021
Private Insurance	1.30	.025	.32	.079	-.19	.005
Set 2: Immigration Interactions with Time and Covariates						
Time^2*Immigration	**.08**	**.363**	-	-	-	-

Note. Bolded predictors within each model were those focused on for interpretation based on the study's research aims.

There was a significant main effect of immigration status on FIM motor trajectories, suggesting that immigrants with TBI had overall lower scores over time than individuals born in the US (Figure 2).

Figure 2. *Main effect of immigration status on FIM Motor trajectories.*



There was also a significant time^2*immigration effect (Table 7), suggesting that FIM motor trajectories changed differentially over time, with the U.S.-born group improving more rapidly over the first five years, plateauing between years 5 and 10. Conversely, the immigrant group improved little over the first 5 years but increased markedly at the 10-year follow up.

Primary Set 2. The HLM with demographic and injury-related covariates added to the model found that the effect of immigration status on FIM motor trajectories remained, even after controlling for possible confounds (Table 7). Because the original time^2*immigration effect was significant, a follow-up analysis was run with the addition of covariates. However, the interaction term was no longer significant (Table 7), suggesting that FIM motor trajectories did not change differentially as a function of time after controlling for possible confounds.

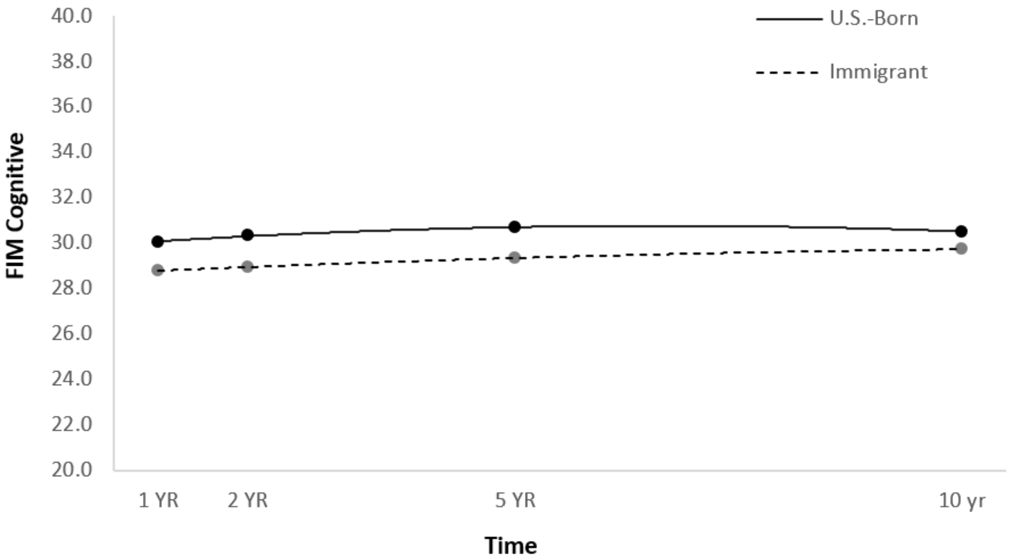
Functional Independence Measure – Cognitive (FIM Cognitive)

Descriptive and Assumption-Focused Analyses. Means and standard deviations (*SD*s) for the FIM Cognitive at each time point were calculated (Table 5). The average participant FIM cognitive score in the sample reflected similar cognitive impairment levels in previous TBI research (De Guise et al., 2005), with a slight upward movement for the first five years, and then scores remained relatively stable between the 5- to 10-year time points (Table 5). Normality tests of the FIM Cognitive suggested that it was not normally distributed, with skewness and kurtosis values above the cutoff of 2.0 for all four time points (Table 5). Again, square root, log, and inverse square root transformations were performed but did not improve skewness and kurtosis. As noted previous, this may likely be due to FIM's ceiling effects with many participants scores approaching the scale's highest value (35); therefore, the original variables were used. The Little's MCAR test indicated that the data were not missing completely at random (χ^2 [28] = 247.38, $p < .001$). As above, in order to avoid a biased sample from using listwise deletion, FIML was used to account for missing data.

Preliminary Curvature Analyses. A comparison of curvature models suggested that a quadratic, or U-shaped, trend best fit FIM Motor trajectories over time (Table 6).

Primary Set 1. The first set of HLMs examined whether quadratic FIM cognitive trajectories could be predicted by immigration status. All statistically significant and non-significant fixed effects from the HLM and their b-weights and *p*-values appear in Table 7. There was a significant main effect of immigration status on FIM cognitive trajectories, suggesting that immigrants with TBI had overall lower scores over time than individuals born in the U.S. (Figure 3). However, there was no significant time^2*immigration effect (Table 7), suggesting that FIM cognitive trajectories did not change differentially over time.

Figure 3. *Main effect of immigration status on FIM Cognitive trajectories.*



Primary Set 2. The HLM with demographic and injury-related covariates added to the model found that the effect of immigration status on FIM cognitive trajectories remained, even after controlling for possible confounds (Table 7). Because the original time^2*immigration effect was not significant, follow-up analysis with the addition of covariates was not conducted.

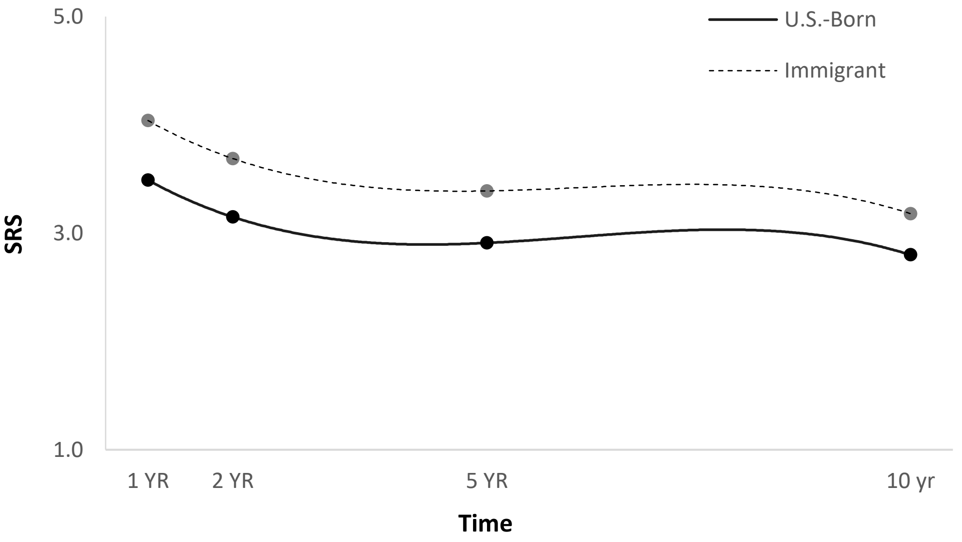
Supervision Rating Scale (SRS)

Descriptive and Assumption-Focused Analyses. Means and standard deviations (*SD*s) for the SRS at each time point were calculated (Table 5). SRSs scores across the full sample reflected an initial steep drop (with people becoming more independent), a slight leveling off by the 5-year data collection, and then a slight continued drop to the 10-year time point (Table 5). Normality tests of the SRS suggested that it was not normally distributed, with skewness and kurtosis values above the cutoff of 2.0 for most time points (Table 5). Although square root and log transformations improved skewness and kurtosis, visual inspection of histograms at each time point suggested that the data were extremely zero-inflated, with 66.6%, 79.2%, 78.3%, and

82.5% of the sample receiving the lowest score of “independent” at each successive time period, respectively. As a result of this and to increase interpretability of results, the data were retained in their raw form. The Little’s MCAR test indicated that the data were not missing completely at random (χ^2 [28] = 97.73, $p < .001$). As above, in order to avoid a biased sample from using listwise deletion, FIML was used to account for missing data.

Preliminary Curvature Analyses. A comparison of curvature models suggested that a cubic, or S-shaped, trend best fit SRS trajectories over time (Table 6).

Primary Set 1. The first set of HLMs examined whether cubic SRS trajectories could be predicted by immigration status. All statistically significant and non-significant fixed effects from the HLM and their b-weights and *p*-values appear in Table 7. There was a significant main effect of immigration status on SRS trajectories, suggesting that immigrants with TBI had overall higher scores over time, reflecting greater supervision needs, than individuals born in the U.S. (Figure 3). There was no significant time^3*immigration effect (Table 7), suggesting that SRS trajectories did not change differentially over time.



Primary Set 2. The HLM with demographic and injury-related covariates added to the model found that the effect of immigration status on SRS trajectories remained, even after controlling for possible confounds (Table 7). Because the original time^3*immigration effect was not significant, follow-up analysis with the addition of covariates was not conducted.

Discussion

The purpose of this study was to examine the influence of immigration status on mental health (i.e., life satisfaction, depression, and anxiety) and functional independence (i.e., motor and cognitive, as well as supervision needs) outcomes in individuals with TBI at 1, 2, 5, and 10 years post-injury. Immigrants exhibited higher life satisfaction trajectories than those born in the U.S., even after controlling for demographic and injury-related covariates, but comparable levels of depression and anxiety. Immigrants also exhibited lower motor functional independence trajectories than those born in the U.S., again even after controlling for demographic and injury-related covariates. However, immigrants generally showed a stronger upward quadratic trajectory in motor functional independence with the greatest gains between the 5- and 10-year time points, whereas those born in the U.S. improved more quickly but then plateaued between the 5- and 10-year time points; these differential effects over time dissipated with the addition of demographic and injury-related covariates. Immigrants exhibited lower cognitive functional independence trajectories, as well as greater supervision needs trajectories, than those born in the U.S., even after controlling for demographic and injury-related covariates.

Mental Health

The average participant score in the full sample fell into the slightly satisfied range, with a slight upward movement for the first five years, and scores remained relatively stable from the 5- to 10-year time point. This is in line with previous research, which showed that life satisfaction is generally lower among individuals with TBI in the first year after injury (Dijkers, 2004) and improves over time (Brown et el., 2011; Wood et al., 2008). In a Swedish sample, Jacobsson et al. (2013) found that participants were satisfied with life across 10 domains of life satisfaction 15 years post-injury. Williamson et al. (2016) also found in a U.S TBIMS sample that life satisfaction trajectories increased over 10 years post-injury. The average participant PHQ-9 and GAD-7 score fell into the mild depressive and anxiety symptom range over time (Kroenke, Spitzer, & Williams, 2001) which remained relatively stable at each successive time point with no upward or downward movement. The results were contrary to other previous literature, where depression has been reported to either increase over time (Deb et al., 1999; Fann et al., 1995; Holsinger et al., 2002) or decrease over time (Singh et al., 2019).

Despite the hypothesis that immigrants with TBI would have worse life satisfaction, depression, and anxiety (based in previous research finding racial/ethnic disparities in mental health after TBI; Arango-Lasprilla et al., 2007; Perrin et al., 2014), immigrants in the current study actually had comparable depression and anxiety to those born in the U.S. and paradoxically higher life satisfaction trajectories over time, even after controlling for covariates. This set of findings adds to current research regarding protective and resilience factors among immigrants. In order to fully conceptualize the psychosocial adjustment process in TBI in culturally diverse individuals, it is important to consider the contributing factors of the individual’s larger culture. Culture plays a vital role in decisions about health, long-term care service use, and rehabilitation (Wolinsky, 1994). Knowing the cultural preferences of individuals with TBI may provide a greater understanding of patient psychological adjustment, not only facilitating the development of culturally competent services but also increasing treatment adherence and patient quality of life (Uomoto & Wong., 2015). These cultural values have often been suggested to include familialism, collectivism, and interdependence (Marin & Marin, 1991).

In most countries, particularly Latinx, Asian, and African countries, collectivism tends to be embedded in societal structure more so than individualism. As family members are the major source of support for individuals with TBI, they play a pivotal role in promoting healthy adjustment throughout the rehabilitation process. Gan et al. (2006) found level of family functioning is inversely associated with patient stress levels. Increased family collaboration in rehabilitation processes is linked to better TBI rehabilitation outcomes (Sander et al., 2002; Sander et al., 2012; Macaden et al., 2010). Social support, in general, has been linked to greater rehabilitation following TBI (Leach et al., 1994); thus, close family involvement may contribute to milder depression and anxiety than might be expected in immigrants with TBI or greater life satisfaction. Family cohesion has been shown to be a protective factor for Asian American immigrants, with higher levels of family cohesion associated with lower rates of depressive disorders (Alegrıa et al., 2008). However, studies also show that greater family cultural conflict is associated with higher rates of depression and lower psychological well-being among immigrants (Walton & Takeuchi., 2010; Farver et al., 2002; Greenberger and Chen 1996), so in cases where this conflict is high, immigrants with TBI may now show the comparable or better mental health found in the current study.

It should also be noted that mental health among immigrant groups in the U.S. can be difficult to assess and treat due to several factors. Negative social attitudes toward mental illness, somatically focused symptom presentation, lack of understanding of mental illness among family members or care providers, and avoidance of mental health services by patients (Roy et al., 2015) are common among immigrant groups. Due to the negative stigma that is generally associated with mental health issues, immigrants are less likely to disclose their emotional symptoms, and they may have more difficulty receiving treatment (Nadeem et al., 2007). Culture affects the prevalence of mental illness, issues with diagnosis and assessment, etiology, course of the disease, how distress can be expressed, certain coping styles and help-seeking behaviors, as well as issues with treatment (Hwang et al., 2008). As a result, in the current sample, immigrants may have been under-reporting their mental health issues or over-reporting their life satisfaction, in line with cultural norms.

The psychological health of immigrants is a very complicated subject, with significant variations depending upon a multitude of factors and community integration regarded as one of the more significant factors (Moore, 2017). Early research on immigrant mental health has helped uncover the unique challenges faced by immigrants in adjusting to unfamiliar and often unwelcoming social milieus. This often results in extraordinary challenges such as acculturative stress, negotiating a new language, altered gender roles, discrimination, intergenerational family conflict, and socioeconomic barriers (Kuo & Tsai, 1986; Rumbaut, 1994). The mode of migration can also impact the degree of mental distress experienced as with undocumented immigrants, refugees, and other victims of violence (Moore, 2017).

Conversely, research has also investigated the phenomenon known as the “immigrant paradox,” which posits that immigrants tend to be healthier when initially confronting the challenges of immigration (Moore, 2017). Some immigrant groups, notably Mexican immigrants, initially report lower incidents of mental issues as compared to U.S.-born Latino and non-Latino populations (Algeria et al., 2008; Moore, 2017). Although the immigrant paradox holds true for some immigrant groups, caution has been exerted in generalizing the immigrant paradox for all inter-ethnic group members (Algeria et al., 2008). The immigrant paradox also falls short in that second-generation immigrants born in the U.S. often fare worse in terms of depression and other health issues than the first immigrant generation (Moore, 2017). Subsequent studies have focused on identifying other risk and protective factors for immigrants. Moreno et al. (2021) investigated the effects of private and social religious coping on life satisfaction with a majority Latinx immigrant sample. The study found a positive direct relationship between both private and social religious coping and life satisfaction, with acculturation and biculturalism both moderating the relationship between private religious coping and life satisfaction. The study suggested that private and social religious coping is both important predictors for increasing perceived life satisfaction in a majority immigrant Latinx population. The study also found increased life satisfaction from the use of private religious coping among participants with low levels of acculturation. As a result, in the current study, religiosity and biculturalism, where present, could be affecting the mental health of immigrants with TBI. In another study examining Mexican immigrant women, the study showed that having fewer Hispanic friends, speaking English almost exclusively, and spending most of one's childhood only in the U.S. predicted fewer depression symptoms (Dinh et al., 2009). Some studies have found that strong ethnic identity promotes psychological well-being among immigrants and ethnic minorities (Phinney et al., 2001; Gong et al., 2003), while others have shown that strong ties to one's ethnic identity increase the odds of depression and anxiety, particularly among immigrant Asian women (Leu & Takeuchi, 2011).

Functional Independence

Functional Independence Measure-Motor. The finding of lower motor functional independence trajectories in the immigrant with TBI group than those born in the U.S. parallels current literature showing ethnically diverse groups to have lower motor independence than

Whites with TBI (Dehnadi-Moghadamet al., 2017). However, Immigrants generally showed a stronger upward quadratic trajectory in motor functional independence with the greatest gains between the 5- and 10-year time points; these differential effects over time dissipated with the addition of demographic and injury-related covariates. The findings also parallel previous literature which showing greater motor independence over time (Walker & Pickett, 2007).

To date, no studies have explored how culture and cultural practices impact motor independence with immigrants with TBI. However, one can infer that immigrant caregivers may respond to and provide care based in part on their cultural norms and values. Rehabilitation methodologies in the U.S. are largely centered on an individualistic approach, which encourages rehabilitation programs to focus on improving self-determination, increasing productivity, and enhancing one's individualism and independence (Uomoto & Wong, 2015). The ability to become self-sufficient is the ideal outcome for most rehabilitation programs (Jezewski & Sotnik, 2001). Conversely, people from racially and ethnically diverse groups, and particularly immigrants, generally ascribe to more collectivistic approaches, which may have an entirely different approach to rehabilitation (Ingstad & Whyte, 1995). Those from diverse backgrounds may focus on functional interdependence within a group rather than the through the individual self (Jezewski & Sotnik, 2001).

Man (1998) found that Hong Kong Chinese families expressed their care for family members with brain injury through physical care and providing material assistance, such as assisting brain-injured persons with self-care needs. In a number of cultural groups, definitions of family may also involve close participation of extended family members beyond the nuclear family in the protection and care of the person with TBI (e.g., Hispanic families; Simpson et al., 2000). Misinterpretation of FIM-Motor abilities (which assesses grooming, feeding, dressing, bathing, and toileting) may very much be evident in the current study findings, especially without the consideration of how immigrant groups may provide a very high level of care for family members with TBI and may potentially result in lower FIM-Motor scores. Further studies are needed to further explore these considerations.

Functional Independence Measure-Cognitive. Regarding FIM-Cognitive, the average participant score in the sample showed a slight upward movement for the first five years, and then scores remained relatively stable between the 5- to 10-year time points. These findings also align with previous literature, which has shown that a high number of post-discharge comorbidities impacts cognitive functioning during the first few years (Zarshenas et al., 2019). As hypothesized, the current study showed that immigrants with TBI had lower FIM-Cognitive scores over time than individuals born in the U.S. Various studies have also shown an effect of culture/ethnicity on cognitive performance. Lower performance in African-American, Hispanic, and Asian groups relative to White people has been observed across numerous neuropsychological evaluations (Norman et al., 2000; Patton et al., 2003; Coffey et al., 2005; Schwartz et al., 2004). These differences were reduced when the effects of acculturation were considered. A study by Boon et al. (2017) showed that when comparing White (non-Hispanic), African American, Hispanic, and Asian individuals, significant group differences on a third of the scores from the neuropsychological battery used emerged, with disparities in cognitive functioning (executive tasks) where group differences were found.

The FIM-Cognitive subscale also assesses communication, expression, comprehension, social interaction, problem solving, and memory. The FIM-Cognitive ratings represent an accumulation of observations of a patient’s receptive and expressive abilities, where the responsibility for scoring the FIM-Cognitive is shared by healthcare personnel. An accurate rating of functional communication abilities is integral for making recommendations and treatment planning for people with TBI (Lequerica et al., 2015). The physician-patient relationship is dependent upon effective communication. Therefore, limited English-speaking patients must be able to communicate well enough with their healthcare provider about their care needs. Limited English proficiency has been associated with a multitude of factors, such as the inaccuracy of medical diagnosis, inadequate health treatment, and overall affects the patient-provider relationship (Baker, Hayes, & Puebla-Fortier, 1998; Flores, 2006). As a result, bias stemming from linguistic issues may be in part contributing to the lower FIM-Cognitive scores for the immigrant sub-sample in the current study, as has been documented in previous research (Lequerica et al., 2015).

Similar to the current study findings, previous studies have also shown that individuals from racially/ethnically diverse backgrounds exhibited lower functional independence and greater disability (Haider et al., 2007; Hanks et al., 2003). Various studies have documented the negative implications that cultural differences in communication and language can have in healthcare settings (Judd, 2005; Meeuwesen, 2012). From the patients' perspective, feeling of shame for not speaking better English may arise, and they may just smile and nod even though they do not fully understand what is being said to them; Some patients may self-identify as English speakers and may be embarrassed or ashamed to admit that unfamiliar medical concepts and terminology are difficult to understand (Uomoto & Wong., 2015). Several studies have documented that immigrants often have significant language and health literacy difficulties, which are further exacerbated by cultural barriers and economic challenges to accessing and making sense of relevant health information (Kreps & Sparks, 2008; Kimbrough, 2007; Becerra et al., 2017; Johnson et al., 2019).

Supervision Needs. SRS scores across the full sample reflected an initial steep drop (with people becoming more independent), a slight leveling off by the 5-year data collection, and then a slight continued to drop to the 10-year time point, indicating lower overall supervision needs over time. Similarly, Hawkins et al. (1997) found that by 1-year post-injury, 59% of participants in their sample were independent of supervision. Previous studies have documented psychosocial and activities of daily living as areas that need the most support. In a 10-20 year follow-up study, Hoofien et al. (2001) found that ongoing need for supervision centered on psychosocial support, particularly in the areas of emotional functioning, vocational functioning, psychomotor functioning, and information processing. Previous studies have also shown that supervision needs following severe TBI were consistently high 3-5 years post-injury (Tate et al., 2020). However, no studies have reported cubic movement of supervision needs over time.

Immigrants with TBI in the current study had overall higher scores over time than individuals born in the U.S., reflecting greater supervision needs, even after the addition of demographic and injury-related covariates. DeJong et al. (1990) found primary responsibility for the lifelong well-being of TBI patients falls on their immediate family, who often manage physical, emotional, and supervisory needs for individuals with TBI (Harris, 2001). Given that various immigrant groups align with more allocentric and collectivistic social and familial structure, supervision needs for individuals with TBI may be unique. McCubbin and McCubbin (1987) found families that emphasize optimism, collectivism, and their family unit, as well as shared values and goals, were more likely to positively adapt to TBI. As reflected in higher scores in the current study, immigrants may have higher supervision needs based on a greater TBI severity (though it is unlikely as TBI severity was controlled for), or immigrant families may simply provide a higher level of supervision and care to their injured family member based on these particular cultural values, thereby resulting in higher SRS scores.

Clinical Implications

The current study findings have several implications for TBI rehabilitation and future directions to improve rehabilitative care, particularly for immigrants. Rehabilitation professionals must consider the mechanisms that influence both functional and mental health outcomes of immigrants. This can likely involve patient-provider interactions, experiences of perceived and everyday discrimination, and strategic ways to attend to environmental and social disparities (Benjamins & Whitman, 2014). Previous research has shown that rehabilitation clinicians are often inadequately prepared to provide culturally sensitive care (Niemeier & Arango-Lasprilla, 2007). Indeed, clinicians need increased awareness and knowledge of the cultural beliefs and customs of their patients, which could be delivered through continual education training. Previous research has shown healthcare providers encounter many challenges in providing care for immigrants and their families around language and communication, particularly in dealing with translators (Lindsay et al., 2012; Boulware et al., 2003). More time should be allotted when working with immigrants with TBI, to build rapport and to allow time for working with interpreters.

Healthcare providers have reported several discrepancies around how disability is understood and responded to (Lindsay et al., 2012), and researchers argue that there is a need for a greater emphasis regarding the intricate dynamic between the cultural lens of U.S. health care providers and patients from immigrant and diverse backgrounds (Dickie, 2004; Niemeier & Arango-Lasprilla, 2007). One way to reduce this gap is by hiring more ethnically and linguistically diverse staff, possibly matched with patients from similar backgrounds; this would be especially imperative in major cities where there tend to be higher numbers of immigrants. Although the current study did not yield significant differences in depression and anxiety symptoms, establishing integrative care with more ethnically and linguistically diverse staff may also buffer possible disparities in mental health diagnosis and treatment, or help immigrants work within their own cultural norms around the disclosure of mental health issues. Clinicians should also assess the patient's level of health literacy and provide appropriate interventions. Clinicians should be wary when patients ask few questions, rarely initiate conversation, simply nod or say "yes" in response to the clinician's questions or comments or provide inappropriate or inconsistent responses to questions. Having patients repeat back what was discussed can help clarify the level of understanding and whether an interpreter is needed (American Medical Association [AMA], 2013). The Teach-Back method is a documented Health literacy intervention that aims to ensure that patients understand the information they have been given (AHRQ Health Literacy Universal Precautions Toolkit, 2020). The Teach-Back method has also been documented and used with individuals with TBI (Oyesanya, 2019).

In regards to assessment with and interpretation of measures like the FIM, given that assessment outcomes are highly variable when accounting for acculturation factors (Boon et al., 2007), ideally, future normative studies should stratify data according to acculturation, rather than just race or ethnicity. Until then, the use of measures like the FIM should be administered and interpreted with appropriate cultural adjustments informed by the available literature. This would ameliorate mischaracterizations of the cognitive or motor abilities of immigrants with TBI. Clinical diagnosis based purely on such data must include prominent caveats about sources of measurement error. Lastly, it is important to consider the limitations of functional measures, especially the FIM, in immigrant groups with TBI. Findings from the current study indicate that immigrants experience lower functional independence over time when compared to U.S.-born individuals. These finding may be conflated with potential bias based on health care providers' interpretation of patients' cognitive and motor presentation.

Limitations and Future Directions

Despite the notable findings of the current study, there are several limitations and as a result, directions for future research. First, although advanced trajectory modeling was used, these data were not experimental, and as a result, the analyses were unable to determine causality in the series of relationships. Future research should consider crossed-lagged panel analyses to better investigate theoretical causality. Second, normality testing indicated skewed and kurtotic data for measures of functional independence. Although this may be attributed to ceiling effects and zero inflation of data points, caution should be considered in the interpretation of these variables. Third, previous studies have shown that the TBIMS national database does not encapsulate the full U.S. TBI patient population (Corrigan et al., 2012). Studies have shown that more severe disability due to TBI will lead to greater support needs that persist over a long period of time (Tate et al., 2020). As a result, caution should be taken in generalizing the current findings to all immigrant groups with TBI.

Overrepresentation of participants with moderate or severe TBI in the TBIMS database may not be fully representative of supervision needs trajectories of those with mild TBI. Also, the current study sample of individuals with TBI was predominately male in both immigrant and U.S.-born groups. As such, the findings may reflect an overrepresentation of men with TBI. Fourth, although immigrants with TBI may share cultural collectivistic commonalities and may experience similar sequelae due to TBI, the difference between cultural groups (e.g., African vs. Asian vs. Latinx) and well and intragroup differences (e.g., differences within African, Asian, and Latinx groups) may also highlight nuances in cultural beliefs, attitudes, and behaviors in response to rehabilitative care. Fifth, the generation level was not captured in the current sample. Future studies should examine how generational immigration differences affect rehabilitation outcomes. One major aspect of the immigrant paradox postulates that the second-generation individuals born in the U.S. fare worse than the first immigrant generation for major mental health issues such as depression and anxiety (Teruya & Bazargan-Hejazi, 2013; Moore, 2017). Sixth, an important consideration of this study is that all Asian, Latinx, Black, and White individuals born outside of the U.S. collectively represented the immigrant group. Various groups can have very different immigration experiences, which are dependent in part upon the region from which they immigrated. Seventh, it is also important to temper the generalizability that all immigrants ascribe to a collectivistic culture. Because 24% of the immigrant sample in the current study identified as White, it is likely that a portion of the participants may not come from a collectivistic culture.

Conclusion

The current study examined the degree to which disparities in functional and mental health outcomes exist between U.S.-born vs. immigrant individuals with TBI at 1, 2, 5, and 10 years after injury. The study examined whether demographic and injury-related characteristics contribute to some of these disparities. Results suggested that immigration-related disparities in longitudinal trajectories exist, particularly regarding functional independence. Specifically, immigrants displayed lower functional and motor independence trajectories compared to U.S.-born individuals, but nonetheless greater life satisfaction, even after controlling for demographic and injury-related characteristics. This study supports future exploration for possible other cultural and acculturative factors that may better explain these disparities.

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