TRAJECTORIES OF LIFE SATISFACTION DURING THE FIRST 10 YEARS FOLLOWING TRAUMATIC BRAIN INJURY

A Dissertation

by

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ABSTRACT

To examine the predictive relationships of functional ability, gender, and age on the longitudinal trajectories of life satisfaction across 10 years following onset of traumatic brain injury (TBI). Participants were part of the Traumatic Brain Injury Model Systems (TBIMS) longitudinal study of outcomes following TBI. Hierarchical linear modeling (HLM) was employed to assess changes in life satisfaction across 10 years post-injury as a function of functional ability, gender and age. The sample included 7,813 participants (2,170 women, 5,643 men) who were included in the TBIMS database. Satisfaction with life across 10 years post-injury was measured by the Satisfaction with Life Scale administered at 1, 2, 5, and 10 years post-injury. The Functional Independence Measure (FIM™) was administered to measure functional ability at 1, 2, 5, and 10 years post-injury. Additional predictor variables included gender and age. Participants' life satisfaction scores remained stable across 10 years post-injury. Greater functional ability as measured by the FIM™ Total scale, FIM™ Cognitive subscale, and FIM™ Motor subscale was associated with greater life satisfaction across time. A significant interaction effect between age and functional ability was present. Gender was not a significant predictor of life satisfaction. Life satisfaction across 10 years post-injury is relatively stable. Greater functional ability was associated with greater life satisfaction. Older participants with greater functional impairments had higher life satisfaction scores across 10 years post-injury compared to their younger counterparts.

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CHAPTER I

INTRODUCTION

In the United States, 1.7 million individuals sustain a traumatic brain injury (TBI) every year (Faul, Xu, Wald, & Coronado, 2010). Along with the staggering number of newly acquired TBIs in the United States annually, medical advances continue to increase the life expectancy of individuals following TBI (Straus, Shavelle, & Anderson, 1998). As a result, TBI has become a significant public health concern and been dubbed the "silent epidemic" (Faul et al., 2010). However, healthcare providers, policymakers, and the insurance industry view TBI as a distinct, disabling "event" instead of acknowledging the long-term consequences of TBI on individuals, families, and society at large (Masel & DeWitt, 2010). Thus, it is imperative that adjustment following TBI be conceptualized from a chronic disease model instead of a short-term, acute rehabilitation perspective (Corrigan & Hammond, 2013).

Understanding the trajectory of adjustment following TBI is paramount to the development of important medical and psychological interventions for individuals living with TBI (Mailhan, Azouvi, & Dazord, 2005). Yet, the tremendous variance in the sequelae of TBI including affective and behavioral disruptions (e.g., major depressive disorder, posttraumatic stress disorder, generalized anxiety disorder), cognitive impairments, paralysis, persistent pain and additional physical impairments, creates unique challenges when studying adjustment following TBI (Wilson, 2008). Although significant individual differences exist in post-injury outcomes, longitudinal research suggests social and behavioral factors provide the greatest influence on adjustment following traumatic injury and disability (Glass & McAtee, 2006; Israel, Schulz, Parker, & Becker, 1998). Therefore, research initiatives that shed light on the dynamic and multifactorial nature of patient-oriented outcomes are greatly needed to advance the clinical and theoretical understanding of adjustment following TBI.

Subjective Well-being and TBI

Subjective well-being is potentially a very influential factor impacting long-term adjustment following TBI and other neurologic injuries (Fuhrer, 2000). Over the last decade subjective well-being research focused on measuring and predicting life satisfaction among individuals with TBI has proliferated; however, results have been inconsistent. The pervading finding is a steady decline in life satisfaction over time although some research suggests long-term stabilization (Corrigan, Bogner, Mysiw, Clinchot & Fugate, 2001; Dijkers, 2004; Johnston & Miklos, 2002). Additionally, research is inconclusive regarding the predictive relationship of various premorbid and injury-related variables on life satisfaction. For example, Corrigan et al. (2001) found evidence that premorbid factors including substance abuse following TBI predicted decreases in life satisfaction in a sample of persons with TBI at 1 year and 2 years post-injury. In contrast, Bush et al. (2003) failed to find significant predictive relationships among premorbid variables and life satisfaction among individuals with TBI at 1 year post-injury. Subsequently, Bush et al. (2003) reported significant predictive relationships between injury severity and life satisfaction at 1 year post-injury. Yet, other work concludes that injury severity is only modestly predictive of life satisfaction following

TBI (Testa, Malec, Moessner, & Brown, 2005), weakly predictive (Cappa, Conger, & Conger, 2011), or not predictive at all (Dijkers, 2004).

Dynamic Model of Adjustment Following TBI

The conflicting results in the literature on adjustment following TBI are further complicated by the paucity of research analyzing longitudinal trends of life satisfaction and adjustment. The majority of relevant research has been confined to prospective designs along with cross-sectional studies that imply rather linear trends in long-term adjustment (Resch et al., 2009). Consequently, there has been limited research on recently developed models of adjustment following disability that describe adjustment as a non-linear process influenced by a broad spectrum of psychosocial and disability-specific factors (Elliott & Mullins, 2004; Elliott & Warren, 2007). Further, Elliott, Kurylo, and Rivera (2002) proposed a dynamic model of adjustment which suggests lifelong adjustment following TBI may be best conceptualized by nonlinear trajectories facilitated or obstructed by a vast array of biopsychosocial factors throughout the lifespan (Resch et al., 2009).

In a study guided by this dynamic model, Resch et al. (2009) analyzed individual-level growth trends in life satisfaction over time among persons with TBI. Hierarchical linear modeling was employed to model longitudinal trajectories of life satisfaction within the first five years post-discharge from an acute care rehabilitation center following TBI. Additionally, Resch et al. (2009) examined the relative contributions of functional ability, age, and gender on trajectories of life satisfaction. Resch et al. (2009) reported overall decline in life satisfaction across the 5 year period.

Further, individuals who reported lower functional independence throughout the 5 years post-discharge had significant rates of decreases in life satisfaction compared with participants with greater functional independence. Subsequently, participants with greater functional independence at 1 year post-discharge had higher life satisfaction at 1 year post-discharge. Resch et al. (2009) failed to find any significant gender or age-related differences in trajectories of life satisfaction following TBI.

Purpose

The purpose of the present study is to analyze the trajectories of subjective well-being over the first 10 years following onset of TBI. As a result, the present study aims to replicate and extend several aspects of the Resch et al. (2009) study. In accordance with Resch et al. (2009), the present study will examine the individual-level growth trends of life satisfaction with covariates functional ability, gender, and age across the first several years following TBI. As an extension of the Resch et al. (2009) study, participants' trajectories of life satisfaction will be extend beyond a 5 year period (1, 2, 4, and 5 years) to a 10 year period post-injury (1, 2, 5, and 10 years). Additionally, the participants included in the present study will be from the Traumatic Brain Injury Model Systems (TBIMS) National Database, the largest database of individuals with moderate to severe acquired TBIs, which allows for greater generalizability. Statistical analyses of longitudinal trajectories will be completed within a hierarchical linear modeling (HLM) framework to allow for multiple observations nested within each individual, unequal spacing between time intervals, accommodation of missing data, and greater precision in the estimation of standard errors compared with traditional regression analysis (Raudenbush & Byrk, 2002).

Based on the results from the study by Resch et al. (2009), trajectories of life satisfaction will be expected to significantly vary based on functional ability. Specifically, greater functional independence is hypothesized to positively influence the trajectories of life satisfaction over the first 10 years post-injury. Finally, similar to Resch et al. (2009), the present study will examine differences in gender and age throughout the trajectories of life satisfaction following TBI. Specifically, regarding gender and age differences, the null hypothesis will be assumed: there will be no significant differences in life satisfaction trajectories as a function of gender or age.

CHAPTER II

LITERATURE REVIEW

Traumatic Brain Injury

TBI is the leading cause of disability and mortality worldwide (Steel et al., 2010). Annually, 1.7 million Americans sustain a TBI; the majority (96%) will be treated in an emergency setting or hospitalized to receive acute and rehabilitative care while the remaining 4% will die (Faul et al., 2010; Langlois, Rutland-Brown, & Thomas, 2004). The economic burden placed on society and the financial hardship among individuals and their families following TBI is tremendous (Gary, Arango-Lasprilla, & Stevens, 2009). Within the first 6 months following TBI, the personal costs for acute and rehabilitative care often exceeds $130,000 (Davis, Joshi, Tortella, & Candrilli, 2007). Additionally, Finkelstein and Corso (2006) estimate the cost of TBI to society to be around $60 billion dollars due to the loss of productive years of employment and potential income among individuals with disabling TBIs.

According to the Traumatic Brain Injury Model Systems (TBIMS) National Statistical Center, TBI is best defined as damage to brain tissue that is caused by an external mechanical force. Evidence of one of the following is required to be diagnosed with a TBI: posttraumatic amnesia, loss of consciousness resulting from trauma to the brain, or neurological difficulties resulting from TBI as observed upon physical examination (Dijkers, Harrison-Felix, & Marwitz, 2010). Further, any injury that is caused by penetrating wounds and meets the above criteria is also identified as a TBI (Dijkers et al., 2010).

In recent years, the number of individuals surviving moderate to severe TBIs has significantly increased due to improvements in the efficiency and effectiveness of emergency services, safer and faster transport to rehabilitation treatment facilities, and advanced management of medical problems within acute care (Arango-Lasprilla et al., 2007). Despite increased survival rates, many persons living with moderate to severe TBI suffer from consequences of their injuries including physical, cognitive, behavioral, and psychological disabilities (Lippert-Gruner, Lefering, & Svestkova, 2007). As a result, debilitating impairments following TBI may compromise long-term activity patterns including physical and psychological functioning (Mailhan et al., 2005). Unfortunately, research to date on the long-term adjustment following TBI has been limited in number, scope of predictor variables examined, and statistical methodology employed (Hoofien, Gilboa, Vakil, & Donovick, 2001; Resch et al., 2009).

In many respects, long-term adjustment following TBI can be best conceptualized and treated as a chronic disease (Corrigan & Hammond, 2013; Masel & DeWitt, 2010). The World Health Organization classifies disabilities including TBI as chronic disease processes when the disabilities meet one or more of the following criteria: are permanent, caused by irreversible pathological changes, require long-term supervision, care, or observation, and/or require rehabilitative treatment (World Health Organization [WHO], 2001). Conceptualization of TBI as a chronic disease is in stark opposition to the "find it and fix it" approach prevailing within the medical model of disability. From the perspective of the medical model, TBI is understood as a single injury "event" that is treated with acute care interventions and rehabilitation services. In recent years the medical model of disability has revolutionized emergency and rehabilitation services for persons who acquire TBIs which has led to substantial increases in life expectancy among this population (Crews, 2012). The chronic disease and disability process, including prevention of complications secondary to TBI, as well as, the achievement of optimal functioning and well-being is primarily influenced by social and behavioral mechanisms (Elliott & Warren, 2007). Unfortunately, the medical model of disability fails to adequately explain the chronic nature of TBI following initial acute care service delivery. Elliott et al. (2002) devised a holistic model of disability that encompasses a biopsychosocial perspective of both acute and long-term adjustment following disability to overcome the limitations of the medical model.

Dynamic Model of Adjustment Following Traumatic Brain Injury

According to Elliott et al. (2002), adjustment following TBI should be studied from a longitudinal, dynamic perspective. Elliott et al.'s (2002) dynamic model of adjustment to disability is useful for understanding the contextual relationships between various factors in the adjustment process over time. The model describes adjustment following TBI as a fluid and dynamic process in which behavior is a function of person-environment interactions (Elliott et al., 2002). Specifically, the model outlines how (a) individual differences and enduring characteristics, along with (b) social and environmental factors affect (c) phenomenological appraisal processes that, in turn, influence the ongoing interactions between (d) physical health and (e) psychological well-being. Additionally, these five components of the dynamic model are framed within a developmental continuum that accounts for individualized changes in long-term adjustment following TBI (Elliott et al., 2002).

The majority of research on TBI within the field of rehabilitation psychology has examined simplistic associations between psychological well-being, physical health, and demographic characteristics (Elliott & Warren, 2007). Elliott et al. (2002) highlighted the limited utility of these associations in understanding the dynamic and multifaceted nature of the long-term adjustment process following TBI. These authors outline the need for studies that measure the nonlinear trajectories of demographic and psychosocial variables, as well as environmental characteristics at multiple time points beginning during rehabilitation and continued for many years thereafter.

The Traumatic Brain Injury Model Systems (TBIMS) program was originally developed to address the complex nature of adjustment following TBI. From its inception in the late 1980s data has been collected on thousands of individuals with moderate to severe TBIs. As a result, the TBIMS National Database allows researchers to assess the long-term influence of personal, social, and environmental factors on adjustment following TBI. However, research focused on nonlinear trajectories of individual adjustment has been largely neglected. Thus, the present study will utilize the TBIMS National Database to extend previous correlational research by analyzing nonlinear trajectories of subjective well-being along with covariates including functional ability, gender, and age up to 10 years post-injury to advance our current knowledge of long-term adjustment following TBI.

Subjective Well-Being

Historically, the most widely accepted theory of subjective well-being has been Brickman and Campbell's (1971) *hedonic treadmill theory*. The central tenant of this theory is that subjective well-being cannot be significantly altered (Brickman & Campbell, 1971). Brickman and Campbell (1971) proposed that particular circumstances or events could temporarily change individuals' level of subjective well-being; however, these temporary changes in subjective well-being eventually return to an approximate baseline or pre-event level. In one principle study supporting the hedonic treadmill theory among persons with acquired disabilities, Brickman and colleagues (1978) found that persons with acquired SCI reported low levels of subjective well-being shortly after paralysis, but over time subjective well-being returned to the pre-injury level. In contrast, recent studies of persons with acquired disabilities have shown decreases in subjective well-being that fail to return to pre-injury levels (Lucus, 2007b) or steadily decline over several years post-injury (Resch et al., 2009). Thus, several researchers have begun to question the utility of the hedonic treadmill theory for describing subjective well-being among persons with TBI (Lucas, 2007a; Resch et al., 2009).

Diener, Lucas, and Scollon's (2006) research on the hedonic treadmill theory suggests wide intra-and inter-individual variability in subjective well-being following significant life circumstances. Furthermore, research by these authors indicates that subjective well-being may change at various rates and never return to its original level inconsistent with Brickman and Campbell's (1971) idea of a set-point or baseline of subjective well-being. In order to fully explain subjective well-being, Diener et al.

(2006) encourages future research that provides greater understanding of the individualistic patterns of subjective well-being and of predictors of subjective well-being.

Regardless of the model of disability used, Fuhrer (2000) asserts that outcome evaluations of rehabilitation services are inadequate if subjective well-being of individuals with acquired TBI is ignored. Over the past decade, research on subjective well-being following acquired injury has proliferated in part, as a reaction to the vast literature on the negative aspects of disability (Diener, Suh, Lucas, & Smith1999). When conceptualizing subjective well-being among persons with acquired disability, Dunn (2009) suggests “well-being should not be equated with the absence of disability nor should chronic disability be misconstrued as a ‘permanent illness or loss’” (p. 386). Thus, changes in subjective well-being among persons with TBI may be understood as dynamic individualistic processes.

Defining Life Satisfaction

Subjective well-being is an overarching construct that can be divided into three disparate components: negative affect, positive affect, and life satisfaction (Andrews & Withey, 1976). The focus of the affective components of subjective well-being is emotional response. Life satisfaction, in contrast, refers to “cognitively oriented, subjective judgments of one’s current life situation in relation to one’s own expectations” (p. 227; Mailhan et al., 2005). The underlying assumption of life satisfaction is that objective reality may be cognitively perceived and experienced differently based on current expectations, previous life experiences, values, and goals

(Berger, Leven, Pirente, Bouillon, & Neugebauer, 1999). The present study will focus on the life satisfaction component of subjective well-being. Several measures have been developed to assess global life satisfaction. The Satisfaction with Life Scale (SWLS; Diener, Emmons, Larsen, & Griffin, 1985) was employed to measure life satisfaction in the present study. Scores on the SWLS have been significantly correlated with other assessments of subjective well-being (Diener et al., 1985). Further, the SWLS is a frequently used measure in the literature on life satisfaction among persons with acquired TBI.

Life Satisfaction and TBI

According to Hicken, Putzke, Novack, Sherer, and Richards (2002), life satisfaction among persons with TBI has not been thoroughly explored. The lack of research has been attributed to concerns that cognitive impairments in areas such as judgment and self-awareness that are commonly experienced within this population, may limit the interpretability of self-report measures of life satisfaction (Burleigh, Farber, & Gillard, 1998). However, it should be noted that Granger, Divan, and Fielder (1995) failed to find a significant relationship between life satisfaction and cognitive status although other research does not support this finding (Warren, Wrigley, Yoels, & Fine, 1996). Moreover, the subjectivity of self-reports of life satisfaction suggest that by definition responses on life satisfaction measures by persons with acquired TBI should be considered just as valid as other populations of respondents (Hicken et al., 2002).

Research to date on life satisfaction following TBI has resulted in conflicting findings. In a review of the literature, Dijkers (2004) concluded that individuals generally report lower life satisfaction than comparison groups after TBI. Subsequently, Resch and colleagues (2009) found decreases in life satisfaction across the first 5 years post-discharge from an acute care facility. Other studies have demonstrated that life satisfaction can be maintained over time. Corrigan et al. (2001) reported relatively stable life satisfaction over the first 2 years post-injury in a sample of over 200 participants with TBI. Additionally, cross-sectional research of persons with severe TBI 2 or more years post-injury has indicated nonlinear relationships between life satisfaction, TBI, and disability (Mailhan et al., 2005). Thus, the adjustment process appears to be quite diverse among individuals with TBI.

Numerous studies have examined relationships between life satisfaction premorbid, demographic, physical and psychosocial variables in order to better understand and explain the adjustment process following TBI. Research predicting outcomes following TBI by analyzing individual variables is often quite complicated, because recovery from TBI is a dynamic, multifaceted process that cannot be explained by a few predictor variables (Bush et al., 2003). Moreover, contradictory evidence exists regarding predictive associations among life satisfaction variables believed to influence the adjustment process following TBI. Corrigan et al. (2001) examined the associations between current employment and a history of premorbid substance abuse. Substance abuse was highly predictive of decreased life satisfaction while current employment was predictive of increased life satisfaction. However, no premorbid characteristics were predictive of life satisfaction in a study of persons with moderate to severe TBI from acute rehabilitation to 1 year post-injury (Bush et al., 2003). Additionally, injury severity has failed to reliably predict life satisfaction with some research indicating mild predictive utility (Testa et al., 2005) and others reporting no predictive relationship (Dijkers, 2004). The strength of relationship of injury severity to life satisfaction also depends upon the way in which injury severity is measured (Cappa et al., 2011) and the predictive power of injury severity wanes considerably over time (Wood, 2008).

Psychological variables such as depression have been hypothesized to significantly alter life satisfaction over time. A self-reported diagnosis of depression was significantly associated with lower life satisfaction among persons with TBI at 2, 4, and 5 years post-discharge from an acute care facility (Underhill et al., 2003). However, other studies have found depression to be an insufficient predictor of life satisfaction (Mailhan et al., 2005). Further, additional studies have provided a laundry list of variables that have been found to be predictively associated with life satisfaction. In a study comparing variables associated with life satisfaction between persons with TBI and spinal cord injury at 1 year post-discharge, Warren et al. (1996) reported significant increases in life satisfaction related to being married, being employed , total family satisfaction, bowel independence, and memory ability. Life satisfaction has also been associated with social integration and productivity among persons with TBI (Burleigh et al., 1998). Overall, the inconclusive evidence of predictors of life satisfaction and changes in rates of life satisfaction following TBI highlights the need for additional research that takes into account individual differences of adjustment.

Functional Ability, Life Satisfaction, and TBI

Research suggests that adjustment following TBI is often influenced by the degree of functional ability (Johnson et al., 2010). Functional ability refers to an individual's capacity to independently perform daily activities requiring both motor and cognitive abilities. The Functional Independence Measure (FIM™; Keith, Granger, Hamilton & Sherwin, 1987) will be employed to measure functional ability within the present study. The FIM™ is a standardized measure that has been extensively utilized and validated with TBI populations (Corrigan, Smith-Knapp, & Granger, 1997; Granger et al., 1995). Further, according to the TBIMS program the FIM™ is "the most widely accepted measure of functional impairment within the rehabilitation community" (Wright, 2000).

Several studies have explored the relationship between life satisfaction and functional ability. Within the first year post-injury, Hicken et al. (2002) found a significant predictive relationship between functional impairment and decreased life satisfaction. Corrigan and colleagues (2001) reported greater life satisfaction was associated with increased motor independence as measured by the FIM™ at 1 year post-injury. Functional independence at 2 years post-discharge from an acute care facility was significantly predictive of increased life satisfaction in a path analysis conducted by Webb, Wrigley, Yoels, and Fine (1995). Functional impairment was also predictive of decreased life satisfaction in two prospective studies of long-term adjustment following TBI (Johnson et al., 2010; Resch et al., 2009). However, in a cross-sectional study of persons with moderate to severe TBI Corrigan, Smith-Knapp, and Granger (1998) did not find significant correlations between functional ability and life satisfaction in a sample of persons with TBI ranging from 6 months to 5 years post-injury. Nevertheless, there is evidence to suggest functional ability is one of the more important factors in adjustment following TBI.

From a theoretical perspective, functional ability may be construed as a capacity to engage in "intentional activities"—cognitive, behavioral, or volitional—following the onset of disability. Lyumbomirsky, Sheldon, and Schkade (2005) argue that intentional activities account for a greater degree of variance in enduring levels of happiness and well-being (as much as 40%) compared to "circumstantial" variables (e.g., marital status). Thus, intentional activities have the potential to significantly influence life satisfaction following acquired disability (Dunn, Uswatte, & Elliott, 2009).

Gender, Life Satisfaction, and TBI

Although research remains mixed regarding the relative contributions of demographic variables in the prediction of life satisfaction following TBI, there is some evidence to suggest that gender may be an important variable to consider. Recent meta-analytic research on gender differences following TBI indicates that women have greater difficulties in adjustment post-TBI compared to men (Farace & Alves, 2000). Results from one study by Seibert et al. (2002) suggest that women have worse overall quality of life in comparison to their male counterparts. However, gender is not always significantly predictive of life satisfaction. Resch et al. (2009) failed to find significant gender differences in a prospective study of life satisfaction trajectories over the first 5 years post-discharge from an acute care facility. Gender will be taken into account in the present study in light of evidence suggesting gender differences in post-TBI outcomes may exist (Farace & Alves, 2000).

Age, Life Satisfaction, and TBI

The research on age, life satisfaction, and TBI is quite sparse. Among persons without TBI, life satisfaction has not been found to decline as individuals age (Diener & Suh, 1998). Corrigan et al. (2001) also failed to find a significant association between age and life satisfaction following TBI. Subsequently, in the only 5 year longitudinal study of age and life satisfaction, Resch et al. (2009) found no statistically significant differences in life satisfaction trajectories as a function of age. In order to replicate the study by Resch et al. (2009), post-hoc analyses will be conducted in the present study to explore the association between age and life satisfaction in a larger and more nationally representative sample.

Methodological Issues

The majority of existing literature on adjustment after TBI has been limited to analyzing data within prospective, cross-sectional studies. Further, research has been primarily limited to predictive models assessed at one time point. As a result, there are very few studies accounting for long-term trends in adjustment over time. Longitudinal research is ideal for understanding adjustment following TBI; however, longitudinal studies are often fraught with high attrition rates. In one outcome study of persons with TBI, attrition rates were 40% at year 1 post-injury and 60% at year 2 post-injury (Corrigan et al., 2003). Nevertheless, knowledge about the dynamic nature of adjustment following TBI cannot be gained without longitudinal assessment of outcomes.

The nonlinear process of adjustment following TBI may be best studied using multilevel modeling (MLM) techniques. This is because these MLM techniques are equipped to study changes across an extended period of time. Although these techniques are frequently employed in educational research, they are infrequently found in rehabilitation literature, implying the field has yet to fully embrace these techniques. Specifically, hierarchical linear modeling (HLM) is one MLM technique that can be employed in longitudinal research. HLM is considered a robust statistical analysis that is able to solve many of the problems often hindering longitudinal designs using traditional ANOVAS and linear regression analyses (Kwok et al., 2008).

HLM will be employed in the present study to predict long-term adjustment following acquired TBI. The present study will replicate and extend the first application of growth models in studying life satisfaction by Resch et al. (2009). Resch and colleagues (2009) were also the first to suggest that individuals with more severe functional impairments have greater decreases in life satisfaction over the first 5 years post-discharge from an acute care facility. Additionally, potential differences in gender, age, and functional ability will be assessed through modeling of life satisfaction trajectories. The present study will extend the Resch et al. (2009) study by employing a more diverse, nationally representative sample with greater injury severity, along with extending the time since injury to 10 years post-injury.

CHAPTER III

METHODS

Participants

Participants in the present study were part of a larger longitudinal study, the Traumatic Brain Injury Model System (TBIMS) program, funded by the U.S. Department of Education, National Institute on Disability and Rehabilitation Research (NIDRR). The TBIMS program includes 16 Level I trauma centers from which participants receive initial care in the emergency department, followed by treatment of acute neurotrauma and full participation in inpatient rehabilitation programs, and subsequent long-term continuous care by outpatient services (Harrison-Felix, Newton, Hall, & Kreutzer, 1996).[1] Level I trauma centers provide the highest level of trauma care including the presence of a wide array of medical specialties and diagnostic equipment for treating every aspect of trauma injuries. The TBIMS centers also collect data for longitudinal, prospective multicenter research focused on examining numerous variables influencing outcomes and recovery following TBI.

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

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[1] The 16 institutions currently participating in the TBIMS program include: (1) University of Alabama at Birmingham, Birmingham, AL; (2) Santa Clara Valley Medical Center, San Jose, CA; (3) Craig Hospital, Englewood, CO; (4) The Rehabilitation Institute of Chicago, Chicago, IL; (5) Wayne State University, Detroit, MI; (6) Mayo Foundation, Rochester, MN; (7) JFK-Johnson Rehabilitation Institute, Edison, NJ; (8) Kessler Medical Rehabilitation Research & Education Center, West Orange, NJ; (9) Mount Sinai School of Medicine, New York, NY; (10) Carolinas Rehabilitation/ Carolinas Healthcare System, Charlotte, NC; (11) The Ohio State University, Columbus, OH; (12) Moss Rehabilitation Research Institute, Philadelphia, PA; (13) TIRR/Memorial Herman, Houston, TX; (14) University of Texas Southwestern Medical Center/Baylor Institute for Rehabilitation, Dallas, TX; (15) Virginia Commonwealth University, Richmond, VA; and (16) University of Washington, Seattle, WA.

by medical documented loss of consciousness or posttraumatic amnesia (PTA) due to brain trauma or by objective neurological findings that can be reasonably attributed to TBI on physical examination or mental status examination" (Traumatic Brain Injury Model Systems National Data and Statistical Center, 2008). Additionally, participants included in the TBIMS database were required to be consecutively enrolled in the TBIMS program based on the following criteria: (1) moderate to severe TBI classification based on intracranial neuroimaging abnormalities, Glasgow Coma Scale less than 13 (unless due to intoxication, intubation, or sedation) in the emergency department, loss of consciousness exceeding 30 minutes (unless due to intoxication or sedation), or post-traumatic amnesia exceeding 24 hours; (2) at least 16 years of age at the time of injury; (3) admitted within 72 hours of injury to an emergency department at a TBIMS hospital; (4) consecutively received acute care and participated in an inpatient rehabilitation program at TBIMS hospital or a comprehensive rehabilitation facility supervised by a physician association with TBIMS; (5) informed consent signed by the patient, family, or legal guardian to allow medical records, laboratory tests, and other relevant health information to be included in the TBIMS national database (Traumatic Brain Injury Model Systems National Data and Statistical Center, 2008). Participants included in the TBIMS database are representative of a national sample of persons who received high quality care including inpatient rehabilitation services following moderate to severe TBI (Hammond & Malec, 2010).

A total of 11,868 persons with acquired TBI between 1989 and 2013 were included in the TBIMS database. In order to assess longitudinal changes in life satisfaction as a function of functional ability, gender, and age, criteria for inclusion in the present study included the presence of one or more measurements of life satisfaction at 1, 2, 5, or 10 years post-injury, one or more measurements of functional independence at either the first or second year post-injury, and no missing values on both gender and age. As a result, a total of 7,813 participants (2,170 women, 5,643 men) were included in the present study. Participants ranged in age from 16 years to 95 years (*M* = 38.27; *SD* = 17.74) at the time of injury. A majority of participants identified as White (70.52%); 18.42% identified as African American; 7.33% identified as Hispanic; 2.36% identified as Asian/Pacific Islander; and less than 1% identified as Native American or an unspecified ethnicity. In regards to marital status at the time of injury, 48.44% of the participants were single and 32.76% were married. Most individuals had obtained a high school diploma or greater educational status (69.13%) at the time of injury. More than half the sample was competitively employed (65.15%) and the majority of participants earned an annual salary less than $40,000 (54.14%) at the time of injury.

The most frequent cause of injury was motor vehicle accidents (55.51%) followed by falls (20.91%; See Table 2). The severity of injury upon admission to an acute care TBIMS center was measured by the Disability Rating Scale (DRS; Rappaport, Hall, Hopkins, Belleza, & Cope, 1982). The average DRS score was 11.91 (*SD* = 5.40). The distribution of injury severity ratings based on DRS scores for the sample is presented in Table 1. The amount of time between admission and discharge from an inpatient rehabilitation hospital ranged from zero days to 421 days (*M* = 26 days; *SD* = 23 days).

Procedures

During acute care hospitalization, inpatient rehabilitation, and a series of follow-up appointments (1, 2, and 5 years post-injury along with every 5 years thereafter) a standard assessment protocol was administered to participants enrolled in the TBIMS program or their proxy through in-person interviews, telephone interviews, or mailed self-report questionnaires. Participant information collected from these assessments was entered and stored in the TBIMS national database located at the TBIMS National Data and Statistical Center currently lodged at Craig Hospital in Englewood, Colorado. The TBIMS data collection and data storage procedures were approved by and conducted under the auspices of the institutional review boards of all TBIMS institutions included in the multicenter program.

According to the TBIMS Data and Statistical Center, a de-identified copy of the TBIMS National Database can be requested by researchers in the general scientific community. In order to obtain a copy of the database, researchers must email the TBIMS National Data and Statistical Center Project Director and provide the Project Director a completed Data Request and Use Agreement Form. The author of the present study obtained access to the de-identified TBIMS National Database by following these procedures. Once submitted, the TBIMS National Data and Statistical Center along with the TBIMS Research Committee reviewed the proposal to determine any scientific overlap with ongoing research projects. Subsequently, the TBIMS National Data and Statistical Center posted the original proposal and recommendations from the TBIMS Research Committee to the TBIMS Notification Listserve to allow TBIMS personnel an opportunity to provide any concerns about overlap with ongoing research projects and identify potential collaborators for the research initiative under review. Following feedback from the TBIMS Notification Listserve, the TBIMS Program Manager made the final decision to approve the proposal with feedback from the TBIMS National Data and Statistical Center, Research Committee, and the Project Directors.

With receipt of approval to conduct the present study, the TBIMS National Data and Statistical Center released a copy of the most recent de-identified TBIMS National Database. Using the TBIMS National Database, the present study will examine the relationship of functional ability, gender, and age on self-reported life satisfaction among participants consecutively enrolled in the TBIMS program between 1988 and 2013. Data will be extracted from the TBIMS National Database to conduct all statistical analyses assessing longitudinal trajectories of life satisfaction. Specifically, variables including life satisfaction, functional ability, gender, age, and severity of injury collected across the first 10 years post-injury (1, 2, 5, and 10 years post-injury) will be extracted from the de-identified TBIMS National Database. Prior to data extraction, the present study was approved by the institutional review board at Texas A&M University.

Measures

Severity of TBI. The Disability Rating Scale (DRS) is a measure of injury severity across multiple domains of functioning from eye opening to employability (Rappaport et al., 1982). DRS scores range from 0 (*no disability*) to 29 (*extreme vegetative state*). Higher scores on the DRS indicate greater injury severity. The DRS can be administered as a self-report measure or scored by a trained rater through an interview with participants or their family members. All trained TBIMS raters are bi-annually certified to administer the DRS based on requirements outlined by the TBIMS Uniform Data System for Medical Rehabilitation. The DRS was administered upon admission to acute care TBIMS centers and was continuously collected throughout the latest follow-up assessments (up to 20 years post-injury).

Several studies have shown adequate inter-rater reliability for administration of the DRS with TBI populations (Gouvier, Blanton, LaPorte, & Nepomuceno, 1987; Novack, Bergquist, Bennett, & Gouvier, 1991; Rappaport et al., 1982). Gouvier et al. (1987) reported good test-retest reliabilities with a Spearman rho correlation of .95. The internal consistency of items on the DRS was .87 in the present study.

Functional Ability. The Functional Independence Measure was used assess motor and cognitive independence (FIM™; Keith et al., 1987). The FIM™ consists of 18 items with Likert-type rating scales ranging from *need for total assistance* (1) to *complete independence* (7). The level of assistance needed to complete activities of daily living across six functional domains including self-care, locomotion, transfers, communication, sphincter control, and social cognition are included on the FIM™. A score of 7 on the FIM™ indicates complete independence in activities of daily living, while a score of 6 suggests need for assistive device to complete activities, activities require safety considerations, or activities take more than a reasonable amount of time to complete independently. Scores ranging from 1 to 5 indicate need for total assistance (1) to need for supervision by a support person (5). Scores can be summed together to provide a total FIM™ score indicating overall functional ability with higher scores indicating greater independence. Further, items on the FIM™ can be divided into two domains of functional independence: motor (FIM™ Motor; 13 items) and cognitive (FIM™ Cognitive; 5 items). The FIM™ has been administered to participants in the TBIMS program throughout all time points from acute care to the latest follow-up assessments (up to 20 years post-injury). The FIM™ is typically administered by a trained TBIMS rehabilitation healthcare provider or telephone interviewer. Both rehabilitation healthcare providers and qualified telephone interviewers are required to be bi-annually certified as FIM™ raters based on requirements outlined by the TBIMS Uniform Data System for Medical Rehabilitation.

Items on the FIM™ have been shown to have good internal consistency (Cronbach's alpha between .86 and .97) with TBI populations, and the FIM™ has been shown to be sensitive to changes in functional ability from the time of admission to discharge and follow-up (Dodds, Martin, Stolov, & Deyo, 1993; Resch et al., 2009; Stineman et al., 1996). Specifically, there is evidence that the FIM™ is sensitive to subtle changes in functional ability between 1 and 5 years post-injury (Hammond et al., 2001). Across all time periods, the internal consistency of FIM™ items for the present study was high (Cronbach's alpha = .95 to .96).

The distribution of FIM™ scores in the current study evidenced strong ceiling effects. Fischer (1976) concluded that strong ceiling effects can cause problems when examining changes over time. As a result, the FIM™ scores in the present study were linearized using Rasch scaling procedures in order to overcome this limitation (Bond & Fox, 2001). Winsteps 3.75.0 (Linacre, 2012) was employed to fit the data for the FIM™

total scale (FIM™ Total), motor subscale (FIM™ Motor) and cognitive subscale (FIM™ Cognitive) to the Rasch partial credit model for polytomous items. FIM™ items across all time periods were combined into one Rasch analysis to provide a common frame of references for the FIM™ measures (Wright, 2003).

Item reliabilities for the FIM™ total and subscale items were greater than .99. The person separation reliability values (comparable to Cronbach's alpha with corrections for measurement) for persons without extreme values were .83 for the FIM™ Total scale, .83 for the FIM™ Motor subscale, and .77 for the FIM™ Cognitive subscale. When person separation reliabilities for persons with and without extreme scores were computed, the reliability values decreased to .75, .68, and .73 for the FIM™ Total, FIM™ Motor, and FIM™ Cognitive scales respectively. Person separation reliability values of .70 and greater are considered adequate with lower values indicating that persons in a given sample do not differ greatly on the selected measure (J. W. Berry, personal communication, June 24, 2013). Thus, results from the person separation reliability analyses suggest that overall person separation reliability for the FIM™ is adequate; however, persons in the present sample have limited variability in motor functioning.

Item quality was assessed using information-weighted mean square fit statistics. Fit statistics less than 1.50 indicate that items provide good contributions to the development of the identified measurement continuum; fit values between 1.50 and 2.00 are suggestive of "noisy" items but these items do not definitively degrade measurement systems; values greater than 2.00 suggest that the items degrade the measurement system

(Linacre, 2012). For the FIM™ Total scale, all but two items (Item 16 “Problem Solving”, fit statistic = 1.55; Item 18 “Expression”, fit statistic = 1.59) evidenced fit statistics less than 1.50. All items except for one item (Item 7 “Bladder Management”, fit statistics = 1.90) on the FIM™ Motor subscale had a fit statistic less than 1.50. For items on the FIM™ Cognitive subscale, every item fit value was below 1.50.

Assessment of the consistency of item estimates across 10 years post-injury was conducted to provide confirmation for pooling items into a combined analysis as recommended by Chang and Chan (1995). Uniform differential item functioning (DIF) across the time periods was examined to evaluate item stability across time (Bond & Fox, 2001). In order to complete Rasch DIF analyses, scaling is initially completed on item responses among participants in a combined sample from across all time periods, which produces anchor values for both the structure of the rating scale and participant measures. Subsequently, the anchor values from the combined analysis are utilized to compare the measures from each time period separately to a common scale (Bond & Fox, 2001). DIF was assessed by subtracting the difficulty estimates of every item at the individual time points of the four time periods from an average estimate of every item throughout all time points. Stability is present if the differences are less than half a logit (Linacre, 2012). For the present study, the individual items of the FIM™ were stable in measurement structure across time. DIF by gender was also examined. For FIM™ Total and FIM™ Motor and FIM™ Cognitive subscales, the logit differences by gender ranged from -.26 to .26 which suggests no significant gender bias in the FIM™ items.

Life Satisfaction. The Satisfaction with Life Scale (SWLS) consists of 5 self-report items developed to provide a global measure of life satisfaction (Diener et al., 1985). SWLS was administered at admission to acute care TBIMS centers and was continuously collected throughout the latest follow-up assessments (up to 20 years post-injury). Responses on the SWLS are 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 (Pavot & Diener, 1993). Pavot and Diener (1993) report a score of 20 on the SWLS represents a point of neutrality where individuals are neither satisfied or dissatisfied with their lives. Further, *slight satisfaction* with life is represented by scores between 21 and 25, while *slight dissatisfaction* with life is represented by scores ranging from 15 to 19 on the SWLS (Pavot & Diener, 1993). *Extreme satisfaction* and *dissatisfaction* with life are represented by scores ranging from 26 to 30 and 5 to 9, respectively (Pavot & Diener, 1993). According to Pavot and Diener (1993) most individuals have total scores ranging from 23 (slightly satisfied) to 28 (satisfied).

Pavot and Diener (1993) reported good internal consistency of items on the SWLS (coefficient alpha = .87) and an adequate 2-month test-retest reliability of .84. The test-retest reliability coefficient after a four year period decreased to .54 suggesting potential variability in life satisfaction over time (Magnus, Diener, Fujita, & Pavot, 1992 as cited by Pavot & Diener, 1993). Nevertheless, previous research has documented the reliability and validity of items included on the SWLS among persons with TBI (Cicerone & Azulay, 2007; Corrigan et al., 2001). The internal consistency of the SWLS items across all time periods in the current study was high (Cronbach's alpha = .93 to .94).

Statistical Analysis

Descriptive statistics will be generated using SPSS version 20.0. Relationships among demographic characteristics and self-report variables will be examined by calculating *t*-tests and chi-square tests. Data screening will also be conducted to identify participants with missing values on variables included in the present study. In order to assess longitudinal changes in life satisfaction as a function of gender, age, and functional ability, criteria for inclusion in the present study will include the presence of one or more measurements of life satisfaction at 1, 2, 5, or 10 years post-injury, one or more measurements of functional independence at either the first or second year post-injury, and no missing values on both gender and age. All statistical analyses will first be conducted with a sample with missing data from the TBIMS database. Following these statistical analyses, a second set of analyses will be conducted with participants without missing data in the TBIMS database to examine differences between participants with and without missing data.

Hierarchical linear modeling (HLM) will be employed to examine the influence of functional ability, gender, and age on trajectories of life satisfaction over a period of 10 years following discharge from inpatient rehabilitation for TBI. The same measures were collected several times over the span of 10 years. Due to the multiple levels of influence in the present study, a statistical model will be developed that includes consideration of this complexity and yields more accurate results. HLM allows multiple questions to be answered regarding both individual and group differences (Maxwell & Tiberio, 2007). All HLM analyses will be conducted using the multi-level linear growth modeling program in SPSS (see Kwok et al., 2008 for a more detail explanation). Specifically, the data will be analyzed using SPSS Mixed which analyzes data using the restricted maximum likelihood estimation (REML; Kwok et al., 2008). This analysis allows participants without complete data to be included in the analysis and estimations are based on available data points. Growth modeling will also be conducted to assess whether or not there is a quadratic or cubic trend (employed to capture acceleration/curvature among growth trajectories) in the data over time (Raudenbush & Bryk; 2002). Pretz et al. (2013) stress the importance of analyzing linear, quadratic, and cubic trends in longitudinal data to best understand the relationship between the outcome variable of interest and time. The quadratic growth model, cubic growth model, and the linear growth model will be compared with the Maximum Likelihood Estimation Method and assessed with Schwartz's Bayesian Criterion (BIC) model selection guidelines to determine the best fitting model (see Resch et al., 2009 for additional details regarding this procedure).

Compared to traditional regression analyses, HLM is better able to estimate standard errors (Hox, 2002). This is because HLM allows researchers to choose the error structure which increases the accuracy of standard error estimates. Further, HLM is able to accommodate for missing data by assuming that data are missing at random (Maxwell & Tiberio, 2007). As a result, two different samples will be utilized to conduct HLM in the present study. One sample will consist of all participants from the TBIMS database with and without missing data on all study variables. The second sample will include all participants from the TBIMS database without missing data on all study variables. Additionally, unequal spacing of data collection (1, 2, 5, and 10 years post-injury) is readily accounted for in the HLM framework (Hox, 2002).

Repeated data for life satisfaction, the outcome, and functional ability will represent Level 1 in the HLM analyses. Thus, the outcome can be defined by an individualized set of slope and intercept parameters represented as:

$$\text{SWLS}_{ti} = \pi_{0i} + \pi_{1i}\text{Time}_{ti} + \pi_{2i}\text{FIM}_{ti} + \pi_{3i}\text{FIM}_{ti}*\text{Time}_{ti} + e_{ti}$$

The dependent variable, SWLS_{ti}, will be the total life satisfaction score obtained from the five items on the SWLS of each individual (i) at a specific measurement occasion (t). The individual intercept, the initial total SWLS score, will be represented by π_{0i}. The terms of π_{1i}, $\pi_{2i,}$ and π_{3i} will signify slopes or linear rates of change across time for their particular variables and interaction effect. Subsequently, Time_{ti} will represent the measurement event for a given individual. The time-varying covariate at each measurement occasion (t), of each individual (i) for functional ability will be represented by $\text{FIM}_{ti.}$ Finally, the group error will be represented by e_{ti}.

The second level of the model will include data nested for each participant by gender. The possibility that variation exists between participants as a function of gender will be modeled at Level 2. As a result, the slopes and intercepts of each participants' models will become the outcomes which will be attempted to be explained during the second stage of the HLM analysis. The Level 2 equations will first be substituted and then distributed for each respective term in the Level 1 model in order to create a equation that contains all the terms from both Level 1 and Level 2. Thus, the complete HLM model in the present study will be represented as:

$$SWLS_{ti} = \beta_{00} + \beta_{10}Time_{ti} + \beta_{20}FIM_{ti} + \beta_{30}FIM_{ti}*Time_{ti} + \beta_{01}Gender_{i} + \beta_{11}Gender_{i}*Time_{ti} + \beta_{21}Gender_{i}*FIM_{ti} + \beta_{31}Gender_{i}*FIM_{ti}*Time_{ti}$$

This equation will account for the nested structure of the data by nesting the various, time-varying measures for each participant. The model in the present study will represent the multifaceted relationships between life satisfaction and functional independence while providing additional understanding of changes that may occur in these relationships depending on participants' gender. Additionally, in order to conduct a true replication of Resch et al. (2009) post-hoc analyses will be conducted to examine changes in life satisfaction trajectories in relation to age at the time of injury.

CHAPTER IV

RESULTS

Demographic Information

Results of Pearson's chi-square tests for independence and *t*-tests revealed statistically significant gender differences on several demographic variables. Chi-square analyses revealed a statistically significant association between gender and ethnicity χ^2 (4, 7,812) = 20.17, $p < .001$, Cramer's V = .05. A greater proportion of women (73.46%; $p < .001$) identified as White compared to men (69.38%); a greater proportion of men (19.42%, $p < .001$) identified as African American compared to women (15.81%). There was also a statistically significant association between marital status and gender χ^2 (3, 7,802) = 213.40, p < .001, Cramer's V = .17. A greater proportion of men (50.31%, $p < .001$) were single compared to women (43.50%) and a greater proportion of women were divorced/separated (16.87%; $p < .05$) or widowed (14.53%; $p < .01$) compared to men (divorced/separated = 8.25%, widowed = 1.70%). Further, chi-square analyses indicated that education was significantly associated with gender χ^2 (2, 7,813) = 23.32, $p < .001$, Cramer's V = .06. A greater proportion of men (27.45%; $p < .001$) did not earn their high school diploma compared to women (22.86%) and a greater proportion of women (53.32%; $p < .001$) had some college education compared to men (47.71%). There was a statistically significant association between gender and annual earnings χ^2 (10, 3,866) = 104.42, $p < .001$, Cramer's V = .16. A greater proportion of women (47.54%; $p < .01$) earned below $20,000 annually compared to men (33.39%)

and men (36.15%; $p < .001$) had greater proportions of annual earnings between $40,000 and $100,000 compared to women (21.73%).

Additionally, *t*-tests revealed statistically significant gender differences in mean age and mean injury severity scores as measured by the DRS at the time of admission to an acute care TBIMS center. A statistically significant gender difference in mean age ($p < .001$) at the time of injury was present with women ($M = 40.33$ years, $SD = 19.94$ years) having a higher mean age compared to men ($M = 37.47$ years, $SD = 16.76$ years). There was also a statistically significant gender difference ($p < .05$) in mean injury severity score (DRS) with men ($M = 12.01$, $SD = 5.41$) having greater injury severity scores compared to women ($M = 11.66$, $SD = 5.37$). However, the variances in age ($\eta^2 = .005$) and injury severity score ($\eta^2 = .0008$) explained by gender were quite small and provide limited practical significance (Ferguson, 2009).

Preliminary Analyses

Within the total sample, participation ranged from 94.37% ($n = 7{,}373$) on the FIM™ Cognitive at 1 year post-injury to 19.12% ($n = 1{,}494$) on the SWLS at 10 years post injury (see Table 3). Means and standard deviations for all self-report measures included in the HLM analyses at each assessment period are provided in Table 4. The mean SWLS score for all participants across all time periods was 21.51 suggesting that on average participants reported slight satisfaction with their lives (Pavot & Diener, 1993). Examination of a bivariate correlation matrix with the DRS injury severity scores and the Rasched FIM™ variables revealed statistically significant correlations between the DRS injury severity scores and each of the three FIM™ variables (see Table 5). In order to prevent potentially redundant information from complicating subsequent HLM models, the DRS injury severity scores were not included in the HLM analyses.

Hierarchical Linear Modeling

Hierachical linear modeling (HLM) was employed to assess the impact of functional ability, gender, and age on life satisfaction across 10 years post-injury. A preliminary HLM analysis was conducted with a simple random intercept model in which the trajectories of life satisfaction were assessed with no predictor variables in the model in order to determine the appropriateness of HLM analyses by calculating the intraclass correlation coefficient (ICC). The ICC ranges from 0 to 1 and measures the dependence between observations and is the proportion of between-individual variance of life satisfaction to the total between-and within-individual variances of life satisfaction (Kwok et al., 2008). According to Hox (2002), the ICC can be defined as "the proportion of the variance explained by the grouping structure in the population" (p. 15). As a result, an ICC greater than zero provides evidence that HLM analyses should be employed instead of traditional regression techniques due to the group-level clustering effects within the data (Garson, 2013). In the present study, a relatively high ICC value of .58 was calculated indicating that HLM analyses should be utilized. The high ICC value in the present study is likely a result of including longitudinal data (Kwok et al., 2008).

Two additional preliminary HLM analyses were conducted to determine the appropriate growth trend of life satisfaction over time. A linear, quadratic, and cubic growth model of life satisfaction with time as the predictor variable were analyzed to determine the best-fitting model. The variance components of the linear growth model were compared with the variance components of the combined linear, quadratic, and cubic growth model using the Maximum Likelihood Estimation Method by comparing Schwartz's Bayesian Criterion (BIC) between the two models (linear growth model BIC = 119,412.277; quadratic and cubic growth model BIC = 119,417.607). Based on BIC model selection guidelines, the linear growth model (evidence of a linear growth trend in the data) was selected as the best-fitting model due to the presence of a smaller BIC value (Raftery, 1996). Additionally, the quadratic and cubic growth models evidenced nonsignificant quadratic and cubic effects. Therefore, the linear growth model was utilized for all analyses.

Three separate multilevel linear growth models for participants with and without missing data were conducted to predict changes in life satisfaction for both men and women. The FIM™ variables served as the time-variant covariates across the models. Overall, there were six separate HLM analyses conducted to account for the multilevel linear growth models with each of the three FIM™ variables (FIM™ Total, FIM™ Motor, FIM™ Cognitive) and the participants with and without missing data. These analyses provide a detailed description of the distinctive contributions of the three FIM™ variables in predicting changes in life satisfaction in the first 10 years following TBI. Due to the large sample size in the present study, the statistical significance level was set to $p < .001$ and effect sizes (η^2) for each model were computed (Tabachnick & Fidell, 2007).

FIM™ Total. The first model assessed the influence of total FIM™ scores and gender on changes in life satisfaction trajectories across 10 years post-injury. Similar to Resch et al. (2009), the intercept (est = 16.920, *SE* = 0.178, $p < .001$) was statistically significant and FIM total (est = 1.203, *SE* = 0.043, $p < .001$) was a statistically significant predictor of life satisfaction (see Table 6). As a result, at 1 year post-injury, higher FIM™ Total scores (i.e., greater functional independence) were significantly associated with higher life satisfaction scores on average. However, compared to Resch et al. (2009), time was not a statistically significant predictor of life satisfaction trajectories and there were no statistically significant interaction effects among the predictor variables. The nonsignificant effect of time in the model provides evidence that on average life satisfaction trajectories and the significant association between FIM™ Total and life satisfaction remained stable across all time periods. Additionally, both studies failed to find significant gender differences inferring that the life satisfaction trajectories of men and women did not significantly differ over time. Two percent of the total variance was accounted for by the first model suggesting the presence of a small effect size (see Table 14).

The second model assessed the influence of total FIM™ scores and gender on changes in life satisfaction trajectories across 10 years post-injury for persons with complete data. The results were congruent with the first model including missing data (see Table 7). Thus, for participants without missing data greater functional independence was also significantly associated with higher life satisfaction on average throughout the first 10 years post-injury. The total variance accounted for by the second model was 3%, indicative of a small effect size (see Table 14).

FIM™ Cognitive. The third and fourth models assessed the influence of FIM™ Cognitive subscale scores and gender on changes in life satisfaction trajectories across 10 years post-injury for persons with and without missing data. Similar to the previous FIM™ Total models and the Resch et al. (2009) study, the intercept (est. = 16.982, SE = 0.190, $p < .001$) and FIM Cognitive (est. = 0.908, SE = 0.036, $p < .001$) were statistically significant contributors to the third model with missing data (see Table 8). There were also no differences in the results between the third model with missing data and the fourth model without missing data (see Table 9). Similar to the FIM™ Total results, at 1 year post-injury, higher FIM™ Cognitive scores (i.e., greater cognitive independence) were significantly associated with higher life satisfaction scores on average in the third model with missing data and the fourth model without missing data. Small effect sizes were present for the third and fourth models: 2% and 3% of the total variance that was accounted for by the third and fourth models respectively (see Table 14).

In contrast to the Resch et al. (2009) study, time was not a statistically significant predictor of life satisfaction trajectories and there were no statistically significant interaction effects among the predictor variables in the third model. Lack of statistical significance of time in the third and fourth models suggest that on average life satisfaction trajectories and the statistically significant relationship between FIM™ Cognitive and life satisfaction remained stable across the first 10 years post-injury. Further, the Resch et al. (2009) study and the present study failed to find significant gender differences inferring that on average the life satisfaction trajectories of men and women did not significantly differ over time.

FIM™ Motor. The final two models assessed the influence of FIM™ Motor subscale scores and gender on changes in life satisfaction trajectories across 10 years post-injury for persons with and without missing data. In comparison to the previous models and results from Resch et al. (2009), the intercept (est. = 17.705, *SE* = 0.202, $p < .001$) and FIM Motor (est. = 0.648, *SE* = 0.034, $p < .001$) were statistically significant contributors to the fifth model with missing data (see Table 10) and sixth model without missing data (see Table 11). These findings suggest that higher FIM™ Motor scores (i.e., greater motor independence) were significantly associated with higher life satisfaction scores on average at 1 year post-injury. Only 1% of the total variance was accounted for by the fifth model suggesting an effect size below the recommended value to be considered significant (Cohen, 1992). A small effect size ($\eta^2 = .02$) above the recommended value to be considered significant was calculated for the sixth model (see Table 14).

Unlike the Resch et al. (2009) study, time was not a statistically significant predictor of life satisfaction trajectories and there were no statistically significant interaction effects among the predictor variables in the fifth and sixth models. The nonsignificant effect of time in the fifth and sixth models indicates that on average life satisfaction trajectories and the statistically significant relationship between FIM™ Motor and life satisfaction remained stable across each time period. Additionally, results from both Resch et al. (2009) and the present study failed to find significant gender differences inferring that on average the life satisfaction trajectories of men and women did not significantly differ over time in the fifth and sixth models.

Post-Hoc Analyses

In order to fully replicate the Resch et al. (2009) study, post-hoc HLM analyses were conducted with age as a Level 2 predictor to dispel any possibility that the age of participants may have been associated with life satisfaction in the present study. As a result, two additional models (with and without missing data) were analyzed to assess the influence of total FIM™ scores, gender, and age on life satisfaction trajectories across 10 years post-injury. Resch et al. (2009) reported a statistically significant intercept when age was included in a post-hoc model. Comparatively, when adding age as a predictor variable in the first model with missing data in the present study, the intercept (est. = 13.439, *SE* = 0.356, $p < .001$) was statistically significant. Additionally, FIM™ Total (est. = 1.681, *SE* = 0.075, $p < .001$) and age (est. = 0.085, *SE* = 0.008, $p < .001$) significantly contributed to the model (see Table 12). Two percent of the total variance was accounted for by the first model, indicative of a small effect size (see Table 14).

There was also a statistically significant interaction effect between FIM™ Total and age (est. = -0.011, SE = 0.002, $p < .001$). Results of the interaction between FIM™ Total and age suggest that on average younger participants with lower FIM™ Total scores (i.e., greater functional impairment) had lower life satisfaction scores compared to older participants with lower FIM™ Total scores. Further, on average older and younger participants with higher FIM™ Total scores (i.e., greater functional independence) had similar life satisfaction scores. The effect of time was nonsignificant suggesting that on average the life satisfaction trajectories and the results of the interaction effect were consistent across all time periods. The interaction effect is depicted in Figure 1.

With regards to the second model with complete data, the intercept was statistically significant and FIM™ Total was a statistically significant predictor in the model. However, the interaction effect between FIM Total and Age was not statistically significant. Nevertheless, the coefficients for the two models were not considerably different (see Tables 12 and 13).The discrepancy in statistical significance of the interaction effect between the two models is likely an artifact of power due to the large disparity in sample size between the first model with missing data (N = 7,813) and the second model with complete data (N = 706). Subsequently, the present study failed to find significant gender differences inferring that on average the life satisfaction trajectories of men and women did not significantly differ over time when age was added as predictor variable. The total variance accounted for by the second model was 3% providing evidence of a small effect size (see Table 14).

Summary of Results

The average life satisfaction score for all participants provides evidence that persons with TBI in the present sample had slight satisfaction with their lives on average (Pavot & Diener, 1993; see Table 4). In agreement with the Resch et al. (2009) study, results from the present study were supportive of the hypothesis that trajectories of life satisfaction would be expected to significantly vary based on functional ability. Specifically, on average greater functional independence as evidenced by higher FIM™

Total, FIM™ Cognitive, and FIM™ Motor scores was positively associated with higher life satisfaction at 1 year post-injury. However, in contrast to the Resch et al. (2009) study, on average life satisfaction trajectories did not decrease as a function of time and the relationship between functional ability and life satisfaction did not vary with time. Overall, life satisfaction trajectories and the relationship between functional ability and life satisfaction remained stable throughout the 10 years post-injury. Thus, at years 1, 2, 5, and 10 post-injury, on average participants who were better able to function independently had higher satisfaction with their lives across time. Furthermore, according to Cohen (1992) the effect sizes for all models except for the fifth model (FIM™ Motor, Gender, and Life Satisfaction with missing data) reached the recommended minimum effect size ($\eta^2 \geq .02$) implying evidence of small practically and statistically significant effects for the majority of models based on effect sizes across the social science literature.

The results from the present study and the Resch et al. (2009) study were consistent with regards to gender differences. Findings from both studies supported the null hypothesis that stated the presence of differences in life satisfaction trajectories would not be a function of gender. As with the Resch et al. (2009) study, on average life satisfaction trajectories between men and women in the present study did not significantly differ across the 10 years post-injury.

The null hypothesis for age was not supported in the present study. Although Resch et al. (2009) failed to find significant differences in life satisfaction trajectories as a function of age, the present study found a significant interaction effect between FIM™

Total and age. Thus, on average younger participants who had greater functional impairment (i.e., low FIM™ Total score) were less satisfied with their lives when compared to older participants who experienced greater functional impairment. Both younger and older participants with greater functional independence had similar levels of satisfaction with their lives on average.

Overall, the models with and without missing data produced similar results. The lack of conflicting results supports the assumption that data from the TBIMS database are missing completely at random (MCAR) or at least missing at random (MAR; Enders, 2011). Although the statistically significant interaction effect between FIM™ Total and age was no longer present when participants with missing data were removed, the coefficients for the two models were not considerably different (see Tables 12 and 13). Furthermore, the differing results between the two models are likely a function of discrepancies in power due to substantial differences in sample size between models with and without missing data.

CHAPTER V

CONCLUSIONS

The purpose of the present study was to investigate the influence of functional ability, gender, and age on the trajectories of life satisfaction among persons with moderate to severe TBI. As a replication and extension of Resch et al. (2009) the present study is the first study to evaluate the predictive utility of these variables on changes in life satisfaction across 10 years post-injury among participants from the TBIMS database. In recent years, increased research has focused specifically on life satisfaction following TBI in order to better understand the ways in which satisfaction with life may be experienced differently following TBI based on person-specific goals, expectations, and values along with previous life experiences (Mailhan et al., 2005). Although studies of life satisfaction have proliferated, patterns of long-term outcomes have been limited with the majority of research restricted to single time points without accounting for longitudinal trends across time. Subsequently, past longitudinal research has been fraught with large attrition rates and small sample sizes (Corrigan et al., 2003; Johnson et al., 2010; Resch et al., 2009). Thus, the present study was conducted to extend the knowledge of longitudinal outcomes of life satisfaction using MLM techniques with a nationally representative sample to provide unique insights into the trajectories of life satisfaction.

Life Satisfaction

Diversity in adjustment following TBI has resulted in considerable variability in life satisfaction trajectories following TBI. As a result, researchers have reached contrary conclusions regarding the stability of life satisfaction across time. Several studies have provided evidence that life satisfaction trajectories steadily decline across time; however, long-term stabilization has also been reported (Corrigan et al., 2001; Dijkers, 2004; Johnson et al., 2010; Johnston & Miklos, 2002; Resch et al., 2009). Upon examination of mean life satisfaction scores across all time periods, the participants in the present study appear to have slight satisfaction with their lives on average (Pavot & Diener; 1993; See Table 4). In the present study, time was not a significant predictor of life satisfaction trajectories suggesting that life satisfaction is stable across 10 years post-injury. Therefore, the decrease in life satisfaction across 5 years post-injury found by Resch et al. (2009) was not supported. Additionally, in a recent longitudinal study assessing outcomes across 20 years post-injury with a sample from the TBIMS database, Pretz et al. (2013) found life satisfaction steadily increases until 9.7 years post-injury and then declines until 20 years post-injury with the fastest rate of decline occurring between 19 and 20 years post-injury.

Heinemann and Whiteneck (1995) suggest that remediation efforts following disability including supportive rehabilitation interventions focused on skill acquisition may be a significant factor influencing life satisfaction within the first several years following TBI. Stark variations in the provision of rehabilitation services exist between the present sample and participants in the Resch et al. (2009) study. Compared to Resch et al. (2009), participants in the present study received state-of-the-art rehabilitation services from a TBIMS center following their TBI, while participants in the Resch et al. (2009) study received less consistent or extensive rehabilitative post-injury care.

Disparity in rehabilitation care is one of many factors that may account for the differences in life satisfaction trajectories between the two samples. As a result, uncovering additional predictors of life satisfaction is crucial to understanding individualistic patterns of life satisfaction (Diener et al., 2006). Furthermore, future research should be conducted to extend the results of the present study by examining life satisfaction trajectories beyond 10 years post-injury to 20 years post-injury and beyond.

Functional Ability and Life Satisfaction

Functional ability has been shown to account for significant variations in life satisfaction across time (Hicken et al., 2002; Johnson et al., 2010; Resch et al., 2009). Dunn et al. (2009) asserted that rehabilitation interventions may have their greatest impact on life satisfaction after disability within the realm of volitional, behavioral, and cognitive activities which comprise the construct of functional ability. In the present study, higher functional independence (as measured by the FIM™) including both motor and cognitive independence was associated with higher life satisfaction both at 1 year post-injury and across time. These results are congruent with previous longitudinal research suggesting that persons with TBI who are able to engage in both motor and cognitive activities of daily living are likely to have greater life satisfaction (Resch et al., 2009). However, compared to Resch et al. (2009), the relationship between functional ability and life satisfaction appears to remain stable throughout 10 years post-injury.

Unfortunately, the underlying mechanism of the differential influence of functional ability on life satisfaction over time between the present study and Resch et al. (2009) is uncertain. Adjustment following TBI is considered a dynamic process that can only be understood by considering a multitude of variables within specific personal and environment contexts throughout the lifespan (Elliott & Warren, 2007). For example, the ability to participate in meaningful activities is one psychosocial variable that may be hindered or helped by one's functional ability. Individuals with TBI who have greater functional impairment may experience more difficulties participating in meaningful daily activities that would result in decreases in life satisfaction over time. In contrast, persons with greater functional independence may be more likely to participate in enjoyable activities, engage in meaningful pursuits, and experience higher life satisfaction following their injury.

Active participation in meaningful activities has been associated with increases in positive emotional experiences that facilitate social connections, personal resilience and life satisfaction among individuals with acquired disabilities such as TBI (Cohn, Fredrickson, Brown, Mikels, & Conway, 2009; Dunn et al. 2009; Kok, Catalino, & Fredrickson, 2008). Pierce and Hanks (2006) reported restrictions in participation as a result of functional impairment accounted for 17% of the variance in life satisfaction within their sample of persons with TBI. Kalpinksi et al. (2013) found participation mediated the relationship between functional ability and life satisfaction in a sample with TBI. Therefore, additional longitudinal research is needed to examine mediating and moderating demographic, premorbid, and psychosocial variables such as participation to better understand the underlying mechanism between functional independence and life satisfaction.

Gender

Some researchers suggest gender is an important demographic variable to consider when studying life satisfaction and overall quality of life (Seibert et al., 2002). However, both the present study and the study by Resch et al. (2009) failed to find significant gender differences. As a result, life satisfaction trajectories between men and women did not significantly differ across time. Despite the failure to find gender differences in the present study, there are various factors that may be responsible for differences between men and women in life satisfaction trajectories following TBI. Previous research provides evidence that gender differences may exist in employment rates (Corrigan et al., 2007), depression (Schopp, Shigaki, Johnstone, & Kirkpatrick, 2001), and grief reactions (Niemeier, 2008) among persons with TBI. Furthermore, these psychosocial variables along with other health-related variables such as neurological functioning and substance abuse were not accounted for in the present study and may prove to be mechanisms through which gender differences in life satisfaction become evident throughout future research (Niemeier, Marwitz, Lesher, Walker, & Bushnik, 2007; Nosek, Hughes, & Robinson-Whelen, 2008).

Age

In a review of life satisfaction across the lifespan, Diener (1998) concluded that in general life satisfaction does not decline as persons approach old age. However, less is known about the relationship between age of injury and life satisfaction among persons with TBI. In a study of life satisfaction in the first 2 years post-injury, Corrigan et al. (2001) failed to find an association between age and life satisfaction. Subsequently, Resch et al. (2009) failed to find a significant relationship between age and life satisfaction across 5 years post-injury. In contrast with previous research, in the present study there was a significant interaction effect between age and functional ability that remained stable throughout the 10 years post-injury. The results suggest that younger participants with greater functional impairments had lower life satisfaction scores compared with older participants. Further, both older and younger participants with greater functional independence had similar life satisfaction scores.

One explanation for the significant association between age, functional ability, and life satisfaction in the present study is a potential difference in the adjustment processes among younger and older persons with TBI. Dunne, Wrosch, and Miller (2011) suggest that following a physical disability, the capacity to make adjustments to goals that are no longer attainable may buffer older individuals from experiencing negative psychosocial consequences including decreased life satisfaction. Specifically, when persons with TBI are confronted with unattainable goals, these individuals may benefit from abandoning these goals and reengaging in alternative goals which may allow them to continue experiencing a sense of purpose in their lives by finding other pursuits they value (Brandtstädter, Wentura, & Greve, 1993; Wrosch, Scheier, Miller, Schulz, & Carver, 2003).

For example, an individual who is having vestibular dysfunction following TBI will likely have extreme difficulty engaging in vigorous physical activities such as running a marathon. If this individual continues to attempt to train for a marathon while experiencing increased vestibular dysfunction they are likely to become increasingly frustrated as they work to achieve this goal (Carvier & Scheier, 1999). However, if they are able to recognize their inability to engage in an unattainable goal and engage instead in a new, more attainable goal such as walking or jogging in a 1 mile race they are likely to experience less psychosocial distress and report greater life satisfaction. Further, as adults naturally age they are likely faced with more limitations in their ability to engage in vigorous motor and cognitive activities.

It is possible that older adults with greater functional impairments (motor and cognitive) in the present study were able to more easily able to recognize their inability to engage in an unattainable goal and engage instead in more attainable goals based on their value systems compared to younger adults with greater functional impairments who had been faced with fewer obstacles in achieving their goals prior to their injury. Additionally, younger adults with greater functional impairments may possibly have had more unattainable goals they desired to achieve or failure to disengage from their unattainable goals may have had more severe negative consequences on their life satisfaction compared to their older counterparts. Conversely, both older and younger persons who experienced greater functional independence possibly experienced fewer motor and cognitive limitations that precluded them from achieving their goals or having to make adjustments to unattainable goals.

In support of this, Brandstädter and Renner (1990) found an age-related increase in goal disengagement in a cross-sectional study of adults between the ages of 34 and 63. Heckhausen (1997) also found age-related increases in flexible goal adjustment within a sample of 20 year old to 85 year old adults. In a study comparing goal disengagement and reengagement among a sample of younger adults ages 19 to 35 with a sample of older adults ages 55 to 89, Wrosch et al. (2003) found goal disengagement was associated with higher levels of subjective wellbeing in older adults. Moreover, the older adults reported greater ease with giving up unattainable goals and engaging in the pursuit of new goals compared to the younger adults (Wrosch et al., 2003). Consequently, the increase in goal disengagement when goals are no longer attainable and reengagement in more attainable goals has been viewed as an adaptive resource that assists aging individuals by helping them maintain a positive developmental perspective despite the increased barriers to achieving functional goals later in life (Boerner, 2004). Thus, compared with younger adults, older adults may show greater flexibility in regards to making adjustments in their goals and priorities due to more life experiences, losses, and limitations that frequently arise as people age (Brandtstädter & Rothermund, 1994; Krueger & Heckhausen, 1993).

Importantly, 61% of all TBIs among older adults (65 years and above) caused by falls (Faul et al., 2010). Thus, the relationship between functional ability before and after TBI and life satisfaction may vary within specific age groups. More information about the nature of functional independence and life satisfaction among older individuals with TBI is needed. It is possible that an individual’s capacity to recognize their inability to engage in an unattainable goal and engage instead in more attainable goals following TBI may be a critical process that is vital to a positive adjustment process. Future research should explore the multifaceted relationship between goal attainment, functional ability, age at injury, and life satisfaction to better understand how to assist younger and older persons as they make both short-term and long-term adjustments following their injury. Furthermore, as a dynamic process, adjustment from TBI is likely influenced by a wide array of person-specific and environmental variables that should continue to be explored longitudinally to further deconstruct the adjustment process.

Missing Data Analyses

In longitudinal analyses, missing data is frequently present and increases as time progresses. Missing data was evident in the present sample and increased across time (see Table 3). When conducting analyses with HLM, persons with data for only one time point contribute less information compared to those with data for all time points; however, individuals with only one data point do not need to be removed from the analyses (Snijders & Bosker, 2012). Therefore, it is not necessary to exclude participants with missing data from HLM analyses.

Missing data can occur completely at random (MCAR), missing at random (MAR), or missing not at random (MNAR; Enders, 2011). When data are missing completely at random (MCAR), the values that are absent have no relationship to variables being measured and the missingness in the data is believed to be random and unpredictable. Subsequently, if the data are missing at random (MAR) there could be some systematic explanation for the missingness within the data such as differences in demographic variables between participants with complete data versus ones with missing data. In contrast, data that are MNAR often include programmatic missingness or missing data based on a study design created to maximize resources.

In order to assess whether or not data was MNAR, MAR or MCAR all HLM analyses in the present study were conducted with and without missing data. Comparison of the life satisfaction trajectories among participants with and without missing data with several demographic predictor variables (age and gender) included in the models revealed similar results. The only difference evident in the datasets with and without missing data was the statistically significant interaction effect between FIM™ Total and age. Although this interaction effect was no longer statistically significant when participants with missing data were removed, the coefficients for the two models were not considerably different (see Tables 12 and 13). Consequently, the lack of statistical significance of the interaction effect was likely a function of decreased power due to the elimination of thousands of participants with missing data. Overall, the results from analyses with and without missing data are largely congruent providing evidence that missingness in the TBIMS database is most likely completely at random (MCAR; Enders 2011)

Additional research is needed to clearly determine whether the data in the TBIMS database are MNAR, MCAR or MAR. The current analyses with and without missing data provide some insight into the missingness of the data but listwise deletion methods frequently lead to a decrease in power and assume missing data are not related to other variables (MNAR and MCAR) when the true mechanism could be MAR (Enders, 2011). As a result, it would be beneficial if future research was conducted utilizing methodologies outlined by Enders (2011) for assessing missingness within the

TBIMS database to identify the underlying mechanism of the missing data instead of assuming data are completely missing at random (MCAR).

Limitations and Future Research Directions

Although the TBIMS database includes the largest and most nationally representative sample of individuals living with TBI, there continue to be limits to the generalizability of the TBIMS database to the population of persons with TBI as a whole. The TBIMS database includes individuals with moderate to severe TBI who have received state-of-the-art acute and rehabilitative care. The results of the present study can be generalized to persons with TBI who received similar services. However, there is limited generalizability to those individuals with mild TBI who received limited or no medical or rehabilitation treatment immediately following their injury or throughout the years thereafter. Further, research by Corrigan et al. (2003) suggests that there may be systematic biases in follow-up data within the TBIMS database due to higher dropout rates among individuals with a history of drug or alcohol abuse, persons from socioeconomically disadvantaged groups (persons requiring public funding to pay for hospital bills, persons identifying as racial and ethnic minorities, and persons with few years of education), and individuals who acquired their TBI through other- or self-directed violence. Taken together, the generalizability of the results from the present study needs to be considered when drawing conclusions about persons with TBI who are likely to be lost to follow-up and have not received acute and rehabilitative care from a TBIMS center.

The present study is also limited by the reliance on self-report measures and a failure to include detailed neuropsychological data describing the extent of injuries experienced by the participants. With the lack of information about the neurological status of the individuals in the current study it is uncertain whether the cognitive problems of participants may have influenced their responses on the self-report measures. However, Johnston and Miklos (2002) suggest there is little to "…no evidence that assessments of function and [quality of life], based on persons with TBI in the community are significantly less valid or reliable than reports from other individuals (p.S33). Furthermore, rehabilitation psychology places considerable emphasis on the subjective experience of individuals with disability that can only be gleaned from the individualized perspectives of individuals with TBI (Dunn et al., 2009). Nevertheless, the role of neuropsychological functioning in the accurate completion of self-report measures and its predictive value in the changes in life satisfaction following TBI are significant issues that needs to be explored in future studies.

Additionally, this study examined only a few predictor variables in the analyses. Elliott et al.'s (2002) dynamic model of adjustment following TBI suggests that a wide array of variables besides those included in the present study may account for changes in life satisfaction over time. For example, Corrigan et al. (2001) reported significant associations between substance abuse and lower life satisfaction following TBI. Psychosocial variables including depression (Underhill et al., 2003; Williamson et al., 2013) and family satisfaction (Johnson et al., 2010) have also been linked to variations in life satisfaction after TBI. Participation in desired activities, a valued outcome in TBI rehabilitation (Stiers et al., 2012) is an important predictor of life satisfaction post-TBI, and there is evidence that it may mediate the prospective influence of injury severity and functional impairment to life satisfaction (Kalpinski et al., 2013). Future research on long-term life satisfaction trajectories among participants in the TBIMS database should consider these and other factors such as race and ethnicity, age, and employment based on their previous effects on life satisfaction throughout the extant literature.

Despite these limitations, the present study provides a potentially meaningful advancement in the understanding of long-term life satisfaction trajectories following TBI. This was the first study to examine the relationship between functional ability, gender, age, and life satisfaction utilizing the nationally representative TBIMS database. Altogether, the results from the present study suggest that life satisfaction trajectories between 1 and 10 years post-injury remain relatively stable over time. Further, greater functional independence appears to lead to an increase in life satisfaction. Subsequently, there appears to be a significant relationship between age and functional ability such that younger participants with greater functional impairments seem to have lower life satisfaction compared to their older counterparts. To expand the knowledge of the outcomes from the present study, future longitudinal research with the TBIMS database should continue to utilize advanced multilevel-modeling statistical techniques including HLM. With the increases in life expectancies in recent years for persons with TBI, future HLM analyses will need to be employed to reassess the results from the present study to better understand adjustment processes well beyond 10 years post-injury to 20 years post-injury and beyond (Crews, 2012; Pretz et al., 2013). Additional variables (depression, PTSD, race and ethnicity, social integration, participation, pain, etc.) should also be added to the present model to uncover the underlying, complex mechanisms responsible for changes in life satisfaction following TBI. Subsequently, measures of quality of life beyond life satisfaction may also provide unique insights into the dynamic and multifaceted adjustment processes post-injury (Dijkers, 2004). Rehabilitation researchers and clinicians alike would benefit from greater understanding of individual differences in long-term adjustment trajectories as they continue engaging in rehabilitation care and research aimed at improving the quality of life among all persons with TBI throughout the lifespan.

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APPENDIX

Table 1.

Distribution of Injury Severity Descriptive Categories from the Disability Rating Scale

Injury Severity Category	Frequency	%
None	4	0.06
Mild	5	0.07
Partial	96	1.33
Moderate	943	13.04
Moderate to Severe	2,835	39.21
Severe	1,714	23.70
Extremely Severe	1,188	16.43
Vegetative State	336	4.65
Extreme Vegetative State	110	1.52
Total	7,231[a]	100.00

[a] The DRS score for 582 participants is unknown.

Table 2.

Distribution of Cause of Injury

Cause of Injury	Frequency	%
Motor Vehicle	4,328	55.51
Falls	1,630	20.91
Acts of Violence	842	10.80
Recreational Activities	352	4.53
Other[a]	643	8.25
Total	7,795[a]	100.00

Note. Motor Vehicle = motor vehicle, motorcycle, all-terrain vehicle, and all-terrain cycle accidents; Acts of Violence = gunshot wounds, assault with blunt instrument, and other violence; Recreational Activities = bicycle, water sports, field/track sports, gymnastic activities, winter sports, air sports, and other sports accidents; Other = pedestrian, hit by falling/flying object, and other unclassified accidents.
[a]Cause of injury for 36 participants is unknown.

Table 3.

Number of Observations for Measures

	Number of Observations			
Measurement Occasion	FIMTot	FIMCog	FIMMot	SWLS
Time 1: 1 Year Post-Injury	7,319	7,373	7,329	6,615
Time 2: 2 Years Post-Injury	6,374	6,418	6,385	5,745
Time 3: 5 Years Post-Injury	4,105	4,135	4,118	3,699
Time 4: 10 Years Post-Injury	1,583	1,597	1,589	1,494

Note. FIMTot = Functional Independence Measure Total scores; FIMCog = Functional Independence Measure Cognitive subscale scores; FIMMot = Functional Independence Measure Motor subscale scores; SWLS = Satisfaction with Life Scale scores.

Table 4.

Means and Standard Deviations for Measures by Time

Measurement Time	FIMTot	FIMCog	FIMMot	SWLS
1 Year	*n* = 7,393	*n* = 7,386	*n* = 7,391	*n* = 6,615
M	3.25	4.31	4.93	21.14
SD	2.02	2.41	2.72	8.22
2 Years	*n* = 6,441	*n* = 6,434	*n* = 6,439	*n* = 5,745
M	3.46	4.49	5.17	21.51
SD	2.03	2.39	2.65	8.32
5 Years	*n* = 4,153	*n* = 4,150	*n* = 4,152	*n* = 3,699
M	3.56	4.55	5.28	22.01
SD	2.08	2.43	2.67	8.36
10 Years	*n* = 1,606	*n* = 1,603	*n* = 1,606	*n* = 1,494
M	3.53	4.50	5.28	21.85
SD	2.01	2.39	2.59	8.48
Overall	*N* = 19,593	*N* = 19,573	*N* = 19,588	*N* = 17,553
M	3.41	4.43	5.11	21.51
SD	2.04	2.41	2.68	8.31

Note. FIMTot = Rasched Functional Independence Measure Total scores; FIMCog = Rasched Functional Independence Measure Cognitive subscale scores; FIMMot = Rasched Functional Independence Measure Motor substance scores; SWLS = Satisfaction with Life Scale scores.

Table 5.

Bivariate correlations of the DRS Injury Severity Scores with FIMTot, FIMCog, and FIMMot at 1 Year Post-Injury

Variable	IS	FIMTot	FIMCog	FIMMot	*M*	*SD*
Injury Severity					11.91	5.40
FIMTot	-.259*				3.25	2.02
FIMCog	-.258*	.829*			4.31	2.41
FIMMot	-.204*	.830*	.484*		4.93	2.72

Note. IS = DRS Injury Severity Score on Admission; FIMTot = Rasched Functional Independence Measure Total scores; FIMCog = Rasched Functional Independence Measure Cognitive subscale scores; FIMMot = Rasched Functional Independence Measure Motor subscale scores.
*$p < .01$.

Table 6.

Estimates of Fixed Effects of FIMTot, Gender, Time on Life Satisfaction

Parameter	Estimate	Std. Error	*p*-value
Intercept	16.913	0.178	<.001
Time	0.094	0.046	.040
FIMTot	1.203	0.043	<.001
Gender	0.541	0.323	.094
Gender X Time	-0.034	0.083	.683
FIMTot X Gender	0.029	0.080	.712
FIMTot X Time	-0.002	0.011	.858
FIMTot X Gender X Time	0.013	0.021	.516

Note. FIMTot = Rasched Functional Independence Measure Total scale.

Table 7.

Estimates of Fixed Effects of FIMTot, Gender, Time on Life Satisfaction with Complete Data

Parameter	Estimate	Std. Error	*p*-value
Intercept	17.100	0.550	<.001
Time	0.103	0.084	.220
FIMTot	1.205	0.118	<.001
Gender	-0.558	0.947	.555
Gender X Time	0.140	0.142	.323
FIMTot X Gender	0.098	0.204	.630
FIMTot X Time	0.006	0.019	.762
FIMTot X Gender X Time	-0.014	0.033	.665

Note. FIMTot = Rasched Functional Independence Measure Total scale.

Table 8.

Estimates of Fixed Effects of FIMCog, Gender, and Time on Life Satisfaction

Parameter	Estimate	Std. Error	*p*-value
Intercept	16.982	0.190	<.001
Time	0.065	0.049	.185
FIMCog	0.909	0.036	<.001
Gender	0.006	0.355	.986
Gender X Time	-0.098	0.095	.304
FIMCog X Gender	0.096	0.067	.151
FIMCog X Time	0.007	0.009	.455
FIMCog X Gender X Time	0.020	0.018	.271

Note. FIMCog = Rasched Functional Independence Measure Cognitive subscale.

Table 9.

Estimates of Fixed Effects of FIMCog, Gender, and Time on Life Satisfaction with Complete Data

Parameter	Estimate	Std. Error	*p*-value
Intercept	17.672	0.557	<.001
Time	0.043	0.089	.630
FIMCog	0.861	0.097	<.001
Gender	-0.999	0.982	.309
Gender X Time	0.087	0.159	.584
FIMCog X Gender	0.145	0.170	.395
FIMCog X Time	0.015	0.017	.369
FIMCog X Gender X Time	-0.003	0.030	.914

Note. FIMCog = Rasched Functional Independence Measure Cognitive subscale.

Table 10.

Estimates of Fixed Effects of FIMMot, Gender, and Time on Life Satisfaction

Parameter	Estimate	Std. Error	*p*-value
Intercept	17.705	0.202	<.001
Time	0.142	0.053	.008
FIMMot	0.648	0.034	<.001
Gender	0.528	0.359	.141
Gender X Time	-0.022	0.092	.814
FIMMot X Gender	0.025	0.061	.685
FIMMot X Time	-0.006	0.009	.510
FIMMot X Gender X Time	0.007	0.016	.662

Note. FIMMot = Rasched Functional Independence Measure Motor subscale.

Table 11.

Estimates of Fixed Effects of FIMMot, Gender, and Time on Life Satisfaction with Complete Data

Parameter	Estimate	Std. Error	*p*-value
Intercept	17.981	0.660	<.001
Time	0.122	0.101	.226
FIMMot	0.649	0.099	<.001
Gender	-0.750	1.120	.503
Gender X Time	0.163	0.163	.316
FIMMot X Gender	0.120	0.171	.483
FIMMot X Time	0.003	0.016	.833
FIMMot X Gender X Time	-0.016	0.027	.556

Note. FIMMot = Rasched Functional Independence Measure Motor subscale.

Table 12.

Estimates of Fixed Effects of FIMTot, Age, Gender, and Time on Life Satisfaction

Parameter	Estimate	Std. Error	*p*-value
Intercept	13.439	0.356	<.001
Time	0.054	0.045	.223
FIMTot	1.681	0.075	<.001
Gender	0.900	0.394	.023
Age	0.085	0.008	<.001
Age X Gender	-0.010	0.009	.292
Age X Time	0.001	0.001	.409
FIMTot X Age	-0.011	0.002	<.001
FIMTot X Age X Time	0.000	0.000	.925

Note. FIMTot = Rasched Functional Independence Measure Total scale.

Table 13.

Estimates of Fixed Effects of FIMTot, Age, Gender, and Time on Life Satisfaction with Complete Data

Parameter	Estimate	Std. Error	*p*-value
Intercept	16.382	1.126	<.001
Time	0.101	0.072	.158
FIMTot	1.363	0.198	<.001
Gender	0.451	1.193	.705
Age	0.016	0.030	.594
Age X Gender	-0.010	0.032	.750
Age X Time	0.001	0.002	.720
FIMTot X Age	-0.004	0.005	.443
FIMTot X Age X Time	0.000	0.000	.679

Note. FIMTot = Rasched Functional Independence Measure Total scale.

Table 14.

Estimates of Effect Sizes

Model	η^2
1. FIM Total, Gender, and Time on Life Satisfaction	.02
2. FIM Total, Gender, and Time on Life Satisfaction with No Missing Values	.03
3. FIM Cognitive, Gender, and Time on Life Satisfaction	.02
4. FIM Cognitive, Gender, and Time on Life Satisfaction with No Missing Values	.03
5. FIM Motor, Gender, and Time on Life Satisfaction	.01
6. FIM Motor, Gender, and Time on Life Satisfaction with No Missing Values	.02
7. FIM Total, Age, Gender, and Time on Life Satisfaction	.02
8. FIM Total, Age, Gender, and Time on Life Satisfaction with No Missing Values	.03

Note. FIMTot = Rasched Functional Independence Measure Total scale.

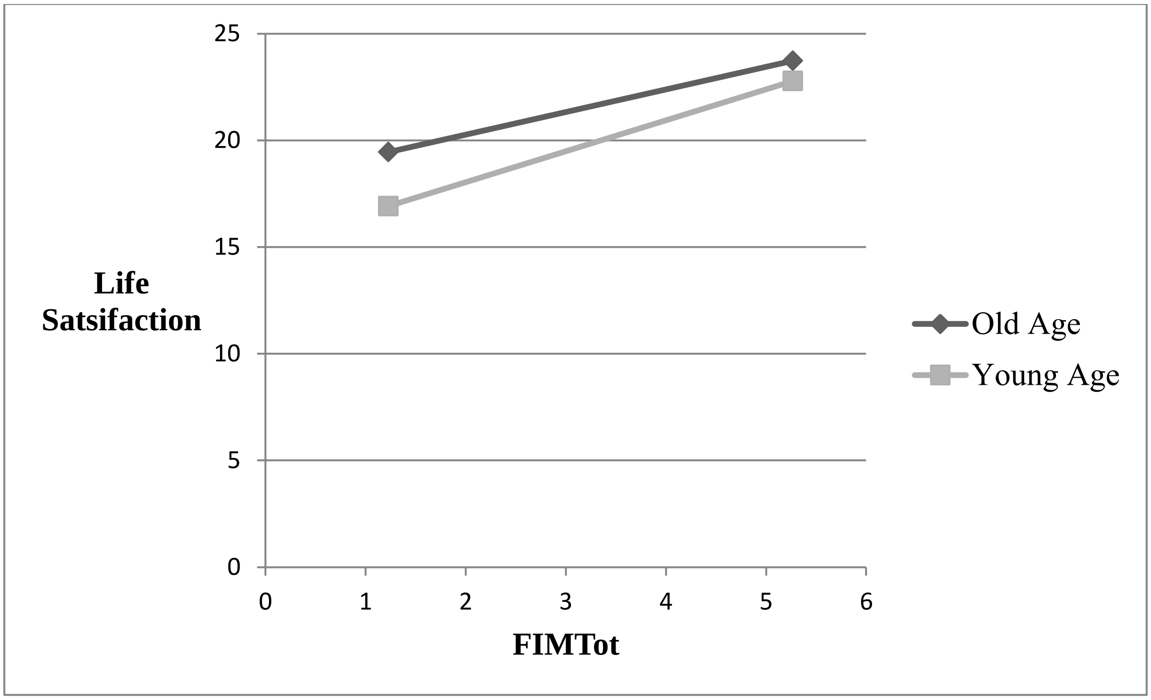

Figure 1. Interaction effect between age and the Rasched Functional Independence Measure Total scale (FIMTot).