Health Disparities within Rehabilitation Outcomes: A Theoretical Framework and Application

by

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Abstract

In America 5.3 million men, women, and children are living with the often devastating and permanent long-term Traumatic Brain Injury-related disabilities. TBIs require thousands of dollars in resources for immediate and often long-term and intermittent rehabilitation to address deficits related to physical and cognitive impairments. This dissertation explores human development interrupted by TBI and evaluates how contextual factors that may impact rehabilitation outcomes above and beyond premorbid status, injury type, and severity. Study 1 consists of a theory adaptation that establishes a new foundational theory that explains rehabilitation outcomes and provides a model against which to test lower order needs of mental health and neighborhood effects, called the Hierarchy of Elevated Rehabilitation Outcomes (HERO). The HERO model consists of a five-level hierarchy: Mental Health; Neighborhood effects; Religion, Culture, and Social Support; Self-Efficacy; and Health Locus of Control. Each level was analyzed to define components and provide a rationale for inclusion. The application of this model was demonstrated via the use of a medical case study.

Study 2 was designed to test components of the first two levels of the HERO model to identify model interactions. Measures of depression (Level 1) and neighborhood disadvantage (Level 2) were selected from the HERO framework. Using secondary data from the Traumatic Brain Injury Model Systems (TBIMS) dataset, the sample consisted of Alabama residents, 63% male, 62.5% European Americans, and 21.5% African American, with an an average age of 39.76 (*SD* = 36.96). Study 2 consisted of the following study aims:

1) To determine if TBI survivors' residing in disadvantaged neighborhoods experienced lower levels of function as measured by Functional Independence Measures (FIMS) scores over time;

2) To determine if the presence of depression in TBI survivors explained the relationship between neighborhood disadvantage and FIMS scores over time; and,

3) To determine if race has a moderating effect on the relationship between neighborhood disadvantage and depression.

The findings indicated no significant main effects of neighborhood disadvantage on FIM scores, no indirect effects of neighborhood disadvantage on FIM scores via depression, and no moderating effects of race. Further research testing various interactions of specific individual contextual factors may better reflect the unique human experiences and factors above and beyond injury type, medical profiles, and treatment modalities. Continued examination of neighborhood context as a predictive factor will be an important next step in fully understanding patient outcomes.

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I: General Introduction

The term *health disparities* was operationally defined by the National Institutes of Health as preventable differences in the burden of disease, injury, violence, or opportunity inability to obtain optimal health (CDC, 2020). Subsequently, thousands of papers have been published and large-scale, federal efforts have been launched to document and gain knowledge regarding, but not limited to, disparities in access to care and preventative services (Horner-Johnson et al., 2014), utilization of services (Gaskin et al., 2012), disparities across racial and ethnic groups (Gaskin et al., 2012; National Center for Health Statistics (US), 2016; Valencia et al., 2012), and persons with disabilities (Krahn & Fox, 2014; Ouellette-Kuntz, 2005).

Though these are significant efforts toward improving health equity, gaps still remain in our understanding of key mechanisms that may underlie and possibly explain inequity within rehabilitation outcomes across all rehabilitation disciplines, specifically speech-language pathology (SLP). SLPs provide care across a variety of settings from inpatient care to home health to the school setting. SLPs serve diverse populations across the life span who have a variety of diagnoses including, but not limited to, traumatic brain injury (TBI).

Rehabilitation Outcomes and Traumatic Brain Injury

Every year thousands of Americans sustain a TBI, defined as a closed or open head injury caused by blunt force trauma or penetrating injury, and it is considered a significant cause of death and disability (CDC, 2021). In 2019, 61,000 deaths resulted from TBI, and the data suggested that there were specific groups within the population examined that were are at a greater risk for sustaining a TBI (CDC, 2021). At-risk groups included: service members and veterans, individuals who reside in rural areas, and survivors of intimate violence (CDC, 2021).

The most common causes of TBI included falls, firearm-related suicide attempts, motor vehicle crashes, and assaults (CDC, 2021).

For survivors of TBI, depending on the severity of the injury, short-term and long-term disability may impair daily function and the ability to lead independent lives. Impairments can include the inability to independently carry out basic home, community, school, and vocational tasks. For some individuals, the recovery from a TBI can be a long journey requiring access to ongoing skilled therapy to address deficits related to motor skills and cognitive-linguistic impairments. Evidence-based practice has provided efficacious treatment models and care plans that are designed to provide patient improvement and reduce caregiver burden. However, scholars have only recently begun to uncover what additional contextual factors may impede or facilitate continued long-term improvements in rehabilitation outcomes. Further, there is currently no guiding framework that organizes potential contextual factors, explains variability in outcomes, and provides actionable intervention points to guide the therapy process access to other medical and community-based resources.

Context Matters

The study of human development is an expansive multi-disciplinary field that seeks to understand changes in development across the lifespan. The field accounts for typical and atypical development and examines contextual factors that can support or impede one's developmental trajectory. Individuals who experience TBI have had a catastrophic health event that impacts their development, as well as their support network, and their community. Bronfenbrenner's ecological model helps to frame our understanding of how an individual's environmental context drives development (Bronfenbrenner, 1975). Environmental context may be a facilitator and/or barrier in achieving optimal rehabilitation outcomes, the extent to which is

not presently well understood. Using Bronfenbrenner's model to inform our understanding of rehabilitation outcomes from the context of *neighborhood disadvantage* as a predictive variable, a new theoretical model was proposed to provide a hierarchical framework from which to consider the role of neighborhood characteristics as a predictor of rehabilitation outcomes when human development is paused, deferred, or derailed by way of TBI.

Before designing a framework, a review of the literature across four main rehabilitation disciplines (occupational therapy, physical therapy, speech therapy, and behavioral mental health services was conducted to discern if any theoretical frameworks currently exist from which to consider healthcare disparities in general and neighborhood specifically. A review of the theories identified major themes such as development and skill acquisition. Theoretical constructs were also identified, such as the Behavior Theory for Language Development (Skinner, 1957) as seen in the SLP field or Sensory Integration Theory (Ottenbacher, 1982; Rosnow, 1981; Tickle-Degnen, 1988) as of that found in occupational therapy literature. The theories identified did not bridge constructs that may impact therapy outcomes over time. No theories were identified, particularly in the field of SLP, that addressed aspects of entry to care, adherence to care, and rehabilitation outcomes that are relevant for patient-specific differences related to race, ethnicity, socioeconomic status, neighborhood, and mental health.

To examine demographic and personal predictors for SLP rehabilitation outcomes following TBI that encompass vital aspects of the neighborhood and mental health, the need for a theoretical framework was identified. From a broader perspective, a discipline-specific theoretical framework provides a structured framework from which to study and make sense of the complex and variable nature of SLP outcomes. Specific application of a theoretical framework may lead to the following: 1) identification of the barriers for referral for SLP care; 2)

identification of patient-specific barriers for service implementation; 3) identification of patient-specific facilitators and barriers for effective patient adherence; 4) identification of vital contexts for intervention (mental health and physical health, neighborhood environment, social support, etc.) to improve long term outcomes; and 5) identification of additional opportunities for interdisciplinary engagement of key stakeholders (i.e. other rehabilitation specialists, community leaders, policymakers). A theoretical framework may also elucidate new pathways for research related to new interventions and quantification of clinical outcomes; provide increased awareness of health disparities within the field of speech-language pathology; inspire novel translational and interprofessional research efforts; and provide a new lens for how scholars research and solve problems for social determinants of speech therapy outcomes.

Study one is a discussion of an adapted theoretical framework, the *Hierarchy for Elevated Rehabilitation Outcomes (HERO),* for use in an SLP rehabilitation context that includes novel components relevant for the study of health disparities, i.e., mental health, neighborhood, religion, and culture. A theoretical adaptation approach provides the opportunity to borrow from an existing theory, Maslow's Hierarchy of Needs, to construct a meaningful framework that could be readily applied to research and clinical practice. Mirroring the hierarchical design of Maslow's Hierarchy of Needs, the proposed theoretical model for rehabilitation outcomes in SLP includes additional relevant components not included in the reference model. Components of each level were identified with extensive rationale provided to support its inclusion as well as provide an explanation for the hierarchy ranking. A case study was included to illustrate the clinical application of the new theoretical model.

The HERO model also provided a systematic means to test empirical research. Study two of this dissertation tested components of the *HERO* model to investigate *The Role of*

Depression in Examining Neighborhood Effects on Functional Independence Measure Scores for Traumatic Brain Injury Survivors. Specifically, this empirical study tested two components of the *HERO* model (level 1: mental health and level 2: neighborhood environment) to determine their relationship in predicting functional patient outcomes over time in a TBI population. A latent growth model testing moderated mediation was applied with 1) depression mediating the relationship between neighborhood disadvantage and change in FIM scores over time, and 2) with race moderating the relationship between neighborhood disadvantage and depression.

The empirical study attempted to answer 3 research aims: Aim 1: To determine if TBI survivors residing in disadvantaged neighborhoods experienced lower levels of function as measured by FIM scores over time; Aim 2: To determine if the presence of depression in TBI survivors explained the relationship between neighborhood disadvantage and FIM scores over time; and Aim 3: To determine if race had a moderating effect on the relationship between neighborhood disadvantage and depression.

In summary, the primary goals for this dissertation were twofold: (1) adapt and expand an existing framework to create a novel theoretical framework from which to study, plan for, and explain rehabilitation outcomes; and, (2) apply the new theoretical model by testing variables (i.e. neighborhood environment and depression) from the framework to predict rehabilitation outcomes over time.

II. Study 1: Hierarchy for Elevated Rehabilitation Outcomes (HERO) Theoretical Framework: Adaptation of Maslow's Hierarchy of Needs to Address Healthcare Disparities in Speech-Language Pathology

Introduction

The general body of health disparities literature points to social determinants of health serving as a key mechanism for explaining the why and how for health disparities. However, a growing body of literature is recognizing that health disparities are linked to a deeper issue of social and structural inequalities that are steeped in historically racist practices and policies (Green et al., 2005). The topic of health disparities within the field of SLP has only recently gained attention in the literature (Hur et al., 2018; Huwyler et al., 2021). The few studies that have examined health disparities within the field have described disparate outcomes for individuals with autism disorder (Bishop-Fitzpatrick & Kind, 2017), head and neck cancer outcomes (Choi et al., 2016; Hsiao et al., 2020), and outcomes in inpatient rehabilitation for stroke survivors using functional independence measure (FIM) scores to measure total change in function (Bhandari et al., 2005). Most of the studies that examine health disparities in rehabilitation outcomes consider total function (Bagg et al., 2002; Corrigan et al., 2015; Corrigan & Bogner, 2008) with few papers published that seek to examine outcomes solely related to the speech therapy discipline. While there are gaps in knowledge in the empirical literature, there are also theoretical gaps. Theory can provide a critical, cohesive foundation to examine complex issues such as health disparities in SLP. It can also inform clinical decisions making, assessment processes, and intervention (Krebs & Harris, 1988; Levac & DeMatteo, 2009). Therefore, this paper proposes

an interdisciplinary theory that can help SLPs and other clinicians rethink the processes and mechanisms for patient rehabilitation.

Each year millions of individuals across the country are serviced by skilled SLPs. Treatment is conducted across various settings (i.e. schools, medical facilities, and clinics) for a variety of diagnoses and clinical outcomes are tracked using various assessment tools and surveys. Research has informed clinicians that, in addition to the therapy techniques and approaches selected to achieve outcomes, patient participation, adherence, and motivation are necessary components when seeking to elevate clinical outcomes(Arvinen-Barrow & Walker, 2013; Dunlay et al., 2009). For patient participation, there are well-documented facilitators and barriers such as financial obligations, lack of medical referral, transportation, family obligations related to childcare, culture and personal beliefs, psychosocial factors, diagnosis, and previous experiences in rehabilitation and the medical system in its entirety (Dunlay et al., 2009; Evenson & Fleury, 2000; Lenze et al., 2004).

Adherence factors contribute to a patient's ability to achieve successful rehabilitation outcomes. The adherence literature has revealed that reduced follow-through and compliance of skilled recommendation, as well as insufficient completion of home programs, are barriers to successful rehabilitation outcomes (Arvinen-Barrow & Walker, 2013). Along with adherence, patient motivation speaks directly to one's willingness to persevere, adapt and overcome challenges and setbacks. Motivation is connected to adherence and participation via direct and indirect pathways. Lack of patient motivation can result in reduced participation, adherence to home programs, and the ability to generalize tasks to the home and community setting (Kusec et al., 2019). Diminished patient motivation links to poor participation resulting in reduced outcomes (Kusec et al., 2019).

Additional contextual factors that may contribute to rehabilitation outcomes are not well understood. Currently, there is no known comprehensive, discipline-specific, or interdisciplinary theoretical model that accounts for environmental context, as well as personal attributes related to motivation, participation, and adherence. One context that has been explored over the last few decades is neighborhood. A review of the neighborhood literature indicated significant relationships between neighborhoods and overall health outcomes (Arcaya et al., 2016; Cohen et al., 2003). The link between neighborhood environment and health outcomes has been well examined in the literature. Neighborhood mechanisms related to environmental toxins, built environment, neighborhood safety, and neighborhood attributes have all been linked to a variety of health outcomes from congenital heart defects to poor cognitive outcomes in children and adults, reduced physical activity, and cancer (Buehler et al., 2019; Cerletti et al., 2021; Jianghong Liu & Lewis, 2014; Lenhart et al., 2017; Nguyen et al., 2019; Nicoll, 2018; Won et al., 2016). In addition, a few studies have examined the relationship between neighborhoods and TBI rehabilitation outcomes. Corrigan & Bogner (2008) examined neighborhood characteristics and outcomes after TBI and determined that economic and social characteristics of a neighborhood predicted outcomes related to life satisfaction and Glasgow Outcome Scale-Extended following TBI beyond that of individual characteristics.

Neighborhood context is important as we seek to solve for immediate environmental factors that may underlie rehabilitation outcomes; however, additional personal contextual factors such as mental health may interact to explain variability within outcomes over time. As defined by the Centers for Disease Control, mental health includes key aspects of one's emotional, psychological, and social wellbeing. Our mental health will impact how we think, our view of the world around us, and our ability to cope and manage life stressors (CDC, 2021). Our

mental health is also connected to overall health and is a key factor when examining the whole person and attempting to identify key mechanisms that may impact rehabilitation outcomes. According to the Centers for Disease Control (CDC), in 2019, about 21% of the population age 18-29 experienced symptoms of depression. Within the first year of post-injury, approximately 50% of TBI survivors will experience major depression symptoms (Bombardier et al., 2010). Depression by definition and symptomology, as well as other mental health issues are linked to motivation and participation in therapy and thus should be explored as a possible individual contextual factor that may influence rehabilitation outcomes over time. Furthermore, clinical observation indicates that despite limited resources and environmental supports, some patients persevere and demonstrate the ability to meet therapy goals and maintain high levels of motivation, while others do not. Unpacking this phenomenon would be a worthwhile pursuit as scholars work to uncover new relationships and predictors for rehabilitation outcomes.

Developing a Cohesive Theoretical Model

There were three critical factors in developing a cohesive theoretical model,

1) Identify the critical gap in knowledge for health disparities in rehabilitation medicine and more specifically the field of SLP. A significant gap was identified in our understanding of the contextual factors that may predict rehabilitation outcomes. Many of the current theories in the discipline of speech and language pathology center
around the development of speech and language and provide models to explain how speech and language disorders may be acquired.
2) Generate a person-centered perspective that encompassed modern-day factors and integrated key features of the United States healthcare system and neighborhood environments.

3) Include aspects of clinical practice and observation. Too often there is a disconnect between research and clinical practice and there is a need to build a model that would be both unifying and collaborative. Therefore, application to clinical practice and research will be explored for each level of the final model.

Model Rational

From the review of the literature and years of clinical experience, the significant role that personal motivation plays in therapeutic outcomes became apparent. Clinical observation of patients with limited resources and few environmental supports, who persevered to meet therapy goals and maintained high levels of motivation indicated the need to consider additional variables that influence the therapy process. What makes these patient cases and outcomes so unique? One answer may lie in patient motivation and participation. In rehabilitation literature, motivation to participate in therapy has been studied as one of many important personal predictors for determining patient therapy outcomes (Kusec et al., 2019; Maclean & Pound, 2000).

Patients' participation in therapy and adherence to therapy recommendations can be sourced from both intrinsic and extrinsic motivating factors (Bishop-Fitzpatrick & Kind, 2017). However, a patient's motivation for therapy may be grounded in their fundamental beliefs about what they may or may not be able to accomplish within a given length of stay in an inpatient or outpatient rehabilitation setting. Accounting for the construct of self-efficacy within the proposed theoretical model acknowledges the role of limiting and empowering beliefs on patient outcomes. As a result, the significance of integrating Bandura's theory on self-efficacy into a framework that seeks to explain rehabilitation outcomes was an important addition. Bandura defines self-efficacy as one's personal belief about their ability to be successful in various

situations (Bandura, 1977). By accounting for patients' personal beliefs about their ability to make therapeutic gains, clinically it may give the opportunity to challenge negative beliefs.

The rationale for anchoring a new theoretical model with Bandura's work was also supported by a growing body of research that examined self-efficacy on health behaviors, health quality of life, and rehabilitation (Brouwer-Goossensen et al., 2018; Carlsen et al., 2017; Picha et al., 2021). Brouwer-Goossensen et al. (2018) described high self-efficacy scores for health-related behaviors in recent ischemic stroke patients. Other studies have revealed that self-efficacy predicts communication participation in adults who stutter (Boyle et al., 2018). Self-efficacy has also been used along with other constructs such as resilience to predict transition readiness in adolescents with inflammatory bowel diseases even when accounting for patient demographics, disease, or socioeconomic factors (Carlsen et al., 2017).

In addition to anchoring the adapted model using Bandura's self-efficacy theory, Bronfenbrenner's ecological and updated Process-Person-Context-Time model was also considered (Bronfenbrenner, 1975; Rosa & Tudge, 2013). Bronfenbrenner's updated model provided a framework and rationale for each adapted level in the final model. As defined by Bronfenbrenner, *process* refers to the processes that human beings are constantly exposed to and engaging with that drive human development. For example, rehabilitation from a medical event such as a stroke or TBI could be considered one of many processes that one engages with that may improve or impede function. The *person* is made up of unique genetic and biological features that according to Bronfenbrenner, help make up unique personal characteristics that are present in social situations. He divided the characteristics into three categories: *demand* (age, race, physical appearance) *resources* (mental and emotional resources), and *force* (temperament, motivation, persistence) characteristics. *Resources* and *force* are not necessarily obvious personal

features that are routinely accounted for in the therapy process; however, based on our review of mental health and rehabilitation literature they may be of value when seeking to explain the variability within therapy outcomes.

Bronfenbrenner (1975) defined context across several environments based on time spent. For example, high-frequency environments (microsystems) such as school, home, and neighborhood will directly influence development or in the case presented in this paper, rehabilitation. Additionally, he also defined context as it pertains to culture or groups with shared values (macrosystem). The influence of culture on rehabilitation outcomes is certainly not well understood nor is it routinely accounted for when discussing rehabilitation outcomes. Including culture in a formal rehabilitation theory, may support and encourage the inclusion of cultural aspects in the empirical study of rehabilitation outcomes as well as inform clinical practice. Last, units of time were addressed and defined by Bronfenbrenner (1975), as chronosystem, mico- and meso-time. Not explicitly included in our adapted model, however, it could be argued that meso-time (the consistent occurrence of specific activities in one's environment that informs development) is implicitly discussed as we link patient participation in therapy and what needs (i.e. mental health, social support, etc.) have to be addressed to improve participation to increase outcomes.

After accounting for personal beliefs on a macro level, attention was given to viewing personal beliefs with a narrower focus to include one's beliefs about their health. Health locus of control is defined as one's belief about their health as it pertains to how much of their health is in one's control (intrinsic) or not in their control (extrinsic) (Nazareth, 2016; Wallston & Wallston, 1982). Studies have shown that extrinsic health locus of control can negatively impact patient adherence, overall health, and rehabilitation outcomes (Keedy et al., 2014; Milte et al., 2015;

Nazareth, 2016). For example, a study by Nazareth et al. (2016) revealed that external control was negatively associated with transition readiness and positively associated with emergency room visits and the number of inpatient nights at the hospital. Health locus of control has also been studied in a variety of adult diseases and medical outcome-based studies such as cardiac (Mercer et al., 2018) and hypertensive patients (Omeje & Nebo, 2011), multiple sclerosis (Wilski et al., 2019), and maternal health (Lawal & Idemudia, 2017) to name a few. It has also been examined in combination with other constructs such as health behaviors and self-efficacy (Clark et al., 2018; Grotz et al., 2011).

Grounding the model in well-established constructs that span across fields of psychology was a key strength and a solid foundation upon which to address the second criteria - designing a person-centered model. The frameworks of self-efficacy and health locus of control accounted for individual differences in patient motivation and fundamental beliefs about personal ability to make change. The design of a model should acknowledge the dependency, interaction, and bidirectional nature of environmental constructs and personal attributes.

A review of existing theoretical models led to Maslow's Hierarchy of Needs (Maslow, 1954b, 1954a) as the most appropriate base model for adaptation. Maslows Hierarchy of Needs has been adapted and applied to several contexts: achieving human potential in hospice (Zalenski & Raspa, 2006); exploring the relationship between unmet needs and health-related quality of life (Schölzel-Dorenbos et al., 2010); improving patient care in intensive care units (Jackson et al., 2014); and, informing policy to resolve COVID-19 related crises for community stabilization and reducing racial and ethnic health disparities (Ryan et al., 2020).

Review of Maslow's Hierarchy of Needs

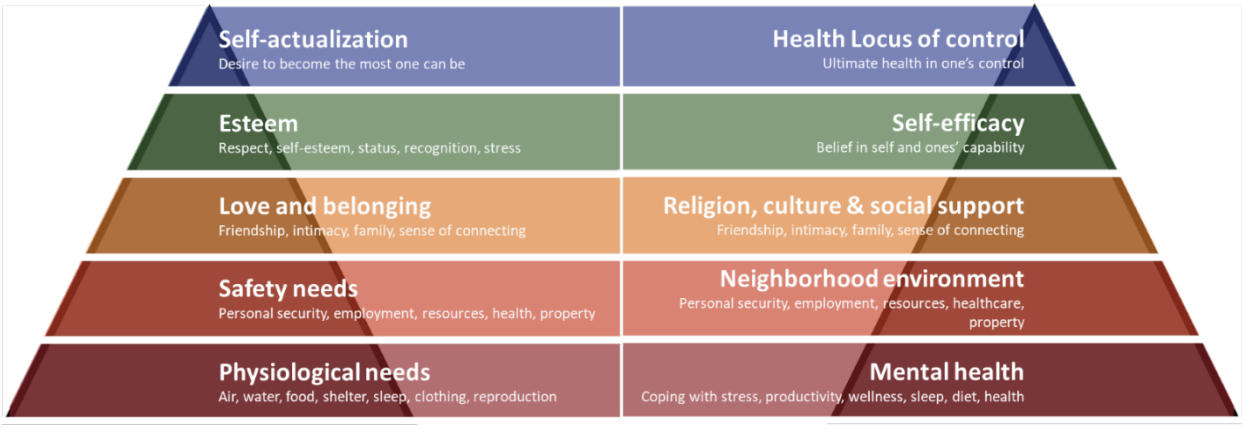
Created by psychologist, Abraham Maslow, Maslow's hierarchy of needs and motivation is a theory of human motivation that posits that a human's basic needs must be met before they are motivated to achieve a higher goal. This universally recognized pyramid shape ranks needs based on the level of importance from the base to the apex, with the most critical needs serving as the foundation for motivation. Unmet needs at the lower level may lead to reduced upward mobility in obtaining higher-order needs. Also, when lower-level needs are not satisfied they may dominate and overshadow critical thinking skills, actions, and overall being until they are addressed and solved for. Maslow emphasized that this model should be referenced as more of a schema that is not rigid or viewed with an *all or nothing* or a *one size fits all* approach; indicating that unique human experiences and individual differences may impact the ranking order of the hierarchy which is not fixed, and that partial fulfillment of lower-level and higher-level needs may be a possibility.

To briefly review Maslow's model, the base level accounts for physiological needs (e.g., food, water, shelter, sleep). The second level accounts for safety needs related to security, stability, and law and order. Level three addresses the need for love and belonging including family, affection, and relationships. Level four, a higher-order need for esteem which encompasses self-esteem, personal achievement, and sense of accomplishment. Lastly, level five is achieved after essential needs have been addressed and one is no longer burdened solving for lower-level needs - one can find high levels of awareness, meaning, and purpose and be free to achieve one's full potential.

Adaptation of Maslow's Hierarchy of Needs to Hierarchy of Elevated Rehabilitation Outcomes (HERO)

The goal of this model adaptation, as illustrated in Figure 1, was to design a framework and flexible schema that could be used to not only explain the diversity seen within rehabilitation outcomes but to also provide additional insight and awareness around patient needs that may be addressed before treatment and identify critical referrals to other rehabilitation professionals. This adapted hierarchy is consistent with Maslow's original hierarchy in that lower-order needs are typically addressed and fulfilled before higher-order needs. However, the interpretation and application of the model are suggestive and should be applied by accounting for unique individual differences. For example, each human experience is unique and though the model suggests the need for lower-order needs to be fulfilled first, some human experiences may require a different order or arrangement and or percentage of the level of fulfillment of the hierarchy. Additionally, there is also the consideration of developmental time points. Each level can account for age and consider how age may interact with the components of each level as well as the order of the hierarchy itself.

Figure 1. *Transforming Maslow's Hierarchy of Need to Hierarchy for Elevated Rehabilitation Outcomes (HERO)*



The adapted model retains the original components of Maslow's hierarchy and expands the components to include mental health; neighborhood effects; culture and religion; self-

efficacy, and, health locus of control. Components of each level were defined with rationale provided that speaks to the significance of the need as well as explains the hierarchy ranking.

Level 1: Mental Health

In addition to Maslow's base physiological needs, an additional first lower order need of the hierarchy was identified - mental health. Mental health as defined by American Psychiatric Association 2018, is a state of mind characterized by emotional well-being, good behavioral adjustment, and the ability to cope with ordinary demands and life stressors. Understanding a person's psychological profile and mental health state may speak to the patient's overall motivation in life as well as motivation within the therapy process. Research in the mental health field indicates that within the TBI population there is a high percentage of survivors that will experience depression and other mental health illnesses (Albrecht et al., 2018a; Lavoie et al., 2017). In addition, there is a well-documented link between mental illness related to depression and daily functioning (American Psychiatric Association, 2013). For example, some of the symptoms of depression include clinical distress or impairment in social, occupational, and other important areas of day-to-day functioning(American Psychiatric Association, 2013. In addition, the very nature of depressive symptoms may be severe enough that they impede one's ability to follow through with daily routines and obligations related to home, work, and community settings. Left untreated, these symptoms may certainly impact one's ability to participate in the therapy process including goal setting tasks and adherence to therapy recommendations. Taking a more holistic approach and definition to mental health, the HERO model centers mental health with the following constructs: coping ability, productivity, as well as wellness indicators related to sleep, diet, and overall health.

Level 2: Neighborhood Environment

In addition to the original components proposed by Maslow, an additional second-order need identified was the neighborhood environment. Neighborhood context as it pertains to social networks (Rigon, Duff, & Beadle, 2019), physical environment (Durish et al., 2018), and social environment (Zhang et al., 2016) has been linked to various individual outcomes including long-term outcomes in TBI populations. Including neighborhood context as a fundamental need signifies the importance of the individual being nested within numerous settings and contexts that may drive a significant impact on rehabilitation outcomes.

The therapy process can only account for one environment that will drive change in outcomes; however, it is important that additional environments and contexts particularly environments in which patients spend significant amounts of time and have extended exposure are accounted for. Neighborhoods provide key social and built environments that provide resources related to education, health services, housing, and employment. Neighborhoods can impact health through many channels such as health behaviors and access to health-promoting resources such as access to adequate healthcare, nutritious food supply, and structural features (i.e access to parks, gyms, public transportation) that promote physical activity to name a few (Vinikoor-Imler et al., 2011; Warren Andersen et al., 2018). Without such key resources, patients may be discharged to neighborhoods identified to have food deserts, poorly rated hospitals, increased exposure to environmental toxins, and poor infrastructure. These neighborhood limitations contribute to inadequate basic needs to support ongoing recovery and rehabilitation. The HERO model proposes that neighborhood environments must be considered a fundamental need that, at minimum, must be addressed and met before addressing higher-order needs within the model.

Level 3: Religion, Culture, and Social Support

At Level 3, Maslow's level related to love and belonging, the HERO model posits that social support via mechanisms related to religion and culture must also be fulfilled to obtain sustainable outcomes and increase one's belief in self and ultimate control in their overall health and outcomes. Key aspects of religion, religiosity, and spirituality have been linked to positive health outcomes, mental health, quality of life, and overall wellbeing (Koenig, 2012; Masters & Hooker, 2013; Waldron-Perrine et al., 2011). For example, scholars have studied Seventh-day Adventist's lifestyles and described that religious affiliation may reduce the risk of diseases such as coronary artery disease and cancer (Kwok et al., 2014). More specifically, religion and spirituality have also been linked to rehabilitation outcomes for TBI survivors. A study conducted by Perrin et al., 2011 described a positive link between religious well-being, life satisfaction, distress, and functional ability among TBI survivors.

Cultural practices and beliefs are also bidirectionally related to religion in that they inform one another. Culture can also inform health beliefs and behaviors (Sadana et al., 2021; Unger & Schwartz, 2012), as well as medication adherence (McQuaid & Landier, 2018). One's culture can also help frame and provide meaning for why a health event occurs and can even determine one's ability or motivation to seek treatment and adhere to treatment recommendations. One's culture and religious practices should not be viewed solely as a need that must be met but, within the HERO model, it should be considered as a key aspect of one's identity and should always be factored into patient care including, but not limited to, aspects of discharge planning, treatment recommendations, and patient and family training.

Though culture and religion are fixed unique, individual, and person-centered characteristics, social support is a need that can be leveraged to bolster esteem, improve quality

of life, and improve coping skills for life events. As defined by the American Psychological Association (2020), social support is the provision of assistance or comfort as a means of helping one cope with biological and social stressors. The psychosocial construct of social support has been studied in various populations such as stroke and TBI and has been indicated in recovery from a variety of diagnoses including depression, and cancer (Fong et al., 2017; Glass et al., 1993; Hurd et al., 2013; Izaute et al., 2008). One study even determined that high levels of social support have been associated with faster and more extensive recovery of functional status following a stroke (Glass et al., 1993). There have even been suggestions regarding cultural differences in the utilization of social support (Kagawa-Singer, 2011). Addressing the need for social support is a vital component in maintaining and improving functional skills over time. Social support is a human need that can be traced throughout many aspects of life. Social support as it applies to rehabilitation science may have many implications for successful outcomes. For example, access to social support may help improve follow-through of home exercise programs, adherence to skilled recommendations, increased participation in therapy, improve coping skills, and increase self-esteem and self-efficacy. The inverse is also true. The lack of fulfillment at this level and reduced social support can serve as a risk factor for poor rehabilitation outcomes.

Level 4:Self-Efficacy

The expansion of Level 4 from Maslow's hierarchy in the adapted HERO model includes self-efficacy. From the review of the literature and anecdotal experience, the significant role that personal motivation plays in therapeutic outcomes is evident. There is a growing body of research that examines self-efficacy on health behaviors, health quality of life, and rehabilitation (Brouwer-Goossensen et al., 2018; Carlsen et al., 2017; Picha et al.,

2021). Brouwer-Goossensen et al. (2018) described high levels of self-efficacy scores for health-related behaviors in recent ischemic stroke patients. Other studies have indicated that self-efficacy predicts communication participation in adults who stutter (Boyle et al., 2018).

The self-efficacy theory was born out of the social-learning framework and postulated that one's perception of their capabilities is linked to their behavior (Bandura, 1977). Self-efficacy is not considered to be a global trait meaning one may have high levels of self-efficacy in one aspect or role in life but may have very low levels of self-efficacy in other areas. Albert Bandura, psychologist, and originator of self-efficacy theory described several pathways of improving self-efficacy. A few of the pathways worth noting are social modeling, social persuasion, and psychological responses (Bandura, 1977). Social modeling is direct observation of another's ability to persevere and triumph over obstacles, thereby raising one's self-perception and belief that they too can be successful. Social persuasion is Bandura's assertion that people could be persuaded to believe they too possess the necessary skills to obtain goals and master new skills via verbal encouragement. Last, psychological responses can also help bolster self-efficacy. Bandura believed that there was value in examining one's perception and interpretation of emotional and psychological responses to unique situations. The ability to practice good coping skills and stress management when engaging in challenging tasks can lead to higher levels of self-efficacy (Scheenen et al., 2017). The inclusion of self-efficacy in the HERO model links concepts of human behavior, motivation, and social support. It also demonstrates the overlapping nature of the hierarchy in that self-efficacy is connecting lower needs from level 1 (mental health) and level 3 (religion, culture, and social support). For patients engaging in new and challenging rehabilitation tasks, a lack of self-efficacy could impede the ability to meet goals and improve function.

Level 5: Health Locus of Control

In Maslow's hierarchy, in order to achieve self-actualization (Level 5), one must meet lower-order needs first. Borrowing from Maslow's hierarchy, in order to achieve health locus of control (Level 5), in the HERO model, patients must account for lower-order needs of mental health, neighborhood effects, social support, and self-efficacy. The construct of health locus of control draws from Julian Rotter's work on locus of control which is the degree to which an individual believes that they have control (internal control) over the outcome of a specific life event versus a thing happens to me, life perspective (external control) (Nazareth, 2016; Wallston & Wallston, 1982). Studies have shown that extrinsic health locus of control can negatively impact patient adherence, overall health, and rehabilitation outcomes (Keedy et al., 2014; Milte et al., 2015; Nazareth, 2016). For example, a study by Nazareth et al. (2016) described that external control was negatively associated with transition readiness and positively associated with emergency room visits and the number of inpatient nights at the hospital. Health locus of control has also been studied in a variety of adult diseases and medical outcome-based studies such as cardiac (Mercer et al., 2018) and hypertensive patients (Omeje & Nebo, 2011), multiple sclerosis (Wilski et al., 2019), and maternal health (Lawal & Idemudia, 2017) to name a few. It has also been examined in combination with other constructs such as health behaviors and self-efficacy (Clark et al., 2018; Grotz et al., 2011). The frameworks of self-efficacy and health locus of control accounted for individual differences in patient motivation and fundamental beliefs about personal ability to make change.

Health locus of control studies have developed specific scales related to a variety of health issues such as hypertension (Omeje & Nebo, 2011), depression (Aarts et al., 2015), and diabetes mellitus (Hummer et al., 2011). Low levels of locus of control following a TBI have

been described (Wielenga-Boiten et al., 2015). A review of the literature has also identified several studies that have linked locus of control to self-efficacy. In a sample of college students, Roddenberry and Renk (2010) discovered that higher levels of stress were linked to higher levels of illness and health locus of control along with lower levels of self-efficacy. In this study, health locus of control served as a partial mediator between stress and illness. Additionally, in a study conducted by Jacobs-Lawson et al., (2011) factors that may impact and improve health locus of control in older adults were identified: demographic factors, psychological variables, and health-related variables (ie. self-rated health and number of health ailments). When possible, sustaining agency and ownership over the rehabilitation process and creating an active partnership where the patient can feel empowered and invested in the therapy process may help improve internal health locus of control. Increasing internal health locus of control may have long-term implications for overall health behaviors and health outcomes.

Application of Hierarchy for Clinical Practice

The application of the HERO model is demonstrated in the following case example. Consider Sheryl, a patient seen in an outpatient clinic. Her name was changed to protect her identity. Sheryl was a 49-year old female who sustained a TBI following a motor vehicle accident. Her injuries included a left-brain hemorrhage with loss of consciousness for 2 hours following the accident. Upon hospital admission she presented at a level 3 on the Rancho Los Amigos Scale and a level 9 is considered with a TBI classification of moderate. She underwent a craniotomy and spent two weeks in the ICU and was deemed appropriate for inpatient rehabilitation. Her medical history was significant for hypertension and diabetes. Moving through the hospital continuum she was discharged from inpatient rehabilitation to outpatient

rehabilitation where we will apply the HERO model to assess needs, establish a plan of care and treatment goals.

A clinical interview was conducted with her and her husband present. Before her injury, she was living at home with her husband and two teenage children and was completely independent in all activities of daily living. She was working full-time as an administrative assistant for a local law firm and had been working in this role for 15+ years. Her hobbies included sewing, reading books with her book club, traveling, and spending time with her family. She presented to the outpatient rehabilitation unit with moderate, cognitive-linguistic impairments including issues with verbal expression, memory, attention, and executive functioning skills. In addition, she was experiencing signs of post-injury depression, impaired gait and balance requiring the use of a wheelchair, and reduced range of motion of her right upper extremity. Her spouse stated that they owned a two-story home with the master suite on the second level. They had been part of their neighborhood for the past 10 years. He described the neighborhood as relatively safe, with access to public transportation, good school systems, and filled with neighbors they consider family. Her long-term goal was to return home, increase independence for ADLs, and return to work.

Application of the HERO model could help the initial outpatient care team (speech therapy, occupational therapy, physical therapy, physician) elucidate contextual needs that will impact clinical recommendations and the success of long-term goals and outcomes. Starting with Level 1 (mental health) of the HERO model, depressive symptoms were identified during the clinical interview and initial assessment. This prompted additional clinical questions that uncovered poor sleep hygiene and inadequate nutrition. A clinical referral to counseling and nutrition services was initiated to help address mental health and dietary concerns.

At Level 2 (neighborhood effects), her spouse described several positive attributes that could be leveraged as meaningful long-term resources. For example, the high level of neighborhood cohesion and social support could directly impact both levels 2 and 3 of the hierarchy and could translate to a variety of meaningful resources which included accountability, emotional support, and improvement in health behaviors to name a few.

At level 3 (religion, culture, and social support) Sheryl shared that she was a devout Christian and had been a part of her church community for over 20 years. She enjoyed reading the Bible and identified this as a functional reading comprehension goal. She expressed that her religious beliefs grounded her, gave her a sense of wellbeing, and the ability to navigate the recovery months ahead. Clinically speaking, long-standing relationships that she had cultivated in this community could serve as secondary support systems to bolster mental health. In addition, this community may also provide unique opportunities for communication partners and social engagement to address specific cognitive-linguistic goals.

Level 4 (Self-efficacy) was measured across the initial 2-3 therapy sessions and it was informally assessed during therapy activities. During therapy tasks, Sheryl made several disparaging comments about her current skills and ability to do functional ADLs without support. She also expressed her concern about long-term abilities. Her personal beliefs about her ability to persevere sometimes impacted her motivation and follow through with therapy tasks. This was addressed in therapy by providing a thorough explanation of therapy tasks and identifying the connections between therapy tasks and generalization to real-world home and community tasks and goals. Therapy sessions were used to create positive experiences in training for adaptive equipment and strategies for successful completion of ADLs. These sessions were also used to help increase Sheryl's awareness and self-esteem around her abilities to meet

goals and master new skills. This increased level of awareness and esteem in return had major implications for her health locus of control. Upon admission to an outpatient clinic, Sheryl's health locus of control (level 5) was externally focused with beliefs that her health and outcomes were controlled by external factors. After several weeks of outpatient therapy where she was encouraged to actively participate in the therapy process including goal setting and was provided with extensive education on the purpose of key therapy activities and how these activities map onto her long-term goals. she became more motivated in therapy. She was able to acknowledge her growth in therapy which improved her esteem, motivation, and adherence to the therapy process.

Discussion

To our knowledge, there is no comprehensive theoretical model that accounts for patient contextual factors that can be applied to the SLP discipline specifically and other rehabilitation disciplines more broadly, explains rehabilitation outcomes, and provides new considerations for optimal care. To address the knowledge gap, Maslow's Hierarchy of Needs was used in the HERO model adaptation to account for health disparities in a comprehensive rehabilitation outcomes model (Maslow, 1954b, 1954a). The goals of this model adaptation were to (1) provide an all-inclusive framework that encompassed a variety of human experiences; (2) provide a person-centered perspective that addressed modern-day proximal and distal contextual factors to integrate key features of our nation's healthcare system and neighborhood environment; and (3) acknowledge key aspects of clinical practice and observation. Additional goals of this model adaptation were to develop a theoretically supported framework and flexible schema that could be used to explain the diversity seen within rehabilitation outcomes and identify additional patient needs that can be addressed before or during rehabilitation to achieve

optimal outcomes. This adapted hierarchy is consistent with Maslow's original hierarchy in that lower-order needs are typically addressed and fulfilled before higher-order needs. However, the interpretation and application of the model are suggestive and should be applied by accounting for unique individual differences.

The first lower-order level of the HERO model included the novel construct of mental health. Understanding a person's psychological profile and mental health state may speak to the patient's overall motivation in life as well as motivation within the therapy process**.** Research in the mental health field indicates that within the TBI population there is a high percentage of survivors that will experience depression and other mental health illnesses (Hart et al., 2012; Lavoie et al., 2017). In addition, there is a well-documented link between mental illness related to depression and daily functioning (American Psychiatric Association, 2013). Failure to consider mental health as a relevant factor in rehabilitation outcomes risks poorly understood clinical processes.

The second-order need innovation was the inclusion of the neighborhood environment in the adapted model. Neighborhood context as it pertains to social networks (Rigon, A., Duff, M., & Beadle, J., 2019), physical environment (Durish et al., 2018), social environment (Wade et al., 2016) as well as the symbolic environment has been linked to long-term outcomes in TBI populations. Including neighborhood context as a fundamental, Level 2 needs operationalizes the importance of the individual being nested within a variety of settings and contexts that may drive a significant impact on rehabilitation outcomes, the impact of which is yet to be fully appreciated.

At level three, similar to Maslow's level related to love and belonging, the HERO model posits that social support via mechanisms related to religion and culture must be

fulfilled to obtain sustainable outcomes and increase one's belief in self and ultimate control in their overall health and outcomes. The inclusion of religion and culture in the model formalizes the importance of accounting for these variables in treatment planning and implementation to avoid a one-size-fits-all approach to clinical care. The inclusion of these variables also aligns the model with the clinical importance of cultural competence and cultural humility as emphasized by the American-Speech-Language-Hearing Association (ASHA, n.d.).

The inclusion of self-efficacy (Level 4) in the HERO model links concepts of human behavior, motivation, social support; and, more importantly, demonstrates the overlapping nature of the hierarchy in that self-efficacy is connecting lower needs from level 1 (mental health) and level 3 (religion, culture, and social support). When lower-order needs are met, one can obtain health locus of control (level 5) which may increase the ability to sustain patient agency and ownership over the rehabilitation process. Creating an active partnership where the patient can feel empowered and invested in the therapy process may help improve internal health locus of control. Inclusion of the self-efficacy construct in the HERO model reminds the researcher and the clinician not to overlook the value of cultivating this perspective as a vital component of clinical service delivery. The clinical application of this model was illustrated in a TBI case study where the hierarchy was used to guide clinical referrals and skilled recommendations as well as identification of barriers to successful clinical outcomes.

The HERO model also provides a framework from which to consider the patient perspective as one of the three primary components of evidence-based practice (EBP). According to the American Speech-Language and Hearing Association (ASHA), EBP should include client, patient, caregiver perspectives (ASHA, 2005). ASHA defines this component as individual contextual factors related to personal and cultural circumstances, values, priorities,

and expectations as identified by either the client and or caregiver. Additionally, as a part of the ASHA position statement, EBP should seek to integrate these individual contextual factors along with trends in current research to assist in making efficacious clinical decisions (ASHA, 2005). The HERO model provided a structured means to organize and integrate contextual factors in an intentional way.

The HERO model can be used as an explanatory tool and an instrument to inform best practices for treatment implementation, research, and policy development. As an explanatory tool, this model stands to be one of the first integrative and holistic models that accounts for individual mental health, environmental context, and personal contextual factors when explaining rehabilitation outcomes for SLP. The novelty and timeliness of SLPs contribution to health disparities within rehabilitation outcomes are critical. This model can serve as an initial framework from which to explore, plan, and execute interdisciplinary efforts to eradicate health disparities and realize optimal rehabilitation outcomes.

The HERO model could also be used as a training tool in graduate training programs. In the graduate training program setting, this model can be used to educate and train future students on the importance of building awareness around contextual barriers and resources that may bolster clinical outcomes. Students could benefit from the ways the HERO model illustrates the interdisciplinary nature of clinical practice and demonstrates rewards gained on behalf of the patient when individual context is factored into a comprehensive treatment model. The HERO model also provided clinical supervisors with an organized framework to model how context can be used to established functional client-centered goals.

In clinical practice, this model could serve as a rubric and guide to goal setting, a barrier identification measure, and a means to identify appropriate referrals. This model can also

inform and serve as a framework to create screening tools to identify risk and intervention points that jeopardize optimal rehabilitation outcomes. A clinical checklist could be developed that assesses a patient's level of need across each level within the hierarchy. For example, questions and or checklist items could be developed across neighborhood environment to assess access or voids in specific neighborhood resources such public transportation, employment status, healthcare benefits, etc. Items from each level could be scored and cut-offs established along with establishing validation and reliability. The development of a clinically useful checklist would be a future direction in which to further develop a standardized approach for applying this framework in the rehabilitation setting.

Lastly, this comprehensive model can provide pathways for discipline-specific and interdisciplinary lines of research spanning the disciplines of rehabilitation medicine, psychology, human development and family science, public policy, rural sociology, urban planning, to name a few. This model provides an organized framework that can be easily translated into scholarly research. A variety of research questions can be generated that support and justify interdisciplinary collaborative research. Additionally, individual levels can be tested as well as the interaction between levels using a variety of statistical models from linear regression to multilevel modeling. The HERO model could also be vetted against existing well-established clinically-based outcome measurement tools such as the Functional Independence Measure (FIM) tool (Keith et al., 1987), National Outcome Measures (NOMS) (Mullen, 2004,) and others.

Limitations of the HERO model are acknowledged. First, this model has not yet been validated. Additional research is required to evaluate and validate the levels of the model to better understand the relationships that may exist across the model and the applicability to

various populations. Future research efforts could apply the model in the development of a clinically useful tool to make sure that all aspects and levels of the model are accounted for in the rehabilitation planning process. Second, similar to most theories, this model is bound and limited by the constructs included in the current version of the model. Additional constructs that may prove equally as valuable in explaining rehabilitation outcomes may be included in future adaptations of this initial model. Future research could also test and or revise the model with a developmental lens and determine how age may influence hierarchy order as well as components included within each level.

Conclusion

The HERO model provides a new framework from which rehabilitation planning, implementation, and outcomes assessment may be determined. Future research might explore additional model adaptations by expanding the scope and borrowing from additional social and human science fields. In addition, future work should seek to test model validity by examining the relationships between the levels using both quantitative and qualitative longitudinal methods in a wide variety of populations (ie. TBI, stroke, MS, etc.) and generate clinically relevant tools such as screeners to provide a formal means of clinical theory application.

III. Study 2: The Role of Depression and Race in Examining Neighborhood Effects on Functional Independence Measure Scores for Traumatic Brain Injury Survivors

Introduction

Every year roughly 2.8 million Americans sustain traumatic brain injuries (TBI) with about 80,000 to 90,000 individuals experiencing long-term disability (CDC, 2017). For survivors of TBI, the effects can vary and include lifelong changes in function and impairment including cognitive-linguistic deficits, neuromuscular changes (i.e. dysphagia, gait disturbances), and emotional functioning (Hart et al., 2005; Levitan & Henderson, 2015; Williams et al., 2009). These impairments typically require inpatient and outpatient rehabilitation to assist in retraining and regaining function. The primary goal of rehabilitation is community reintegration and participation in society including tasks related to employment, independent living, and social engagement (McCabe et al., 2007). Recent studies have examined overall health outcomes, life satisfaction, vocational outcomes, and level of functional independence for individuals who have sustained a TBI (Davis et al., 2012; Johnstone et al., 2003; Seagly et al., 2018). Few if any studies have examined how combined personal contextual factors related to mental health and neighborhood environment (i.e. available resources, overall socioeconomic makeup) predict post-acute rehabilitation outcomes.

Scholars have well documented how neighborhoods impact one's health as it pertains to mental illness, obesity rates (Pruchno et al., 2014), cancer rates (Beyer et al., 2016), mortality rates (Mode et al., 2016), child health outcomes (Madkour et al., 2014), as well as general health outcomes (Keita et al., 2014). In addition, a few studies have examined the relationship between neighborhoods and TBI rehabilitation outcomes. For example, Corrigan and Bogner (2008) examined neighborhood characteristics and outcomes after TBI and determined that economic and social characteristics of a neighborhood predicted outcomes following TBI beyond that of

individual characteristics. In a follow-up study, Corrigan et al. (2012) described that neighborhood characteristics predicted life satisfaction and neighborhood participation after TBI; however, it did not predict it beyond that of individual characteristics. These studies revealed that individuals who have sustained a TBI often reported higher levels of life satisfaction when residing in more stable neighborhoods. The current study will address these gaps by examining key neighborhood characteristics and the relationship to patient mental health status. This study will review the mediating role of depression on neighborhood disadvantage and functional independence measures (FIM) scores over time.

Depression

Mental health, particularly depression is a known risk factor for poor outcomes in the TBI population. Depression is characterized by general feelings of sadness, depressed mood, low energy, and can include issues like difficulty thinking and concentrating to name a few (CDC, 2021). When discussing depression in this population it is important to note that this mental health diagnosis is distinct and different from similar neurogenic impairments that may also result in lack of motivation, lack of participation, and changes in mood. According to the Centers for Disease Control (CDC) in 2019 about 21% of the population age 18-29 experienced symptoms of depression. Within the first year of post-injury, approximately 50 % of TBI survivors will experience major depression symptoms (Bombardier et al., 2010). Research has revealed conflicting findings regarding gender differences for depression in the TBI population (Lavoie et al., 2017). In addition, there are other risk factors for diagnosis in the TBI population such as age and premorbid history of neuropsychiatric disturbances. For individuals who sustained a TBI, they are more likely to be diagnosed with depression when compared to the general population, and diagnosis of depression can have a significant impact on the treatment

and recovery from injury. There is even evidence that supports major and minor depression present up to two years post-injury and is associated with lower cognitive functioning, poor social support, and mental health issues including substance abuse (Hart et al., 2012).

The impact of depressive symptoms on therapy participation and outcomes is not well researched. In a study by Lewis and Horn 2017, depression following TBI was examined. Findings revealed that there was a positive relationship between depression and overall disability such that higher levels of depression were linked to higher levels of disability. When comparing admission and discharge participation scores, for individuals classified as moderately and severely depressed, they experienced higher levels of disability and reduced functional performance than the mild or not depressed groups. Additionally, longitudinal studies have concluded that even after adjusting for predictors of major depressive disorders, TBI individuals diagnosed with major depressive disorder report a lower quality of life at the one-year follow-up (Bombardier et al., 2010). Few studies have examined how depression and mental health may explain the relationship between TBI and FIM scores.

Neighborhood

Research in rehabilitation medical journals has largely focused on community re-entry and identifying specific rehabilitation treatment modalities that will increase the likelihood of successful re-entry across various populations (Burns et al., 2018). Studies have examined key elements of life after discharge, including but not limited to returning to work, school, driving, and planning for a safe and accessible home, community, and work environments for stroke and TBI population (Brannigan et al., 2017; Egeto et al., 2019; Libeson et al., 2020). The sustainability of patient outcomes is not well understood and many clinicians across disciplines often ask what happens after rehabilitation when the patient re-enters the community.

Additionally, studies have yet to examine what factors in communities meet the demands of individuals and support or impede progress made in rehabilitation centers.

The Hierarchy for Elevated Rehabilitation Outcomes (HERO) framework was used to answer the question of what contextual factors influence rehabilitation outcomes. The initial model took the initial steps in advancing the literature and serve as a valuable contribution to rehabilitation science. Measures of depression (Level 1) and neighborhood disadvantage (Level 2) were selected from the HERO framework to test several hypotheses. The first aim of the study was to determine if TBI survivors' residing in disadvantaged neighborhoods experienced lower levels of functioning over time (as measured by FIM scores) when compared to survivors residing in more advantaged neighborhoods over time. It was hypothesized that exposure to neighborhood disadvantage at the time of injury would be negatively associated with FIM scores over time. The second aim was to determine if TBI survivors' severity of depression explained the relationship between neighborhood disadvantage and FIMs over time. It was hypothesized that TBI survivors' severity of depression would mediate the relationship between neighborhood disadvantage and FIMs over time such that higher levels of depression would be associated with lower functional ability as indicated by FIM scores.

Methods

Database

The analytic sample and data proposed for this study were derived from the Traumatic Brain Injury Model Systems (TBIMS). The program is a longitudinal study that began in 1987 and is funded by the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR) in the U.S. Department of Health and Human Sciences. The program was initiated to improve care and outcomes for individuals with TBI. Data collection is ongoing

across 16 TBIMS centers across the U.S. Criteria for participant inclusion are as follows: individuals over the age of 15 and TBI characterized as moderate to severe requiring inpatient stay. Data collection includes measures across the care continuum from acute care and rehabilitation with outcome measures at year 1, 2, and at every 5 years thereafter.

Sample

The final sample consists of $N = 518$ participants, who sustained a TBI, from the University of Alabama at Birmingham (UAB-TBIMS). This collection site was intentionally selected for a few reasons. Alabama is one of 11 states across the southeast region that make up the stroke belt. Studies have revealed that residents in this area are at a higher risk for stroke and cardiovascular disease (Howard & Howard, 2020). In addition, Alabama consists of both rural and urban areas that could lead to more robust analysis and interpretation. This longitudinal dataset was established in 2002 with collection of participant physical addresses starting in 2010. Participants are recruited within 72 hours of injury during treatment at TBIMS. Inclusion criteria included participants with self-reported physical addresses at the time of injury. Only participants with date of injury +/- 5 to 6 years from the 2010 census were included in this study. The sample is 63% male. This sample is racially representative of the population at large with 62.5% European Americans and 21.5% African Americans. The average age of the sample is 39.76 ($SD = 36.96$). For this study, only the following variables were used: Neighborhood Disadvantage (T1-time of injury), Depression (T1, T2, T3), and FIMS (T1, T2, T3). Attrition analysis revealed high retention across waves with 96% from T1 to T2, 85% from T2 to T3, and 81% from T1 to T3.

Measures

Neighborhood Disadvantage (Predictor) (T1)

Neighborhood disadvantage was measured by linking participant home address at the time of injury to geocoded tract-level data from the 2010 US census. An Area Deprivation Index composed of 17 poverty, education, housing, and employment census-tract indicators was evaluated (ADI, Kind, et al., 2014; Singh, 2003). The ADI is a well-known and used measure in the literature to define neighborhood socioeconomic disadvantage. Each indicator was independently weighted according to Singh (2003), such that poverty, education, and income will carry the largest relative weights. These items were highly correlated (*r*s between 0.08 and 0.88). For a full description of the ADI, see Table 1.

Table 1. *Area Deprivation Index (ADI) Indicators and Factor Scores**

	Singh Factor Weights
1. Percent of population ≥ 25 years with **< 9 years of education**	.0849
2. Percent of population ≥ 25 years with ≥ **high school diploma**	-.0970
3. Percent of employed persons ≥ 16 years in **white-collar occupations**	-.0874
4. Median **family income**	-.0977
5. **Income disparity**[a]	.0936
6. Median **home value**	-.0688
7. Median **gross rent**	-.0781
8. Median **monthly mortgage**	-.0770
9. Percent **owner-occupied housing units**	-.0615
10. Percent of civilian labor force ≥ 16 years **unemployed**	.0806
11. Percent of families **below the poverty level**	.0977
12. Percent of population **below 150% of the poverty threshold**	.1037
13. Percent of **single-parent households** with children < 18	.0719
14. Percent of occupied housing units **without a motor vehicle**	.0694

15. Percent of occupied housing units **without a telephone**	.0877
16. Percent of occupied housing units **without complete plumbing**	.0510
17. Percent of occupied housing units **with more than one person per room**	.0556

Note. [a]Income disparity is defined as the ratio of the number of households with <$25,000 income to the number of households with >$100,000 income.
*This table describes Singh factor score coefficients for 17 variables. The raw value for each variable was multiplied by the factor weights. Neighborhoods with higher ADI scores have higher levels of deprivation.

Depression- Patient Health Questionnaire (phq-9) (Mediator) (T1)

Depression is measured via the Patient Health Questionnaire (PHQ-9) which is a 9-item screening tool for major depressive disorder on a 4-point Likert scale (4= nearly every day). Examples of items include: "Little interest or pleasure in doing things", "Feeling down, depressed, or hopeless", "Trouble falling or staying asleep, or sleeping too much", "Feeling tired or having little energy", and "Poor appetite or overeating"; $\alpha = .99$.

Race (moderator)

Participants in the study self-reported their race choosing among the following options: Black/African American; White; Hispanic Origin; Asian/ Pacific Islander; Other. Only participants who self-identified as either Black or White were included in the study.

FIMs (T1, T2, T3)

The FIM scoring instrument is a measure of current disability (CMS, 2004). This assessment tool is often conducted by trained clinical rehabilitation specialists such as speech, physical, and occupational therapists. Follow-up data from three waves at year one, year, two, and year 5 were used in the final analysis. This tool consists of 18 items divided by motor and cognitive skills. For this study, we will focus on five cognitive-linguistic tasks. Examples of items include Problem-solving; "Problem-solving includes skills related to solving problems of daily living. This means making reasonable safe and timely decisions regarding financial, social,

and personal affairs, as well as initiation, sequencing, and self-correcting tasks and activities to solve problems." FIM scoring for 5 cognitive tasks are rated on a 7-point ordinal scale (7= complete independence) includes comprehension, expression, problem-solving, social interaction, and memory; α = .91.

Covariates

Age, sex, preliminary learning, household SES, and TBI severity at T1 (GOS-E) served as covariates.

Analyses

Original data was cleaned using IMB SPSS version 25 software. Data cleaning consisted of addressing issues with normality, recoding of variables, correlation matrix, identifying missing data patterns, and sample descriptives. Missing data analysis was conducted and revealed a range of 0% to 70% missing on study variables. Missingness was addressed using FIML estimator (Enders & Bandalos, 2001). The final analysis was conducted in Mplus (version 8; Muthen & Muthen, 2017) via latent growth curve models and hierarchical linear regression. Unconditional growth in FIMs was tested, then growth in FIMs conditioned on neighborhood disadvantage and depression was tested in separate models. The final moderated mediation model evaluated whether the effect of neighborhood disadvantage significantly predicts change in FIMs, after accounting for the indirect effects of depression on neighborhood disadvantage and FIMs with race moderating the relationship between neighborhood disadvantage and depression. All models included covariates of sex, age, preliminary learning, household income, and TBI severity at T1.

Results

Data management and cleaning were performed in SPSS. Descriptive statistics for all variables were obtained to assess normality and skewness (see Table 2). A negative skew was observed on the neighborhood disadvantage variable and was resolved using winsoring transformation technique to limit extreme values (Cousineau & Chartier, 2010). A correlation matrix was conducted and revealed that neighborhood disadvantage was positively associated with race and GOS-E and was negatively associated with FIM scores at T1 and T2 age, household SES, and depression (PHQ-9; see Table 2).

Table 2. *Descriptive Statistics and Correlations of Study Variables*

	n	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11
1. FIMCog T1	358	31.24	4.91	-										
2. FIMCog T2	336	31.31	4.45	.75**	-									
3. FIMCog T3	226	31.39	4.47	.55**	.51**	-								
4. Age	500	39.76	36.96	-.03	-.22**	-.16**	-							
5. Sex	500	0.26	0.44	-.03	.02	-.04	-.04	-						
6. Household SES	246	1.84	0.96	.19**	.21**	.12	.00	.07	-					
7. Preinjury Limitation: Lrn	501	1.08	0.27	-.06	-.08	-.04	.16**	-.08	-.16*	-				
8. European Americans	342	1.73	0.45	.03	-.03	-.14	.06	-.10*	.16*	.08	-			
9. PHQ-9	174	5.7	8.83	-.21**	-.23**	-.19**	.02	-.07	.07	.10*	-.00	-		
10. GOS-E	454	5.59	1.83	.65**	.60**	.41**	-.10	.04	.28**	-.09	.07	-.11*	-	
11. Neighborhood Disadvantage	581	0.06	0.8	-.15**	-.15**	-.10	-.10*	.07	-.34**	-.05	-.26**	.05	-.21*	-

(0 = female; 1 = male;)
* $p < .05$. ** $p < .01$. *** $p < .001$.
*Patient Health Questionnaire (PHQ-9)
*Glasgow Outcome Scale- Extended (GOS-E)

Using Mplus for final analysis, a latent growth model testing moderated mediation was conducted. An unconditional and predictive conditional model were fit (see Table 3; Figure 2). The unconditional model was fit to examine variability in depression and the incept and slope of FIM scores. The results of the unconditional model revealed good model fit with two out of three measures meeting criteria: TLI (between .90 and 1), and RMSEA close to 0 and nonsignificant *p*-value, (RMSEA = 0.08, $p = 0.10$; χ^2 (4) = 16.36, $p = 0.00$; TLI = 0.95). The model also showed that participants had an average depression score of 5.70 ($SE = 0.67$, $p < .001$) at year 1 follow-up. The average participant had a FIM score of ($B = 31.14$, $SE = 0.24$, $p < .001$) with a slope that is non-significant ($B = 0.08$, $SE = 0.08$, $p = .30$). Additionally, there was significant variability in

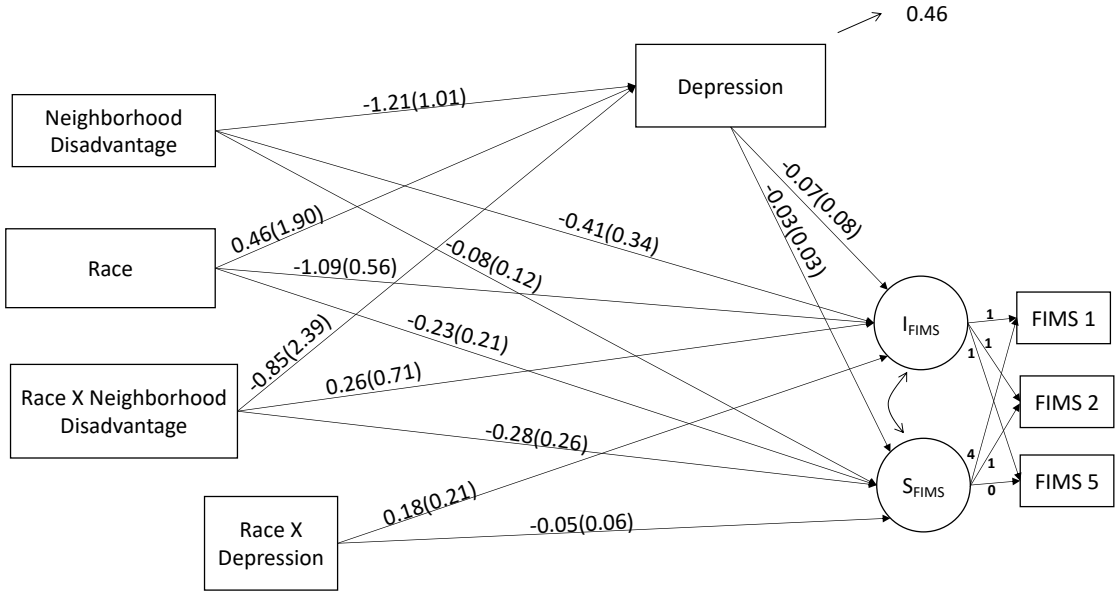
participant FIM scores at year 1 follow-up (B = 19.58, SE = 1.81, p < .001) but not in the slope of FIM scores over time (B = 0.25, SE = 0.39, p = 0.52).

Table 3. *Neighborhood Disadvantage Predicting FIM scores Mediated by Depression and Moderated by Race (N = 581)*

	Depression		Intercept FIMs		Slope FIMs	
Predictor	Estimate	SE	Estimate	SE	Estimate	SE
Neighborhood disadvantage	-1.21	1.01	-0.41	0.34	-0.08	0.12
Race	0.45	1.9	0.23*	0.02	0.23	0.02
Age	0.05	0.04	0.1	0.02	0.11	0.02
Household income	-6.14***	1.59	0.04	0.07	0.02	0.07
GOS-E	-0.77	0.45	-0.07***	0.02	-0.07***	0.02
Sex	-1.79	1.76	0.01	0.03	-0.01	0.03
Preinjury Learning	-3.26	-0.90	0.57	0.13	0.63	0.13
Neighborhood disadvantage X Race	-0.85	2.37	0.06	0.02	0.06	0.02
Race x Depression					0.64	0.12

Note: Unstandardized parameter estimates and standard errors are shown. ***p <.001, **p < .01, *p < .05.

Figure 2. *Results for Neighborhood Disadvantage Predicting FIM scores Mediated By Depression and Moderated By Race*



Note. Covariates age, sex, TBI severity at T1, Preinjury learning, household income;
Indirect effects:
$FIMS_I$ = 0.09 (0.12); $FIMS_s$ = 0.03 (0.07)
Unstandardized parameter estimates and standard errors are shown.

Fitting of the conditional model testing effects of neighborhood disadvantage and race on FIM scores through depression was conducted. To determine model fit, the following estimates were examined and revealed a good fit with three out of three measures meeting criteria: chi-square test (non-significant p-value), TLI (between .90 and 1), and RMSEA close to 0 and nonsignificant *p*-value, (RMSEA = 0.00, $p = 0.99$; χ^2 (12) = 8.43, $p = 0.81$; TLI = 1). A latent growth model testing mediation effects of neighborhood disadvantage on FIM scores over time through depression (controlling for age, sex, income, injury severity at T1, and premorbid learning) was conducted. Hypothesis 1 was not supported. Neighborhood disadvantage did not

influence or predict the change in FIM scores over time ($b_{intercept}$ = -0.40, p = 0.24; b_{slope} = -0.09, p = 0.50). Hypothesis 2, was not supported. Full mediation was not present meaning depression did not mediate the relationship between neighborhood disadvantage and FIM scores over time with non-significant indirect effects ($b_{intercept}$ = 0.09, p = 0.48; b_{slope} = .03, p = 0.47). Subsequently, hypothesis 3 was not supported. Race did not moderate the relationship between neighborhood disadvantage and depression. When controlling for sex, age, race, household income, injury severity at T1, and premorbid learning, the interaction between neighborhood disadvantage and race did not significantly predict the onset or change in FIM scores over time ($b_{intercept}$ = 0.26, p = .72; b_{slope} = -0.28, p = 0.27). The interaction between race and depression did not significantly predict the onset or change in FIM scores over time ($b_{intercept}$ = 0.17, p = .40; b_{slope} = -0.05, p = 0.40).

Discussion

For survivors of TBI, post-injury deficits can vary and may include lifelong changes in function and impairment including cognitive-linguistic deficits, neuromuscular changes (i.e. dysphagia, gait disturbances), and emotional functioning (Hart et al., 2005; Levitan & Henderson, 2015; Williams et al., 2009). Studies have examined overall health outcomes, life satisfaction, vocational outcomes, and level of functional independence in this population. Few studies have examined how personal contextual, as well as neighborhood environment (i.e. overall socioeconomic makeup), predict post-acute rehabilitation outcomes. Study 2 addressed these gaps by examining key neighborhood characteristics and analyzing the mediating role of depression on neighborhood disadvantage and FIM scores over time while exploring race as a moderator.

This initial application of the HERO framework is the first of many in a long process of evaluating the contextual factors that may influence rehabilitation outcomes. Measures of depression (Level 1) and neighborhood disadvantage (Level 2) were selected from the HERO framework to test the following study aims:

1) To determine if TBI survivors' residing in disadvantaged neighborhoods experienced lower levels of function as measured by FIM scores over time;

2) To determine if the presence of depression in TBI survivors explained the relationship between neighborhood disadvantage and FIM scores over time; and,

3) To determine if race has a moderating effect on the relationship between neighborhood disadvantage and depression (path A of the mediation model).

The findings indicated no significant main effects of neighborhood disadvantage on FIM scores and no indirect effects of neighborhood disadvantage on the intercept and slope of FIM scores via depression with no moderating effects of race found in path A (neighborhood disadvantage to depression). The results of this study did not support the original hypotheses and presented inconsistent findings compared to a similar study (Corrigan & Bogner, 2012).

The Mediating Role of Depression on Neighborhood Disadvantage and Rehabilitation Outcomes

Neighborhood disadvantage did not predict change in FIM scores over time, with lower FIM scores observed relative to greater neighborhood disadvantage. These findings were inconsistent with similar studies that have examined other health outcomes. For example, in a study conducted by Corrigan et. al., (2012), neighborhood characteristics did not predict psychosocial outcomes beyond that of individual characteristics such as demographics and injury characteristics to name a few. However, in a previous study conducted by Corrigan and Bogner

(2008), neighborhood measures indeed predicted satisfaction with life, as well as predicted a significant amount of the variance in the Glasgow Outcome Scale-Extended scores. There has also been support of similar neighborhood disadvantage measures predicting other health-related outcomes in different populations such as stroke (Brown et al., 2011) and cancer survivors (Reitzel et al., 2012; Xiao et al., 2018). The findings in this study join a body of neighborhood literature that has not always consistently found neighborhood as a predictor particularly as it pertains to rehabilitation outcomes

One rationale for neighborhood disadvantage not being predictive in the model applied in this investigation may be a lack of sensitivity and specificity to detect differences that were hypothesized. The measure of neighborhood disadvantage in the literature has evolved over the years; however, it remains a primary measure of socioeconomic disadvantage. Socioeconomic disadvantage influences the availability of local resources, but it is not the only factor. Creating a more expansive and comprehensive measure of neighborhood may allow for increased sensitivity and be a more proximal indicator of neighborhood environment. For example, Geographic Information Systems (GIS) leverages a variety of data regarding spatial patterns, specific data about people (i.e. education, income, etc.), and even location to better examine access and availability of resources within a given environment and to better understand relationships and patterns that exist within an area. Future research efforts could leverage GIS platforms to model more sophisticated research questions and provide a more granular database of neighborhood variables that influence rehabilitation outcomes.

Neighborhood disadvantage not predicting change in FIM scores was also due to the stable nature of the sample. Univariate analysis of FIM scores revealed no significant change in the mean across the three-time points with participants averaging a FIM score of 31 overtime.

The stable mean indicates overall stability in participants functioning and skills. One rationale for a minimum change in scores could be due to the lack of sensitivity of the FIM instrument.

For the second hypothesis, there was no support found for depression mediating the relationship would mediate the relationship between neighborhood disadvantage and change in FIM scores over time, in that higher levels of neighborhood disadvantage did not result in higher levels of severity in depression and higher levels of severity in depression did not reduce FIM scores over time. The literature review revealed a high prevalence of depression in TBI populations with about half the population being impacted by depression within the first year of recovery and more than half the population will experience anxiety (Albrecht et al., 2018b; Lavoie et al., 2017). Though we found support within the literature for including depression in the model no mediating effect was present. There is a unique aspect in the TBI population that may explain the lack of effects within this model. Widely known and observed consequences of TBI include reduced awareness and insight. Depending upon the severity of the injury, these cognitive impairments may play a role in how a TBI survivor experiences and report depressive symptoms. Perhaps pairing the PHQ-9 measure with a measure of depression based on caregiver report may provide some additional insight.

Additionally, age may be another consideration to explore in this sample when trying to further interpret and explain study findings. In this sample, participants ranged in age from 16-89 years of age and older. This is a significant point to consider when assessing measures such as depression and examining recovery and tracking rehabilitation outcomes after a brain injury. Studies have found that features such as the risk factors (Schaakxs et al., 2017), screening measures, and trajectory of symptoms (Sutin et al., 2013) in a typically developing and non-injured population may look different across the lifespan and these findings may be similar in a

TBI population. Studies have also revealed that in a TBI population, age at the time of injury can certainly factor into recovery time from injury as well as one's response to treatment (Marquez de la Plata et al., 2008). One potential future direction to dismantle the impact of age factor in the developmental life course could be to refine study methods with stratified age groups that account for development (i.e adolescent group versus, young adult group, etc). In addition, the use of depression measures that are more sensitive to human developmental periods could be considered.

The Moderating Role of Race

Race did not have a moderating role in the relationship between neighborhood disadvantage and depression. A preliminary review of the literature indicated that there are significant racial differences in access to mental health services as well as differences in the prevalence of mental health disorders (Lo et al., 2014; Smith & Trimble, 2016). Though rates of anxiety and depression are increasing for all racial groups, African Americans have experienced the highest average percent change in recent times (Mental Health America, 2021). Mental health disparities have been documented in the literature with studies identifying underutilization of mental health services across racial groups as one of the most significant and most persistent disparities (Lo et al., 2014; Smith & Trimble, 2016).

Though we found practical and theoretical evidence to support examining race as a potential moderator our findings did not support our original hypothesis. Though the sample consisted of only 3.3% characterized as minimally depressed and only roughly 1 to <1% of the sample characterized as mildly to severely depressed, one rationale could be the overall low response rate for the depression measure used in the study sample contributed to no effect present in the data. Another rationale that may account for the findings in this investigation is

that the process used to validate the depression scale used may not have accounted for race and culture differences in the population studied. Instruments used in research have often been validated on populations that tended to be homogeneous regarding race, culture, and geographical location. Further, the level of detail regarding the validation study population's race and ethnicity is often not described. The PHQ-9 was originally validated on a clinical population and has since been validated in other diverse populations all over the world (AlHadi et al., 2017; Arrieta et al., 2017). However, the generalization of any study instrument that was validated on a homogeneous population may not yield reliable results for underrepresented groups. The cultural sensitivity of the PHQ-9 measure should be examined to determine if it may have impacted findings. Choice of depression scales used in human participant databases should factor in aspects of race, ethnicity, and culture.

Strengths and Limitations

The first strength to be noted is the utilization of a large dataset with a sample derived from a region of the U.S. that is well known for healthcare disparities. The Traumatic Brain Injury Model Systems dataset consists of 16 different collection sites. The inclusion of only one collection site located in Alabama was an intentional decision. Alabama is geographically located in the southeast as is a part of the stroke belt with a high population of individuals that are more likely to need rehabilitation services.

Additionally, this study employed robust design and latent growth modeling to predict change in FIM scores over time. A latent growth model provided the opportunity to change over time, while simultaneously testing for moderate mediation thus provided the opportunity to model several research questions in one analysis. Finally, informed by the HERO model, this study applied the novel constructs of mental health and neighborhood attributes as predictors of

rehabilitation outcomes. For decades western medicine has lagged in the ability to put into practice the mind-body connection when designing assessment tools and treatment protocols. The HERO model provided an intentional, integrated construct from which to establish these connections to offer clinicians and practitioners additional insight and awareness regarding a patient's context and how it interacts to drive outcomes long-term.

Study limitations are acknowledged. First, this study cannot be generalized to individuals who have sustained a mild TBI (mTBI) as this group was excluded from participation. As a part of the inclusion criteria from the Traumatic Brain Injury Model Systems data collection criteria, only participants with moderate to severe injuries met the criteria for participation in the original study. Second, the generalizability of findings should also be made with care given that the database used for this investigation included participants from one TBIMS collection site. Geographically speaking, sample data was used from only one collection site. Replicating this study using a multicenter approach could increase the external validity of the findings; however, the case could be made that the selection of a single site from a state that is well understood to have healthcare disparities may have biased the outcomes toward significant findings.

Third, neighborhood disadvantage as an objective construct applied in this investigation does not account for other equally salient features and characteristics of a neighborhood, as the model assumed that all residents within the neighborhood are exposed to key neighborhood features equally. The use of neighborhood measures is not a one-size-fits-all approach and the design of the measure must be thoughtful in attempting to capture one's true environment. How neighborhood was modeled in this study is, however, a much-improved approach than reliance on zip codes or simple urban versus rural distinctions. In future research efforts, other measures

of the neighborhood could be explored such as the activities-space approach (Gollegde & Stimson, 1997).

In the effort to hone in the research questions on the SLP-related indicators for cognition, the abbreviated use of a subset of five individual FIM scores instead of total FIM scores may have also impacted overall findings. A future study could seek to use total FIM measure scores as an outcome to compare findings; however, there would be risk of losing occupation-specific fidelity. Finally, this study was conducted using pre-existing data thus, research questions and measures were constrained by the dataset. Future studies may look to design a dataset to gain control over selected measures.

Future Directions

Future studies should certainly seek to replicate this study using an expanded dataset to cover samples from a variety of TBIMS collection sites across the county. Division of the dataset into developmentally supported age groups would also be an important future consideration to discern if measures of depression and neighborhood characteristics impact individuals differently at different stages of life. Additionally, future studies should continue to discern neighborhood context factors and continue to refine the measure by incorporating geographic information systems (GIS) to better help us map the locations of resources (i.e. grocery stores, hospitals, etc.), map densities, and better determine the characteristics of a specific area. Using a socioeconomic measure alone to define ones' neighborhood experience is limiting. To better target and understand individual lived experiences within a neighborhood, the use of mixed-methods pairing a similar quantitative study with a qualitative study can better elucidate the day-to-day experiences, one's experiences with resource accessibility, and allow for researchers to

examine additional interactions within the ecological model such as family and community relationships.

In addition, future studies should seek to test additional levels within the HERO model and examine new interactions amongst the levels in the hierarchy. For example, how might one's cultural background interact with neighborhood environment and mental health status to predict rehabilitation outcomes? Identifying the socioecological layers that influence recovery and rehabilitation from TBIs will further advance our ability to achieve optimal healthcare outcomes.

Conclusion

Previous research has confirmed links between individual contextual factors predicting long-term rehabilitation outcomes. The clinical implications for better understanding underlying mechanisms that impact patient rehabilitation outcomes over time are vital for the achievement of optimal rehabilitation outcomes for all patients. This study provided an initial application of the HERO model and attempted to fill in gaps in our clinical understanding of novel considerations for predicting long-term outcomes. Though the results were inconsistent with the current literature with no mediating or moderating effect present, the study elucidated future methodological considerations for how key measures are operationalized. In addition, this study modeled how future research questions and designs that seek to explain rehabilitation outcomes could explore various interactions of specific individual contextual factors to better reflect unique human experiences and factors above and beyond injury type, medical profiles, and treatment modalities. Continued examination of neighborhood context as a predictive factor will be an important next step in fully understanding patient outcomes.

IV. General Discussion

In America, 5.3 million men, women, and children are living with the often devastating and permanent long-term TBI-related disabilities (CDC, 2019). TBIs require not only immediate medical attention but thousands of dollars in resources for long-term and intermittent rehabilitation to address deficits related to physical and cognitive impairments. This dissertation developed a hierarchical, person-centered, theoretically supported framework to guide the exploration of individual contextual factors that may impact rehabilitation outcomes above and beyond premorbid status, injury type, and severity. Study 1 also provided a model against which to test lower-order needs of mental health (depression) and neighborhood effects and higher-order need for culture, religion, and social support, self-efficacy, and health locus of control. The proposed HERO model provides a more cohesive accounting of the gaps in our understanding and ability to explain the inequities in speech therapy outcomes for patients with TBI and what predictors may be at play.

The frameworks that are currently in place to predict outcomes are typically based on disease course and established medical models (Adams, 1971; Guenther & Vladusich, 2012; Tourville & Guenther, 2011). There is little known about the impact of demographic and social factors that may serve as facilitators or barriers for successful speech therapy outcomes. There are even fewer studies that have examined inequities and health disparities within speech therapy outcomes (Hur et al., 2018; Huwyler et al., 2021). The development of the HERO model provides a theoretically-supported hierarchy with novel constructs of mental health, neighborhood context variables, religion, and culture to create a more inclusive, thoughtful organizational structure against which clinical decision making, clinical outcomes determination, and empirical research may be vetted.

Study 1 of this dissertation developed a new fundamental theory known as the HERO model which provides a new framework for clinical and scientific research with an examination of unique personal and contextual factors that may explain rehabilitation outcomes. Informed by existing theories such as Bronfenbrenner's ecological model, this theory invites future research to test model validity by examining the relationships between the levels using both quantitative and qualitative longitudinal methods in a wide variety of populations (ie. TBI, stroke, MS, etc.) and generates clinically relevant tools such as screeners to provide a formal means of clinical theory application.

Study 2 addressed gaps in our understanding of neighborhood characteristics as a facilitator or barrier for rehabilitation outcomes through a novel analysis of the mediating role of depression on neighborhood disadvantage and FIM scores over time while exploring race as a moderator. The strength of the study design is directly informed by the HERO model by addressing level-specific features of mental health (depression) (Level 1), and neighborhood disadvantage (Level 2), by examining the relationships between these levels. Though there was no support found for the *a priori* hypotheses, this study illustrated the type of statistical modeling required to test the complex interactions of the specific variables that help form the HERO model.

The HERO model and the empirical study have key strengths and limitations. Collectively these projects provide a framework for how to introduce a newly adapted theory and test the validity of the theory. With every first iteration, there is always room for improvement. Future iterations of the HERO model may seek to change the model from a hierarchy to a nested model to better illustrate the integration and intersection of contextual factors. Future models may also seek to take a more developmental approach and acknowledge how the model may

evolve and change as we move from one developmental phase to another. For example, the needs of a young adult TBI patient is different than that of a person who is in late life and sustained a TBI. Entirely separate models could be constructed to only reflect key contextual factors reflective of that of one who is a young adult versus middle versus late-life developmental phase. Additionally, there may be sex or gender differences in development that may also be worth exploring in future model adaptations. Furthermore, the initial iteration of the HERO model and the application of the model to an empirical study was centered around a TBI population, however; there is an opportunity and an open invitation to invite this model to be adapted and applied to similar populations such as multiple sclerosis, spinal cord injury, and stroke across both pediatric and adult populations. This initial model is also an open invitation for other rehabilitation specialists and healthcare disciplines to apply this framework in an attempt to vet comprehensive, patient-centered care that seeks to design and implement holistic rehabilitation programs.

Study 2 provided a novel study of the influences of measures of depression and neighborhood on FIM scores moderated by race. Though there was no support found for the hypotheses, the actualization of this empirical study is important for several reasons: (1) it attempted to answer novel research questions to identify contextual factors that may explain variability within rehabilitation outcomes; and, (2) the study variables highlighted the inherent complexity of accounting for more than one contributing factor at a time and the relationship between factors when studying the TBI population within the U.S.

Using a secondary data set comes with limitations including the inability to preselect measures and misaligned project purpose and intent. In future projects that take advantage of using a primary data set, additional measures around depression could be explored such as a caregiver

measure for depression. Including a larger sample could not only serve to improve statistical power but provide an opportunity for a more racially and age-diverse sample. A new data set that included participants from across the adult life span can provide an opportunity to explore a 3-way interaction between neighborhood effects, age, and depression. Our current sample did not have enough clustering to support multilevel modeling however, a larger sample may also provide the opportunity to expand the statistical analyses and compare individual-level effects to neighborhood or group-level effects.

Additionally, future research could also focus on new research questions that target key demographics related to age. For example, TBI across the lifespan may have very different outcomes. Adolescent TBI survivors tend to have very different outcomes, prevalence, and injury types from survivors who sustained injuries in late life (Faul & Coronado, 2015). A similar study could pose the same research questions and examine the hypotheses across age groups. The HERO model could also be tested on caregivers who provide support to TBI survivors. In a report generated by AARP and the National Alliance for Caregiving (2020), 53 million Americans are providing unpaid care to an adult or child with special needs. Caregiving is a unique role that often requires caregiving tasks to be integrated into one's own needs, vocational responsibilities, and other family obligations. Initiating the role of a caregiver may or may not be anticipated and can prove to be challenging when balancing other life responsibilities. The role of a caregiver especially in the TBI population is a critical component in the recovery process as caregivers are trained on the use of adaptive equipment, strategies to increase patient independence, and they serve as a major supporting role in sustaining rehabilitation outcomes. The HERO model could be further adapted to include caregiver needs and or exlore the possibility of integrating the role of caregiver in the current model particularly

at level 3 (culture, religion, social support). There are unanswered questions regarding caregivers for TBI and future studies could help to unpack developmental differences and changes in developmental trajectories for caregivers of TBI survivors.

Conclusion

As an explanatory tool, the HERO model stands to be one of the first integrative and holistic models that accounts for individual mental health, environmental context, and personal contextual factors when explaining rehabilitation outcomes for SLP, designing research methodology, and developing public health policy. This model can serve as an initial framework from which to explore, plan, and execute interdisciplinary efforts to mitigate health disparities and realize optimal rehabilitation outcomes. Second, this model can inform and serve as a framework to create screening tools to identify risk and intervention points that jeopardize optimal rehabilitation outcomes. Lastly, this comprehensive model can provide pathways for discipline-specific and interdisciplinary lines of research spanning the disciplines of rehabilitation medicine, human development, and family science, psychology, sociology, public policy, urban planning, to name a few.

Additional research is required to test and validate the levels of the model to better understand the relationships that may exist across the model and the applicability to various populations. Second, like most theories, this model is bound and limited by the constructs included in the model however, perhaps there are additional constructs that may prove equally as valuable in explaining rehabilitation outcomes. Future research should continue to explore additional HERO model adaptations by expanding the scope and borrowing from additional social and human science fields. In addition, future work should seek to test model validity by examining the relationships between the levels using both quantitative and qualitative

longitudinal methods in a wide variety of populations (ie. TBI, stroke, MS, etc.) and generate clinically relevant tools such as screeners to provide a formal means of clinical theory application.

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