

DESCRIPTION OF THE MODERATE BRAIN INJURED PATIENT AND
PREDICTORS OF DISCHARGE TO REHABILITATION

by

Sandra Rogers
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Committee:

Kathy Richards

Dr. Kathy C. Richards, Chair

Michele R. Davidson

Dr. Michele Davidson, 1st Reader

Ali Weinstein

Dr. Ali A. Weinstein, 2nd Reader

Kathy Richards

Dr. Kathy C. Richards, Assistant
Dean, Doctoral Division and
Research Development

Thomas R. Prohaska

Dr. Thomas R. Prohaska, Dean,
College of Health and Human
Services

Date: 3/31/14

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Fairfax, VA

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A Dissertation submitted in partial fulfillment of the requirements for the degree of
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by

Sandra Rogers
Bachelor of Science
Eastern Kentucky University, 1993

Chair: Kathy Richards, Professor
School of Nursing

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DEDICATION

This work is dedicated to Maggie for her love and support; to Jake, for his courage and strength; and to my Mother, who would have made the sky her limit if given half the support and opportunities that she gave to me.

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LIST OF ABBREVIATIONS

Abbreviated Injury Scale	AIS
American College of Surgeons	ACS
American Hospital Association	AHA
Centers for Disease Control	CDC
Comma Separated Values	CSV
Committee on Trauma	COT
Computed Tomography	CT
Confidence Interval.....	CI
Cumulative Index to Nursing and Allied Health Literature.....	CINAHL
Emergency Department	ED
George Mason University	GMU
Glasgow Coma Scale	GCS
Glasgow Outcome Scale	GOS
Health Information Portability and Accountability Act.....	HIPPA
Health Maintenance Organization	HMO
Injury Severity Score	ISS
International Classification of Disease 9 th Revision Clinical Modification	ICD-9-CM
Length of Stay	LOS
Mechanism of Injury.....	MOI
Motor Vehicle Collision or Crash.....	MVC
National Sample Project	NSP
National Trauma Data Bank	NTDB
Not Applicable	NA
Not Known/Not Recorded	NK/NR
Office of Research Integrity and Assurance	ORIA
Pilot Question.....	PQ
Principal Investigator	PI
Relative Risk.....	RR
Research Question	RQ
Skilled Nursing Facility	SNF
Traumatic Brain Injury	TBI

ABSTRACT

DESCRIPTION OF THE MODERATE BRAIN INJURED PATIENT AND PREDICTORS OF DISCHARGE TO REHABILITATION

Sandra Rogers, PhD

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Dissertation Director: Dr. Kathy Richards

This retrospective, descriptive study characterized moderate traumatic brain injured patients between the ages of 18 to 64 years that were treated at level I and level II trauma centers within the United States and the predictors of discharge to rehabilitation after acute care using data reported in the National Trauma Data Bank (NTDB[®]). A literature review described the issues related to traumatic brain injury, examined conflicting results related to post-acute care discharge, and supported the need for further study of the moderate traumatic brain injured patient. The 2010 National Sample Project (NSP), part of the NTDB[®], provided access to cross-sectional data with which to describe the moderate TBI patient and to explore the demographic, clinical, and financial predictors of discharge to rehabilitation within a sample of TBI patients. Multivariate logistic regression models revealed that demographic (age and region), clinical (injury severity score, Glasgow Coma score, and Abbreviated Injury score of the head), and

financial (primary payment source and length of stay) characteristics influenced the likelihood of being discharged to rehabilitation. Increased age, increased severity, Medicare, longer length of stay (LOS), and trauma center locations in the Midwest and Northeast all increased likelihood of discharge to rehabilitation. Being younger, receiving acute treatment in the South, and self-pay all showed decreased likelihood of discharge to rehabilitation. The decision to discharge a person with a moderate TBI from acute care to rehabilitation appears to be based on factors other than just clinical need. More equitable access to post-acute rehabilitation services for moderate TBI patients is needed because of the risk for long-term disabilities and the potential to return to productive lives with treatment.

CHAPTER ONE: INTRODUCTION

Background of the Study

Traumatic brain injury (TBI) is a leading cause of death and disability in the United States, and is a contributing factor in approximately one-third of all injury-related deaths (Faul, Xu, Wald, & Coronado, 2010). It is estimated that a TBI occurs every 21 seconds in this country alone (Hyder, Wunderlich, Puvanachandra, Gururaj, & Kobusingye, 2007). The Centers for Disease Control and Prevention (CDC) reported in 2006 that at least 1.7 million Americans sustain a TBI each year with 275,000 of them severe enough to require hospitalization (Faul et al., 2010). The annual incidence of TBI in the United States is estimated to be 103 per 100,000 populations; however, the true incidence of TBI remains underestimated because a number of patients with mild symptoms at the time of injury are often not hospitalized (Mosenthal et al., 2004). Nonetheless, hospitalizations related to TBI have continued to rise, with an increase of 19.5% from 2002 to 2006 (Cuthbert et al., 2011).

Emergency medical care improvements, technological advances, and early intervention following a TBI have resulted in greater survival rates, but have also resulted in a large population of survivors with life-long disabilities (Jacobsson, Westerberg, & Lexell, 2010). Long-term disabling effects include various cognitive, psychosocial, behavioral, and /or physical problems (van Baalen, Odding, & Stam, 2008). It is

estimated that 80,000 to 90,000 TBI patients each year will experience permanent disability as a result of their injury. To date, approximately 5.3 million Americans are currently living with a TBI-related disability (Faul et al., 2010).

Since survivors of TBI tend to be young, there is a high lifelong cost of disability that may also affect the family. This includes not only physical challenges, but also financial barriers, and psychosocial factors (Colantonio et al., 2004). These factors make it critical to lessen acute and long-term costs associated with TBIs and the devastating impact it has on the patient, their family, and society.

TBIs account for more years of lost productivity than any other injury (Bergman, Maltz, & Fletcher, 2010). The total lifetime costs of fatal, hospitalized, and non-hospitalized TBI cases that were medically treated in the year 2000 were estimated to be \$60.4 billion, including productivity losses of \$51.2 billion (Corrigan, Selassie, & Orman, 2010). Since these figures do not always include lost earnings, costs to social services systems, and the value of the time and foregone earnings of family members who provide care for persons with TBI, they may grossly underestimate the true, long-term economic and physical burden TBI places on survivors, their families, and society (Johnstone, Mount, & Schopp, 2003; Shigaki, Johnstone, & Schopp, 2009).

There is a complex array of long-term consequences that may persist after TBI that affect all areas of the patient's life. It has been estimated that 43.1% of persons discharged with a TBI from acute hospitalizations develop TBI-related long-term disability (Corrigan et al., 2010). The term disability can be broadly defined but can include the inability or substantial difficulty performing activities of daily living; having

post-injury symptoms that prevents the person from doing things they want to do; or poor cognitive and mental health scores on standard measures (Corrigan et al., 2010). All areas of life can be affected by a TBI, however, functional limitations or psychosocial morbidity are more prevalent and represent the most significant consequences of TBI. A study by Dikmen, Machamer, Powell, & Temkin (2003) observed TBI patients 3 to 5 years post-injury and reported that 30% were unable to return to work or attend school. The problems reported in this study such as lack of independence in self-care, decreased community integration, reduction or inability to pursue employment, and family burden have far reaching economic and social consequences (Dikmen, Machamer, Powell, & Temkin, 2003).

A retrospective look at patients in a rehabilitation unit suggests that patients who progress to rehabilitation earlier do better functionally (Kunik, Flowers, & Kazanjian, 2006). Prompt, coordinated, and expert multidisciplinary response is required in TBI to improve both survival rates and disability outcomes (Connelly, Chell, Tennant, Rigby, & Airey, 2006). While some investigators have suggested that discharge destination from acute care to rehabilitation is mostly related to indicators of premorbid functioning, overall injury severity and recovery; other studies have indicated possible disparities with discharge destination related to demographic, biologic, and socioeconomic factors (Chan et al., 2001; Chen et al., 2012; Cuthbert et al., 2011; de Guise, LeBlanc, Feyz, & Lamoureux, 2006; de la Plata et al., 2007; van Baalen et al., 2008). For this population there is a general consensus that the goal of rehabilitation after TBI involves the resumption of effective functioning in the home and social environment, even though it

may not be possible to eliminate specific neurological, cognitive, or functional impairments necessary for all patients to return to their pre-TBI level of functioning (Cicerone, 2004).

The level of functioning after a TBI is often discussed in regards to the severity of the brain injury. Severity of the TBI can be labeled as mild, moderate, or severe. The mild, moderate, and severe categories of brain injury are based on the acute injury characteristics that suggest the extent of damage to the brain. A gap in the literature relates specifically to patients with moderate TBIs. This gap has resulted in a poor understanding of the high risk for long-term deficits in this group. There is little to no information on the best plan of care for the moderate brain injured patient after an acute hospitalization even though we know as many as 49% of the moderate TBI patients go on to experience long-term symptomology (Vitaz, Jenks, Raque, & Shields, 2003). Patients with moderate brain injuries pose a case management challenge because they represent a diverse population of patients with significant variability in terms of trauma severity, hospital course, and neurological recovery. The majority of clinicians recommend ongoing rehabilitation for the moderate brain injured patient identifying that this pathway is likely to reduce these risks (Cicerone, 2004).

Study Purpose and Research Questions

Patients with moderate TBI are grossly understudied, and there are no specific guidelines for their care or discharge. Although both mild and severe TBI patients have best practice guidelines, patients with moderate TBI are diverse and clinically different from either mild or severe TBI patients (Bergman et al., 2010). It is important to better

characterize moderate TBI patients, and determine predictors of their discharge status so that specific best practice guidelines can be developed in the future. This research may result in improved quality of care and better long-term health outcomes for patients with moderate TBI in the future. Therefore, the purpose of this dissertation research is to better characterize the moderate brain injured patient treated at level I and level II trauma centers and determine predictors of their discharge from acute care hospitalization to rehabilitation.

To fulfill this purpose, data from the 2010 National Sample Project (NSP), which is managed by the American College of Surgeons (ACS), was used. The National Sample Project contains a nationally representative sample of trauma hospitals and a wide variety of diagnostic and clinical indicators complementary to the National Trauma Data Bank (NTDB[®]). The NTDB[®] is the largest trauma registry in the U.S. and is also maintained by the ACS (ACS, 2007). Using this clinical and organizational data the following research questions (RQ) were asked:

RQ1: What are the demographic, clinical, and financial characteristics of the moderate brain injured patient treated at level I and level II trauma centers?

RQ2: What are the predictors of acute care discharge disposition to rehabilitation for patients with moderate traumatic brain injury?

Definitions of Key Variables

Traumatic Brain Injury. TBI is defined as an alteration in brain function, or other evidence of brain pathology, caused by an external force (Menon, Schwab, Wright, & Maas, 2010). Injuries associated with the brain are more likely to result in death or

disability than any other injury (Hyder et al., 2007). TBIs remain a significant public health problem and it is estimated that they will surpass many diseases as the major cause of death and disability by the year 2020 (Hyder et al., 2007). The TBI can be classified as penetrating or non-penetrating (or blunt). Penetrating brain injury is typically caused by a projectile, such as a bullet, which harms brain tissue that is directly in the path of the projectile. Blunt force TBI is typically associated with a motor vehicle crash, fall, or other blunt trauma and is characterized by widespread dysfunction of brain tissue (Greve & Zink, 2009).

Severity of the brain injury can range from mild to severe as determined by the Glasgow Coma Scale (GCS) along with a mechanism consistent with trauma to the head (Bergman et al., 2010). Moderate traumatic brain injury is classified as a GCS score of 9 to 12 with mechanism consistent with brain trauma. This group has not been well described in the prior literature and little is known about the outcome following this type of brain injury. Most patients regain consciousness; however, the full magnitude of long-term cognitive and functional deficits is unknown (Vitaz et al., 2003). The belief is that more attention, including rehabilitation, should be directed to patients with moderate head injury than to those with the most severe injuries, because the severely brain damaged are unable to participate in rehabilitation; the injury is probably irreversible; and all forms of management have demonstrated little success in the most severe TBI's (Rimel, Giordani, Barth, & Jane, 1982).

The moderate brain injury is positioned between the mild and severe injuries with the majority of mild TBI patients being treated and released home from emergency

departments while those with severe brain injuries are typically treated and then referred for rehabilitation or long term care. Individuals with moderate brain injury represent a heterogeneous population that does not have specific or consistent discharge recommendations. Not only is there a gap in management guidelines for the moderate brain injured patient, there is also a lack of understanding of the characteristics of this group and the nature of recovery (Vitaz et al., 2003).

Level of Care. The trauma care system is a network of definitive care facilities that provide a spectrum of care for all injured patients. In the United States, a hospital can receive Trauma Center verification by meeting specific criteria established by the American College of Surgeons (ACS) and passing a site review by the Verification Review Committee. The ACS Committee on Trauma (COT) verification program is not the only system that designates hospitals as trauma centers. Many states have their own accreditation system (ACS, 2007).

Trauma centers vary in their specific capabilities based on annual volume of patients, as well as the number of surgeons, emergency physicians, and anesthesiologists on duty at all times. The level of a trauma center is also determined by the center's geographical location and population density and are identified by "level" designation with level I being the highest, to level-V being the lowest) (ACS, 2007).

Level I trauma centers are typically university based teaching hospitals that provide the highest level of trauma care and in order to receive ACS or state verification they must have the capability of providing leadership and total care for every aspect of injury, from prevention through rehabilitation. Level I trauma centers must also maintain

a research program; be a referral source for nearby regions; and provide leadership in education, research, and system planning (ACS, 2007).

Level II trauma centers can be academic, public, or private community facilities located in urban, suburban, or rural areas that are expected to provide initial definitive care for all patients, regardless of injury severity (Clancy, Gary Maxwell, Covington, Brinker, & Blackman, 2001). Supporting neurosurgical specialty coverage and consistent care of the brain injured patient is essential to be categorized as a level I or level II trauma center (ACS, 2007). Although the ACS COT for each state establishes different criteria for level I and II verification, researchers have found that the care delivered in level I and II centers is comparable (Clancy et al., 2001; Helling et al., 1997). It can be assumed that the care rendered in level I and II centers is comparable based on the resources available and outcomes provided at both levels.

Rehabilitation. Historically speaking, rehabilitation has its clinical origins largely in musculoskeletal issues of such conditions as arthritis, spinal cord injury, stroke, and polio. Based on this tradition, TBI rehabilitation needs have emphasized restoration of physical and medical disabilities and have overlooked the cognitive and neurobehavioral needs of the brain injured patient (Cope, Mayer, & Cervelli, 2005). Rehabilitation is often deemed appropriate based upon the patient's ability to participate at the level required by funding agencies. Conversely, in cases with very rapid recovery, the recommendation may be to bypass rehabilitation and discharge home with or without outpatient rehabilitation services (Malec, Mandrekar, Brown, & Moessner, 2009).

There are several levels of rehabilitation settings with acute rehabilitation being the more intense. The acute, or inpatient, rehabilitation setting provides at least three hours of therapy per day and can include physical, occupational, speech, and recreational therapy. Inpatient rehabilitation units typically have explicit admission criteria that are specific to each institution. Other levels of rehabilitation include transitional care or long-term acute care; general sub-acute care; long term care; home-based care; and day treatment programs.

Although the patient and family are central to such decisions, a large network of individuals including acute care medical providers, rehabilitation therapists, admission coordinators, payers, extended family, friends, and other patients and families, may influence these decisions. For referral to rehabilitation the patient needs an adequate cognition and physical condition to participate in therapy. However, well-accepted algorithms to determine “adequate cognition and physical condition” do not exist (van Baalen et al., 2008). A 2009 prospective study addressed the decision-making on determining whether a patient with TBI would benefit from rehabilitation services and found that rehabilitation was often deemed not appropriate if the patient was unable to participate at the level required by funding agencies (Malec et al., 2009).

Due to this reasoning a number of moderate and severe TBI patients are not candidates for admission to short-term comprehensive rehabilitation programs because of low-functioning and/or no funding. This often results in discharge to non-specialized extended care facilities or non-specialized peripheral health facilities, excluding them from further specialized rehabilitation services (Connelly et al., 2006; Gray & Burnham,

2000). However, many TBI survivors are capable of significant functional gains months or even years post-injury (Gray & Burnham, 2000). A myth exists that significant change does not occur after one year. This phenomenon is often referred to as the “plateau” and can lead to anxiety, depression, and loss of hope among patients, families, and clinicians. Though often less dramatic or noticeable, improvements in behavior, attention, speech and independence from others or devices can be argued equally meaningful and typically do occur after the first year post injury (Hammond et al., 2004).

Although these decisions have significant and wide-ranging consequences for patients, their families, and payers, factors affecting such decisions have not been systematically studied. Since many of the moderate TBI patient’s symptoms are not recognizable upon discharge from acute care, it is currently unknown where the majority of acute care centers discharge moderate brain injured patients. The need for specialized sub-acute, slow-stream, or long-term comprehensive rehabilitation settings is starting to be recognized and these changes could maximize the recovery of function, minimize disability, and reduce long-term costs of care over the remaining life of the moderate TBI survivor. The decision to discharge to rehabilitation appears to reflect sociobiologic and socioeconomic factors; therefore, identifying the factors that are connected with discharge destination may assist in improving resource planning at the facility level (Chen et al., 2012).

Predictors of Discharge Destination. For this study variables were selected that are associated with traumatic brain injury and discharge destination based on published research and availability in the 2010 NSP dataset. Predictors were grouped into three

categories: demographic, clinical, and financial. Demographic predictors included age, sex, race/ethnicity, and region of care. Clinical predictors included the brain injury severity (ISS, GCS, AIS head score), mechanism, and type of brain injury. And financial predictors included primary payment source; the number of days, or length of stay, in acute care; and whether it was a work-related injury.

It is important to understand how the characteristics of individuals with traumatic brain injury affect their trajectory across the health care system since TBI research has suggested that discharge destination decisions may be based on factors other than clinical criteria and that possible disparities may exist related to demographic and socioeconomic factors (Cuthbert et al., 2011).

Demographic Characteristics. TBI patients with moderate to severe brain injury tend to be young, white, and male. Members of minority racial/ethnic groups in the United States are at disproportionate risk of TBI but may also be at a disproportionate risk of not receiving rehabilitation (Hart, Whyte, Polansky, Kersey-Matusiak, & Fidler-Sheppard, 2005). Although research has shown that whites are more likely than their counterparts to be discharged to a sub-acute or rehabilitation facility in which continued medical treatment and follow-up will occur (Cuthbert et al., 2011). Hispanics and African Americans with moderate brain injury (GCS mean of 10) are less likely, when compared with non-Hispanic whites; to receive rehabilitation services post-TBI after accounting for injury severity and insurance status (de la Plata et al., 2007).

Studies have shown patient's age and sex to be factors associated with discharge to rehabilitation (Chan et al., 2001; Cuthbert et al., 2011; Mellick, Gerhart, & Whiteneck,

2003). In male patients, the incidence of TBI peaks between the ages of 15 and 24 and again above 75 years of age and while the incidence in female patients peaks in the same age groups, their absolute rates are lower (Mosenthal et al., 2004). Women are sent to care facilities more frequently than men. This could be related to the fact that women are generally the primary caregivers in the home environment and once they are no longer able to fill that role no family members are available, or willing, to transfer into the care giving role. Or, it could be related to the fact that women tend to outlive their partners and therefore elderly women TBI survivors are forced into care facilities because they are no longer competent to function in their home alone. Region of care has also been shown to be important based on the location of the trauma center (Midwest, Northeast, South, or West) and the allocation of resources from urban to rural areas and the site-specific care (Janus et al., 2013).

Clinical Characteristics. The clinical characteristics of a brain injury relate to how severe the injury is (injury severity) and how the injury occurred (mechanism of injury and injury type). The injury severity of a TBI expresses the intensity of acute disruption of brain physiology or anatomic damage as summarized in Table 1.

Table 1. Traumatic Brain Injury Severity Criteria (Department of Defense and Department of Veteran Affairs Traumatic Brain Injury Task Force, 2009)

Criteria	Mild	Moderate	Severe
Structural Imaging	Normal	Normal or abnormal	Normal or abnormal
Loss of Consciousness	< 30 minutes	30 minutes to 24 hours	>24 hours
Alteration of Consciousness/Mental State	A moment to 24 hours	>24 hours	>24 hours
Post-traumatic Amnesia	0-1 day	>1 and <7 days	>7 days
Glasgow Coma Scale	13-15	9-12	3-8

Ideally, severity is best assessed early in the course of acute care evaluations and classified by the Glasgow Coma Scale (GCS) and the Injury Severity Score (ISS), which solves the problem of summarizing injury severity, especially in patients with multiple trauma (Baker, O’Neill, Haddon, & Long, 1974). The Glasgow Coma Scale was developed to examine the level of clinical consciousness (Teasdale & Jennett, 1974). This standardized bedside tool to quantify consciousness has become a medical classic. In the past 30 years, many coma scales have been proposed as an alternative to the GCS, but none with success. By virtue of its simplicity, the scale has become the most universally used and validated consciousness scale worldwide with more than 4500 publications making reference to its use. The scale remains a key measure in

neurological assessment after head injury and in most studies classification of the severity of the trauma is still based on the admission GCS (Balestreri et al., 2004).

The GCS, which is a purely physiologic measure of injury severity, has become the most widely used measure of brain injury severity with moderate TBI defined as a GCS of 9 to 12 regardless of CT scan findings (Foreman et al., 2007). Studies on brain injury generally stratify patients according to severity of the TBI, and not by the associated extracranial injuries (Foreman et al., 2007). The GCS scale is an objective scale that has three elements including eyes, verbal, and motor. Each element has a range of value: eyes (1-4), verbal (1-5), and motor (1-6). The GCS is the summation of these elements and is generally separated into three classifications; severe (≤ 8), moderate (9-12), and minor (≥ 13) as detailed in Table 2.

Table 2. Glasgow Coma Scale (Teasdale and Jennett, 1974)

Feature	Scale	Score
	Responses	Notation
Eye opening	Spontaneous	4
	To speech	3
	To pain	2
	None	1
Verbal response	Orientated	5
	Confused conversation	4
	Words (inappropriate)	3
	Sounds (incomprehensible)	2
	None	1
Best motor response	Obey commands	6
	Localize pain	5
	Flexion – Normal	4
	- Abnormal	3
	Extend	2
	None	1
Total Coma Score		3-15

The GCS has established reliability with an intra-class correlation coefficient of 0.8 to 1.0 for trained users, Cronbach's alpha 0.69, and test-retest Spearman rho 0.85. Validity of the scale is established by its predictive value 0.56 (Pearson r) when used alone to predict 3-month survival, and when used with age and brainstem reflexes, the scale has a sensitivity of 79% to 97% with a specificity of 84% to 97% (Prasad, 1996). With the Glasgow Outcome Scale (GOS) as the gold standard for outcome, the GCS has

been shown to possess all the necessary clinimetric properties for head trauma patients if it is used by experienced or trained personnel (Stanczak et al., 1984).

The Injury Severity Score (ISS) is an established medical score to assess trauma severity (Baker et al., 1974). A major trauma, or poly-trauma, is defined as having an ISS greater than 15 (Copes et al., 1988). The ISS measures anatomic and structural damage and is based and calculated from the Abbreviated Injury Score (AIS) that measures the injury type and severity of different body systems (Dikmen et al., 2003). The AIS ranks injuries on a scale of 1 to 6, with 1 being minor, 5 as critical and 6 being a non-survivable injury as described in Table 3.

Table 3. Abbreviated Injury Scale Severity (Linn, 1995)

AIS Code	Injury
AIS 1	Minor
AIS 2	Moderate
AIS 3	Serious but not life threatening
AIS 4	Severe, life threatening, survival probable
AIS 5	Critical, survival uncertain
AIS 6	Virtually unsurvivable

The AIS divides the body into nine regions as outlined in Table 4. To calculate the ISS, each of the three most severely injured AIS body regions is then taken and squared.

Table 4. Abbreviated Injury Scale Body Regions (Linn, 1995)

AIS Code	Region
AIS 1	Head
AIS 2	Face
AIS 3	Neck
AIS 4	Thorax
AIS 5	Abdomen
AIS 6	Spine
AIS 7	Upper Extremity
AIS 8	Lower Extremity
AIS 9	External and other

The three squared numbers are then added together. The score will range from 1 to 75 ($ISS = A^2 + B^2 + C^2$). A higher ISS score is associated with more severe injuries and multiple body regions (Baker et al., 1974). If any component of the score is 6 (with mild being 1-2; moderate 3; and severe 4-6), then the value of the ISS is set to the max of 75 (Kim, 2012).

In the TBI literature the injury mechanism, also known as mechanism of injury, typically relates to a motor vehicle crash (MVC), fall, and/or an assault. Whereas the trauma type, such as blunt or penetrating, relates to the circumstances for which an injury occurs. Penetrating injuries can be caused by firearms or other projectile mechanisms, while the majority of blunt injuries are related to MVC's. Studies have shown mechanism of injury to be a significant predictor of discharge to inpatient rehabilitation among TBI patients in that the availability of private insurance, such as automobile insurance, can cover the costs of rehabilitation or home care and might influence discharge destination outcome (Chen et al., 2012).

Financial Characteristics. Source of payment and length of stay in acute care have been viewed as financial characteristics in prior research of TBI patients (Cuthbert et al., 2011; Esselman, Dikmen, Bell, & Temkin, 2004). The source of payment can be described as having availability of payment for health care services and can include Medicaid, Self-Pay, Private or Commercial Insurance, No Fault Automobile; Medicare; or Workers Compensation. Adult trauma studies have described differences in outcomes and discharge dispositions based on insurance coverage and suggested that disparities in rehabilitation placement based on coverage exist (Chan et al., 2001; Haider, Chang, Efron, Haut, & Crandall, 2008). Sources of payment, or economic incentives and insurance status, have been found to be significant determinants of discharge disposition (de la Plata et al., 2007). It may be that insurance status is a surrogate for other factors that affect mortality in a critically injured patient such as health education, awareness and management of co-morbidities, substance abuse, and risk-taking behaviors or in brief,

that insurance status could represent more than just the ability to pay a bill (Haider et al., 2008). If discharge disposition is in part determined by insurance status, it could threaten the quality of patient care (Chan et al., 2001).

Researchers have also suggested that length of stay (LOS) in an acute care setting provides an indirect measure of costs and the amount of treatment received and that LOS may be an indirect measure of injury severity (Chen et al., 2012; McGarry et al., 2002). In the study by Chen et al., (2012), there was a linear relationship with increasing length of stay in the odds of being discharged to inpatient rehabilitation. The Chen et al. (2012) study corroborated with findings from previously published studies that found that patients with longer lengths of stay are significantly more likely to be discharged to inpatient rehabilitation or non-home settings. Research of moderate to severe brain injured patients revealed that LOS plays a role either as a proxy for injury severity (reflecting severity effects that are not well explained by GCS), and/or as an indicator of the seriousness of other co morbidities and/or concurrent injuries, whether injuries associated with the same etiology of the TBI, such as fractures, or preexisting disorders (Cuthbert et al., 2011). There are also extended hospital stays as brain injured patients wait for beds in other facilities, often referred to as wait days. Head injured patients alone account for 80% of the reported wait days (Andersen, Sharkey, Schwartz, & McLellan, 1992).

Occupation or employment status in prior TBI research has focused on patients' ability to return to work after injury. Research on moderate brain injured patients has described upwards of 65 to 75% working full-time prior to their injury with as many as

30 to 40% losing or not returning to work when no rehabilitation was received post-injury (Mellick et al., 2003; Vitaz et al., 2003). No studies were found that focused on work-related injuries as a predictor of discharge destination in the moderate TBI population. Employment could be viewed as a proxy for payment source (private insurance or workman's compensation), which could potentially increase the likelihood of discharge to rehabilitation or it could be viewed as a proxy for education that could then be related to the pre-morbid health status. Patients with more years of education may be more likely to see the benefit of exercise and better nutrition, to be more compliant with medication and medical treatment, have a supportive family network present in the acute care setting, and be more active in their post-acute care options (Cullen, Park, & Bayley, 2008). These factors would contribute to an overall better pre-morbid physical and emotional health status that would also affect functional outcome post-trauma (de Guise et al., 2006).

Study Significance

Rehabilitation programs could return many TBI patients back to productive lives in their communities, including the moderate brain injured patient population. The problems experienced by those suffering moderate TBI are not always physically visible, such as impairments in memory or cognition and are often overlooked by acute care disposition planners. These factors could contribute to TBI being labeled the "silent epidemic" (Hyder et al., 2007).

Moderate and severe TBI cases are often grouped together in both descriptions of this population and research in this area; however, moderate TBI patients can present

with very different clinical appearances in the acute care setting and have different rehabilitation needs and prognosis potential than severe TBI survivors. It is possible that patients with moderate brain injuries may be overlooked for rehabilitation because the majority do not have changes in their roles in life (i.e., employee or spouse) causing them to appear relatively unaffected similar to the mild brain injury group; yet their identity may be affected with changes in cognitive and functional deficits (i.e., memory or concentration problems) at a level more comparable to the more severe brain injured patients. Research has shown that moderate brain injured patients do suffer from cognitive and functional deficits but the full magnitude of the long-term deficits is unknown (Vitaz et al., 2003; Wortzel & Arciniegas, 2012).

The findings of this study will: 1) provide evidence to better enable case planning and management strategies for the moderate brain injured patient, 2) since discharge destination after acute care is a major issue for patients and their relatives (Chen et al., 2012), these findings will assist patients and their families to form their expectations of their hospitalization and the possible outcomes of their hospital stay, and 3) identify whether gaps exist in the delivery of care and disposition to rehabilitation in this unique group.

This information could be vital in not only describing and recognizing the moderate brain injured patient but also beneficial in assisting healthcare providers in optimizing outcomes in moderate TBI patients. It will also enable healthcare providers to recognize disparities in this patient population so that treatment decisions can be based on medical need and not financial or demographic characteristics.

Summary

In conclusion, a comprehensive description of the main variables has been provided. These demographic, clinical, and financial variables were chosen related to their significance in prior research of brain injured patients and predictors of discharge to rehabilitation. A better understanding of these variables and their relationships could ensure continuity of care after acute hospitalization for the moderate brain injured patient and could help answer many of the questions patients and family members have regarding what to expect in the following weeks after acute care. The findings of this study could also provide useful information for clinicians and interdisciplinary teams involved in the evaluation and rehabilitation of patients with moderate TBI in acute care.

CHAPTER TWO: REVIEW OF THE LITERATURE

The purpose of this review of the literature was to identify what has already been determined by previous research on the moderate traumatic brain injured patient and the predictors of discharge from acute care to rehabilitation services. The predictors included the demographic characteristics of age, sex, race/ethnicity, and region of care; the clinical characteristics of injury severity, based on ISS, GCS, and AIS of the head, injury mechanism, and trauma type; and finally, financial characteristics that included primary payment source, length of acute care stay, and work-related injuries with the outcome of rehabilitation or not.

Key terms used to find relevant literature for this study included: traumatic brain injury, moderate brain injury, brain trauma, brain injury, head injury, rehabilitation and combinations of these terms with the demographic, clinical, and financial characteristic variables listed prior. Search strategies to find published articles involved computerized database searches spanning 25-years using the Cumulative Index to Nursing and Allied Health Literature (CINAHL) Plus with Full Text, Medline, ProQuest Research Library, and Google Scholar. Individual publisher databases were also explored including ProQuest Digital Dissertations. Multiple databases were combined during searches of key terms when possible and duplicate articles removed. A second strategy was footnote chasing which involved examining references cited in previous studies. The highest

yielding terms were brain injury (34,097), traumatic brain injury (18,700), and rehabilitation of brain injury (7,001). When brain injury was further defined as moderate, the number of articles dropped to 737. The lowest number of results returned using the combination of databases was financial characteristics of brain injury that resulted in a total of 9 articles. The inclusion criteria for an article to be incorporated in this literature review were based on its relevance to the study concepts. If the title of the article and abstract were irrelevant to the study, the article was excluded and the next one was screened. After screening titles and abstracts, a total of 77 papers were retained for in-depth evaluation because they related directly to the study variables and concepts as defined prior for this proposal. In the end, 3 articles were directly related to moderate TBI; 12 articles related to discharge disposition of the brain injured patient; and three articles used the NTDB® as their data source in brain injury and trauma research. No study was found that incorporated all of the variables in this study to predict discharge destination in the moderate traumatic brain injured patient population. The literature was systematically reviewed and organized by the following four major topics: moderate brain injury and rehabilitation; demographic characteristics and rehabilitation; clinical characteristics and rehabilitation; and finally, financial characteristics and rehabilitation.

Analysis and Synthesis of the Literature

Moderate Brain Injury and Rehabilitation. Moderate traumatic brain injury has been defined as an external force to the head that results in a loss of consciousness of 30 minutes up to 24 hours; or a period of post-traumatic amnesia greater than 24 hours; resulting in a Glasgow Coma Scale score of 9 to 12 (Bergman et al., 2010). Although

guidelines and standards exist for the management and disposition of the mild and severe traumatic brain injured patient, there are currently no guidelines available for the management of moderate TBI in the United States (Bergman et al., 2010). Moderate TBI patients are typically not considered a critical care type of patient, meaning that they do not always require mechanical ventilation or intracranial pressure monitoring but they also do not fit into the mild TBI guidelines that allow discharge home with supervision or outpatient follow-up (Vitaz et al., 2003). In addition, the moderate TBI patient does not match the description of severe TBI patients that are often not functioning at high enough levels for rehabilitation and are commonly transferred at acute care discharge to skilled nursing facilities (Bergman et al., 2010; Hawley & Joseph, 2008). At a minimum, the moderate TBI patient requires hospitalization for neurologic assessments to ensure that they do not have a decline in neurological status. But again, without guidelines for the management of the moderate brain injured patient, the potential exists for vast variation in their acute care management as well as recommendations at discharge (Rimel et al., 1982).

Most moderate TBI patients will have returned to a normal neurological status with a Glasgow score of 15 at the time of discharge from acute care and most will be able to complete their basic physical needs including activities of daily living independently. This can be deceiving since many moderate TBI patients will still have or are at a potential risk for a variety of issues. The cognitive, emotional, and functional problems of moderate brain injured patients are extensive and long lasting (Vitaz et al., 2003). Post-injury issues associated with the heterogeneous moderate TBI population such as

processing speed, episodic memory, and executive function; make discharge referrals as well as the prediction of outcome after traumatic brain injury a challenge for all health professionals who work in this field (de Guise et al., 2006).

Factors that can influence the moderate brain injured patient's discharge to rehabilitation includes the need for the patient to have multidisciplinary rehabilitation goals in all realms of mobility, self-care, and cognition; which may not be the case with the moderate TBI patient. Moderate TBI patients with only cognitive deficits are sometimes refused rehabilitation funding because of the perceived lack of need for comprehensive services, including physical therapy. Thus, the reason for discharge home rather than to rehabilitation may be related to the type of deficit and services needed rather than to the cause of the injury (Esselman et al., 2004). Patients discharged home are significantly less limited than those discharged to rehabilitation; whereas patients discharged to nursing homes tend to be more cognitively impaired than those receiving rehabilitation services. This has been demonstrated in a cross-sectional study among TBI patients (N=111) where a significant ($p<0.05$) number of moderate TBI patients ($n=39$) or 76.9% were discharged home related to cognitive and physical limitations (van Baalen et al., 2008),

Few studies exist that have examined the moderate brain injured patient exclusively. A descriptive study of moderate TBI patients (N=40) treated at a level I trauma center in 2010 described half ($n=20$) of the patients being discharged home while the remaining moderate TBI patients ($n=20$) were discharged to other facilities with rehabilitation services ($n=20$) (Bergman et al., 2010). There was a correlation with GCS

and hospital discharge in this study, however, it was not statistically significant ($p = .087$) and the study suffered from a small sample size and a wide variation in the age range of the patients (2 – 97).

A 2003 prospective observational study evaluated the outcome of patients suffering moderate TBI ($N=79$) that were treated at a level I trauma center and revealed significant cognitive and functional problems in the majority of patients, however, only 61% of the patients had been discharged to a rehabilitation facility. Twenty eight percent of the patients were discharged home, 9% to nursing home, and 2% were transferred to another acute care facility. The Glasgow and injury severity scores were found to not be correlated with outcome at discharge (Vitaz et al., 2003). However the study involved only one facility and the design of this study relied on patient and family reporting and omitted any formal psychological testing. This can be unreliable in that patients tend to minimize or underreport their cognitive and emotional deficits in contrast to family members who tend to overstate them (Spatt, Zebenholzer, & Oder, 1997).

A 2008 prospective study looked at the association of functional status at discharge from hospital and discharge destination of moderate and severe TBI patients ($N=111$). It was found that of moderate TBI patients ($n=39$), 77% were discharged home while 62.5% of the severe TBI patients ($n=72$) were discharged to an institution (van Baalen et al., 2008). Patients with moderate TBI were shown to be 14 times more likely to be discharged home than those classified with a severe TBI. In the moderate TBI group, significantly fewer patients were discharged home with physical limitations ($p<0.001$), which would lead one to believe that the moderate brain injured patients with

physical limitations are more likely to be referred to rehabilitative services (van Baalen et al., 2008). This strengthens the belief that the needs of the moderate brain injured patient in regards to rehabilitation are often overlooked. But as with other studies of the moderate brain injured patient groups, this study suffered from a small sample size of moderates (n=39).

The short-term outcomes following moderate brain injury are quiet unpredictable. In terms of long-term outcomes the majority of the moderate TBI patients appear to make a good functional recovery, however, there continues to be a high incidence of subjective, cognitive, and mental complaints in this patient population that does not equate to normal function (Vitaz et al., 2003). Although experts in the field believe that comprehensive multidisciplinary post-acute rehabilitation is the best approach for addressing impairments from moderate to severe TBI, access to these services can be problematic. Using a conservative estimate that for every 1 patient 16 years and older with moderate to severe TBI who goes to rehabilitation, 3 go directly home, leading us to speculate that in the U.S. each year, as many as 60,000 late adolescents and adults with moderate to severe TBI may go home directly from an acute care hospital (Cuthbert et al., 2011). Therefore we continue to struggle with answering where the majority of moderate brain injured patients proceed after acute care and why.

Demographic Characteristics and Rehabilitation. Certain patient characteristics should be considered in creating more equitable access to healthcare services across the continuum of care such as demographic characteristics. It is important to understand how the characteristics of individuals with traumatic brain injury affect

their trajectory across the health care system as this will ensure a better understanding of the moderate brain injured patient with improved discharge planning. TBI research has suggested that discharge destination decisions may be based on factors other than clinical criteria.

Studies that have looked exclusively at the moderate brain injured patient (Bergman et al., 2010; Rimel et al., 1982; Vitaz et al., 2003) have described the average age to be between 34 and 39.5 years; with the majority of the patients being male (77%). Although the majority of moderate brain injured patients are white, evidence suggests that minorities are at disproportionate risk for TBIs with African Americans having a 35% higher incidence rate compared to non-Hispanic whites. Minorities account for nearly half of post-brain injury hospitalizations (de la Plata et al., 2007). There have been inconsistencies reported in findings of minorities' access to rehabilitation after acute care. Data from a 2007 retrospective study at a level I trauma center (N=476) looked at ethnic differences in rehabilitation placement after TBI and found neither race/ethnicity nor English language proficiency to have a direct influence on receipt of rehabilitation services ($p=.491$) (de la Plata et al., 2007). However, a 2006 retrospective study analyzed a national TBI database and reported that African Americans and Hispanics are less likely to receive rehabilitation services than Caucasians (Shafi et al., 2007). Both of these studies looked at a combination of moderate and severe TBI patients and not a subset of moderates alone.

A patient's age at the time of injury also has been found to influence placement after discharge from acute care. Advanced age increases the probability of placement in

a long-term care facility rather than receiving rehabilitative services (Mellick et al., 2003). The Mellick et al. (2003) study found that persons older than 65 years of age were more likely to be discharged to long-term care facilities or home. This retrospective study (N=1059) was a population-based sample of TBI patients after discharge from acute care. The age group of 65 years or older reported the poorest outcomes with only 17.2% of them receiving rehabilitation while 60% of the same group was discharged home. This study, however, was over-represented by mild TBI patients (76%) while only 8% of the sample was moderates.

Moderate to severe injuries in the older age group have been shown to correlate with higher rates of discharge to inpatient and outpatient rehabilitation when compared to young and middle aged groups matched on severity. In contrast to the Mellick et al., (2003) results, another multicenter prospective study (N=244) reported people over the age of 60 with mild TBI were statistically ($p=0.02$) more likely to be discharged to rehabilitation than younger persons (Mosenthal et al., 2002).

Gender differences in TBI discharge disposition have also been reported. Males consistently represent a higher incidence of TBI in studies with ratios ranging from 1.5:1 in the United States (Langlois, Rutland-Brown, & Wald, 2006). Making the incidence of TBI almost twice as high in male patients than in female patients and almost three times as high in men younger than 65 years of age compared to women (Farace & Alves, 2000). A metaanalysis by Farace & Alves (2000) revealed that worse overall outcomes are demonstrated in women after TBI that could have implications for TBI rehabilitation efforts. However, most studies in the Farace & Alves (2000) metaanalysis did not report

outcome data separately by sex. Other researchers have looked at the association of gender with discharge to rehabilitation (Chan et al., 2001; Chen et al., 2012). A 2012 retrospective cohort study examined a large TBI patient sample (N=5,550) where 34.1 % were female (n=1,887). This study found that 9.6% of the females (n=181) were discharged to rehabilitation as compared to 9.8% of the males, showing gender to not be significantly associated with discharge to rehabilitation compared to home. But they also found that females were significantly more likely to be discharged to “other” compared to home or rehabilitation when compared to males (Chan et al., 2001). The study concluded that females were often the primary caregiver at home and therefore was referred to “other” because no one was available to care for them; however a limitation of the Chan article was that data were collected and analyzed from only one hospital trauma registry.

Further investigation was warranted to determine whether discharge disparities are actually associated with worse outcomes for any one group and whether these disparities are related to demographics including age, sex, racial/ethnic, or regional differences in cultural norms, financial opportunities, or a combination of factors (Hart et al., 2005). To understand observed disparities would enable us to work toward preventing unfavorable outcomes for vulnerable groups, and to better determine how to allocate resources to those with unmet needs.

Clinical Characteristics and Rehabilitation. A review of TBI and discharge disposition would not be complete without a discussion on the association of clinical characteristics and rehabilitation. For the purposes of this study, clinical characteristics

included injury severity, injury mechanism, and type of trauma. One would believe that decisions related to next level of care, such as rehabilitation, would be based on clinical need and not purely on demographic and financial characteristics but the literature has shown mixed results.

There is literature to support that injury severity-related variables have the greatest amount of association with discharge destination and that the decision to discharge a person home or rehabilitation is primarily based on these factors (Cuthbert et al., 2011; Malec et al., 2009; Mellick et al., 2003; van Baalen et al., 2008). These results appear logical in their support of the utility and appropriateness of observing severity measures such as the Glasgow Coma Scale (GCS), Abbreviated Injury Score (AIS) of the head, and the Injury Severity Score (ISS) in the discharge of TBI patients from acute care.

As proposed earlier, injury severity can be rated by but is not limited to the Glasgow Coma Scale (GCS) score and the injury severity score (ISS) based on AIS. Studies evaluating the GCS for correlation with discharge destination have had varying results (Bergman et al., 2010; Cuthbert et al., 2011; van Baalen et al., 2008). A descriptive study of moderate TBI patients (N=40) looked at GCS on admission, at 24 hours, and at discharge but it did not show a correlation with discharge destination ($p=.087$) (Bergman et al., 2010). However, larger studies (N=111) did find initial severity according to GCS to be significantly ($p=0.05$) associated with the patient either being discharged home or to another institution. While an even larger study that looked at three national datasets (N>160,000) found that injury severity related variables were

the biggest drivers of the decision to discharge the patient home or to additional inpatient services. While the decision to discharge to rehabilitation services were to a degree economic factors ($p = .01$) (Cuthbert et al., 2011). In this same study, across the three datasets injury severity-related variables accounted for the greatest amount of association. The Injury Severity Score (ISS) means for moderate TBI patients in the three datasets were (25.4 ± 11.3) , (25.8 ± 11.4) , and (26.0 ± 10.7) and significant at the .01 level. This strengthened the belief that injury severity variables provide a moderately strong prediction of discharge disposition (Cuthbert et al., 2011).

The mechanism of injury (MOI) of a TBI is another significant factor related to outcomes including discharge destination. Motor vehicle collision (MVC) is the most common mechanism of brain trauma in the 18 to 64-age range and is followed by falls and assault (Chan et al., 2001; Langlois et al., 2006). MVC is considered a “blunt” trauma and has been shown to significantly increase the odds of discharge to rehabilitation. TBI patients involved in a MVC were 1.49 times more likely as those not involved in a MVC to be discharged to rehabilitation (Chen et al., 2012). The Chen et al., (2012) study examined a large sample of TBI patients ($N=5,550$) and found blunt trauma as a mechanism of injury to be significant ($p=.002$) and was kept in the final model of the study as a confounder. MVC’s can also cause significant injuries to other body systems as seen in a cohort study of moderate and severe TBI patients ($N=1807$) where patients sustaining blunt impacts such as MVC’s (84.2%) sustained multiple injuries to other body systems, including extremity injuries, pelvic fractures, or intra-abdominal injuries; all of which increased the odds of discharge to rehabilitation (Esselman et al., 2004).

Since an association exists between insurance type and post acute care, injuries suffered in an MVC may have rehabilitation access related to no-fault automobile insurance policies (Chan et al., 2001; Esselman et al., 2004).

Penetrating trauma types, such as TBI caused by firearms, are often associated with violence. Violence-related injuries account for 18% of all TBI, with 10% caused by firearms (Esselman et al., 2004). African American and Hispanic patients are more likely to sustain penetrating trauma than white patients and are less likely to be insured (Haider et al., 2008). This leads us to the following section that will help illustrate what is known about financial characteristics and rehabilitation.

Financial Characteristics and Rehabilitation. In the acute care setting moderate TBI patients require the most extensive and costly resources. The belief is that the least injured do not require intensive services and the most severely injured do not survive long enough to consume extensive resources. It is also estimated that two-thirds of those who survive a TBI before age 30 will likely live for another 30 to 40 years (Homaifar, Harwood, Wagner, & Brenner, 2009).

Funding source is an important factor that influences the discharge decision after TBI. Access to rehabilitation is based on many complex factors including primary payment source and length of stay (LOS). Both have been viewed in the literature as financial characteristics that impact the moderate TBI patient's discharge destination after acute care. A comparison of insurance types revealed TBI patients belonging to a health maintenance organization (HMO) were 23% (RR = 1.23, 95% CI = .90-1.68) more likely to go to a nursing home on discharge than a patient with commercial insurance; whereas,

Medicaid patients were 68% (RR=1.68, 95% CI=1.34-2.11) more likely (Chan et al., 2001). In this same study, over 75% of the patients with commercial insurance were discharged to rehabilitation compared to less than 60% of those with Medicaid or government funded insurance. The retrospective cohort study (N=5,550) was limited in that the researchers looked at a moderate and severe TBI patients combined and did not consider work-related or workers' compensation cases. The study findings did support insurance type as an important determinant of where TBI patients receive post-acute care.

The findings were consistent with reports of disparities in disposition for persons with other types of brain injury (such as stroke). If better outcomes for stroke patients receiving care in a rehabilitation facility rather than a skilled nursing facility (SNF) are supported and if the same holds true for a TBI, then patients discharged to SNF's may have poorer outcomes than if they had received care in a rehabilitation facility (Chan et al., 2001). However, no longitudinal studies have compared the long-term care costs associated with the moderate brain injured patient receiving rehabilitation in comparison with those who have not.

If discharge disposition is in part determined by insurance status, this fact may threaten the quality of patient care. It may be that insurance status is a surrogate for other factors that affect mortality in a trauma patient such as health education, awareness and management of co morbidities, substance abuse, and risk taking behaviors (Haider et al., 2008). Insurance status has been shown to have a stronger association than race with worse outcomes, implying that lack of insurance could be prohibitive to services that improve neurological outcomes (Haider et al., 2008).

Although it is known that disabled workers and their dependents account for 17% of total Social Security benefits paid, little is known about the impact of TBI specifically on public financial support programs. Therefore, it is important that primary payment source be considered in studying disposition outcome since research suggest that addressing disparities in health insurance status may have a significant effect on outcomes of traumatic injuries for African American, Hispanic, and white patients. This implies that better planning should be in place to ensure more equitable access to appropriate treatment and services among persons with TBI.

Besides payment source, another financial characteristic that has been found in the literature to be associated with discharge destination after acute care is length of stay (LOS). A longer LOS is associated with poor functional outcomes and therefore, it is not surprising that TBI survivors with longer LOS in acute care require care upon discharge that is typically not available within a home setting. A cross-sectional study among moderate and severe TBI patients (N-111) revealed that acute care length of stay was a range of 4-173 days with a mean of 34 days but was not associated with discharge destination (van Baalen et al., 2008). Acute care length of stay (LOS) was found significant at the .01 level in a look at moderate to severe TBI patients in three national databases containing over 60,000 cases. In this study it was believed that LOS could be playing a role with for injury severity and/or an indicator of the seriousness of other co-morbidities and/or concurrent injuries, whether injuries were associated with the same etiology of the TBI or preexisting disorders (Cuthbert et al., 2011). A retrospective cohort design study compared TBI patients and non-TBI (or acquired brain injury) patients and

found that patients with increasing LOS significantly increased the odds of discharge to non-home settings. TBI patients with LOS in the 90th percentile were 160.83 times as likely as those in the 25th percentile to be discharged to rehabilitation (Chen et al., 2012).

The majority of the literature on employment and work-related injuries focuses on employment status pre and post-injury (Mellick et al., 2003; Rimel et al., 1982; Vitaz et al., 2003). It has been stated that high unemployment rates after TBI reflect the influence of functional changes and that the ability to return to work represents a key end point for assessing effectiveness of rehabilitation efforts (Cifu et al., 1997; Hart et al., 2005). A couple studies of moderate TBI patients have noted return to work rates of 56% to 74% in subjects working full-time before their injury and that the low return to work rates were associated with the presence of headaches and memory problems (Rimel et al., 1982; Vitaz et al., 2003). However, these same studies suffered from small moderate TBI sample sizes and did not examine work-related injuries for association with access to rehabilitation or as a proxy for other factors, such as a source of payment in the case of workers' compensation.

In an earlier 1982 study of moderate TBI patients (N=199), the pre-morbid descriptors of age, education, employment, and income that had predicted return to work after minor head injury were not significant for return to work after moderate head injury (Rimel et al., 1982). However this study like others did not look at specific work-related injuries and their effect on discharge disposition. A 2010 descriptive study of work-related TBIs (N=435) found the majority of work-related injury victims were male (70.6%) with mechanism consistent with falls. But again, this study did not examine

workers' compensation that may have influenced access to rehabilitation (Wei, Liu, Fergenbaum, Comper, & Colantonio, 2010).

Rehabilitation services provided early after injury have been found to decrease costs, length of stay, and improve functional outcomes for persons with TBI (Frankel et al., 2006). However, there are mixed results about the acute care LOS in the TBI population and the association it has or doesn't have with access to rehabilitation.

Summary

To my knowledge, no one has examined the discharge destination of the moderate brain injured patient and factors that predict discharge to rehabilitation for this group. In making discharge decisions, healthcare professionals must be mindful that decisions for rehabilitation in the moderate TBI population are being made in regards to need and not financial restrictions. The financial burden of post-acute rehabilitation and the lifelong support needs of TBI survivors are being acknowledged and compared now more than ever. The staggering costs and variability in TBI outcomes are being scrutinized by funding bodies that are demanding outcome accountability especially when outcomes are cognitively based. Since rehabilitation may not be considered for a number of patients with moderate to severe brain injuries who go directly home or to long term nursing care, they may be a previously unrecognized component of the public health burden created by TBI.

The initial costs of rehabilitation could be offset by savings in the costs of support in the long term and societal costs. Further research into the economic aspects of care after brain injury is warranted but can be difficult based on the heterogeneous care

provided making comparison difficult. A number of factors must be examined in making this disposition decision including severity of injury, degree of recovery, ability to actively participate in rehabilitation, family support, social support, availability of funding, and the discharge options. As the number of individuals surviving and living with TBI disability continues to increase, social systems are struggling with how to support them as they age (Homaifar et al., 2009). A rare look at long term outcomes after TBI by Colantonio and associates (2004) looked at survivors up to 24 years post-injury and found that 52.6% were receiving government benefits.

A review of predictors of discharge outcomes for patients with TBI provides invaluable data to inform a change in practice in triage criteria, injury prognostication, care and discharge planning, resource utilization and patient and family counseling. Research focusing on primary prevention, emergency care, and rehabilitative services should also be promoted. The factors influencing discharge care options for persons with TBI should be studied to ensure that decisions are based on objective clinical criteria and evidence based practice guidelines (Hyder et al., 2007).

CHAPTER THREE: METHODS

This methods chapter consists of five sections. The first describes the study design. Second, characteristics of the data set and study population are described. Third, variables of interest are elucidated. Next, the analysis plan describes the descriptive statistics and regression modeling that were used to address each research question proposed in this study. And finally, limitations and methodological considerations are addressed.

Study Design

This retrospective, descriptive study characterizes the moderate TBI patient treated at level I and II trauma centers, as defined in chapter one, as well as the demographic, clinical, and financial predictors of discharge from acute care to rehabilitation. Data was extracted from the 2010 National Sample Project (NSP), part of the National Trauma Data Bank (NTDB[®]), which contains data from trauma registries nationwide. The NSP is a stratified sample of 100 trauma centers, with sample hospitals drawn based on probability-proportional-to-size methodology (ACS, 2007). Descriptive statistics, non-parametric statistics, and logistic regression models using both raw and weighted data were used to address each research question conjectured for this study.

Characteristics of the Data Set and Population

Data Source. The NTDB[®] data are submitted voluntarily from trauma centers across the United States and are maintained by the American College of Surgeons (ACS). The registry contains over 3 million records from over 900 U.S. trauma centers. The NTDB[®] includes information on patient demographics, payment source, injury type and severity, hospital treatment, and facility characteristics including teaching status, trauma center level, and bed size. All hospitals with trauma registries are encouraged by the ACS to participate in the NTDB[®]. Most hospitals contributing data to the NTDB[®] have under 600 beds (57.6%) and report being either level I or level II trauma centers (61.7%). The geographic distribution of hospitals contained in the registry includes: Midwest (43.7%), followed by the South (30.2%), Northeast (20.7%) and West (5.4%). Access to the database is controlled by the ACS and requires an online application with a research proposal summary submission for permission to use the data (ACS, 2007).

The National Sample Project (NSP) is sampled from the NTDB[®], stratified by region and level of care. The NSP uses a stratified sample design of 100 designated sample hospitals in their sample frame and uses number of Emergency Department (ED) visits from the American Hospital Association (AHA) 2005 data as the size measure. The strata used for the sampling include NTDB[®] contributing hospitals and non-NTDB[®] contributing hospitals; trauma centers level I or II; and region, including Northeast, Midwest, West, and South. The NSP includes incident-level records and hospital information such as admission and discharge status, patient demographics, injury and

diagnosis, procedure codes, injury severity scores, outcome variables, and weights (ACS, 2007).

Data Collection. The trauma incident information is collected by trauma registrars working within the trauma centers throughout the United States and then submitted to the NTDB[®]. Data abstraction can occur concurrently, retrospective, and hybrid. Concurrent abstraction is the daily abstraction of data by the registrar while the patient is in the acute care setting and can be pulled from the patient's electronic health record or entered manually. Retrospective abstraction can occur after the patient is discharged from acute care and hybrid is a combination of data entry that begins during the patient encounter but the record is closed after the patient is discharged. Patients are identified by the trauma registrars to obtain concurrent data based on trauma lists and ICD-9-CM codes of admission and diagnosis while medical records are the main source for retrospective data collection (ACS, 2007).

There are four basic skill sets that the trauma registrar needs to master including data management; anatomy and conditions of injury; coding and scoring concepts; and registry issues. Several organizations offer learning opportunities as well as certification to assist trauma registrars in developing their knowledge base and skill sets including the American Trauma Society and state registry organizations. The American College of Surgeons registry staffing recommendation for manual entry is one full time registrar for approximately 750 to 1,000 patients annually (ACS, 2007).

The NTDB[®] incorporates data originally collected from the scene of the incident until discharge from acute care using many different trauma registry software programs

including but not limited to TraumaBase™ (Clinical Data Management, Inc., Conifer, CO), Trauma One™ (Lancet Technology, Inc., Boston, MA), Trauma!™ (Cales and Associates, LLC, Louisville, KY), Collector™ (Digital Innovation, Inc., Forest Hill, MD), and NATIONAL TRACS™ (American College of Surgeons, Chicago, IL). The software programs are used for the collection, storage, analysis, and reporting of trauma patient information on individual, regional, and national levels. Capabilities of the software include automated ICD-9-CM coding, AIS-90 scoring and injury severity scoring along with data entry efficiency, unique quality assurance features, and extensive data validation features. The software easily submits data to NTDB® and any other mandated registries and it has extensive security controls (ACS, 2007).

Study Sample and Setting. For purposes of this study, a sample of patients who met moderate brain injury criteria, between the ages of 18-64 years, and that were admitted and treated at level I and II trauma centers in the United States was created. The study sample consisted of de-identified subjects taken from the 2010 National Sample Project (NSP) dataset. Subjects, or incidents, were eligible for this study if they: a) were diagnosed with a TBI based on the International Classification of Disease 9th Revision Clinical Modification (ICD-9-CM) codes; b) were between the ages of 18-64 years; c) sustained a moderate TBI as defined by the study moderate TBI criteria, and; d) were treated at a level I or level II trauma center. Patients who met the inclusion criteria above were retained for the study sample.

The International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) is based on the World Health Organization's Ninth Revision,

International Classification of Diseases (ICD-9) and is the official system of assigning codes to diagnoses and procedures associated with hospital utilization in the United States. ICD-9-CM codes 800 to 854 and 959 are used to code for traumatic brain injuries as illustrated in Table 5 (Medicare, Baltimore, & Usa, 2013).

Table 5. TBI ICD-9-CM Codes (Centers for Medicare and Medicaid Services, 2013)

ICD-9-CM Code	Diagnosis
800-	Fracture of skull
800.0 – 800.9	Fracture of vault skull
801.0 – 801.9	Fracture of base of skull
803.0 – 803.9	Other and unqualified skull fracture
804.0 – 804.9	Multiple fractures involving skull or face with other bones
850 -	Intracranial injury
850.0 – 850.9	Concussion
851.0 – 851.9	Cerebral laceration and contusions
852.0 – 852.5	Subarachnoid, subdural, and extradural hemorrhage following injury
853.0 – 853.1	Other and unspecified intracranial hemorrhage following injury
854.0 – 854.1	Intracranial injury of other and unspecified nature
959.01	Head injury, unspecified

The settings of interest were trauma care centers in the United States. Non-trauma centers were preliminarily filtered by the NTDB[®] according to the ACS COT (Committee on Trauma) criteria, which verifies hospitals as trauma centers according to the level of trauma care available, trauma volume, and other activities. To minimize variation in criteria by designation agencies, trauma centers designated by either ACS or the state were selected for the study. Only trauma centers that had neurosurgical resources available to treat patients with traumatic brain injury, which includes level I and II centers, were utilized. Generally levels III, IV, and V trauma centers have limited or no neurosurgical coverage and ACS COT has documented that neurosurgical specialty is essential to be categorized as a level I or II trauma center, while it is desirable for level III. Thus, levels III, IV, and V trauma centers were excluded to provide a more homogenous hospital sample (ACS, 2007).

Variables of Interest

The study variables selected for this proposal were taken from case definitions that have been defined and used by ACS COT and have been studied in prior research involving traumatic brain injury and discharge destination.

Outcome Measure. The outcome measure of discharge disposition from acute hospitalization was a dichotomous yes/no to discharge from the acute care setting to any rehabilitation service. The disposition of the patient when discharged from the hospital was not considered rehabilitation if they were discharged home with no home services. Exclusion criteria included if the patient expired; left against medical advice or discontinued care.

Predictors of Discharge Disposition. Variables were selected that could be associated with discharge disposition based on published research. Predictors were grouped into three categories: demographic, clinical, and financial factors. Age, sex, race/ethnicity, and region of care were included in demographic characteristics; while injury severity, injury mechanism, and trauma type were considered clinical characteristics. Financial factors included primary payment source, length of acute care stay in days, and work-related injuries. The conceptual definitions of the variables are outlined in Table 6.

Table 6. Conceptual Definitions of Variables

Variable Name	Conceptual Definition
Moderate Traumatic Brain Injury	ICD-9-CM Diagnosis Code which indicates that subject had a traumatic brain injury defined by one of the following: 800.0x-800.9x, 801.0x-801.9x, 803.0x-803.9x, 804.0x-804.9x, 850.0x-850.9x, 851.0x-851.9x, 852.0x-852.5x, 853.0x-853.1x, 854.0x-854.1x, and 959.01 and at least one of two measures of Moderate TBI including: Glasgow Coma Scale total score of 9-12 or AIS of the head score of 3 and 4 if the GCS score is missing.
Level I or II Trauma Centers	ACS or State Verification defined as level I or II.
Rehabilitation	Hospital Discharge Disposition defined as: Discharged/Transferred to short term general hospital inpatient; Intermediate Care Facility; home to Organized Home Health; Skilled Nursing Facility; Hospice Care; or another type of Rehabilitation or long-term care facility.
Age	TBI patients between ages of 18-64 years categorized as 18 to 24; 25 to 34; 35 to 44; 45 to 54; 55 to 64.
Sex	Sex defined by one of the following: male or female.
Race/Ethnicity	Race/ethnicity defined by one of the following: Hispanic; or non-Hispanic Black or African American; non-Hispanic White; non-Hispanic Other; and non-Hispanic Missing.
Region	Region defined as Midwest, Northeast, South, or West
Injury Severity	Injury Severity defined as ISS score with the numeric value ranging between 1 to 75 and categorized as: ISS < 9; ISS 9-15; ISS 16-24; ISS ≥ 25; GCS score 9-12; and AIS score of Head 1-5.
Injury Mechanism	Mechanism defined as Motor Vehicle Collision or not.
Trauma Type	Trauma type defined as Blunt or Penetrating.
Primary Payment Source	Payment source will be defined by one of the following: Private (Blue Cross/Blue Shield; Self-Pay; Medicaid (plus other Government); Not Known; No Fault Automobile; Medicare; Other; Workers Compensation.
Length of Stay	Length of Acute Care Hospital Stay categorized as: 25 th percentile (≤2 days); 50 th percentile (3-5 days); 75 th percentile (6-13 days); and >13 days.

Table 6 (continued)	
Variable Name	Conceptual Definition
Work Related Injury	Work Related Injury defined (yes/no).

Pilot Study

After a summary of the study proposal including feasibility questions was submitted with an online application to the American College of Surgeons (ACS), access to the NSP 2010 data was granted by the ACS and a letter of support generated for the study. The letter of support was provided to the Principal Investigator (PI) and the pilot study proposal was submitted online via IRB.net to the Office of Research Integrity and Assurance (ORIA) at George Mason University (GMU) for review. The NSP data is composed of de-identified data and a determination of exempt status was received from the university ORIA. The NSP data was delivered to the investigator via a secure web delivery system then downloaded and stored on a password-protected hard drive.

Data contained within the NTDB[®] or NSP is organized as a collection of ASCII CSV (comma-separated values) records which are easily imported to most statistical software programs. Each facility that contributes data to the NTDB[®] has a unique serial number that is necessary to import data into the NTDB[®]. Data can be retrieved from the NTDB[®] at the facility level or the incident level. The facility level data contains

characteristics of the submitting facility while incident records contain information regarding the individual trauma patient event.

For the pilot study, the comma-separated values (CSV) records were imported to Stata[®] v13 statistical software and then merged by inc_key (incident level) and fac_key (facility level) as appropriate. For the pilot study, data was then merged based on prior defined study inclusion criteria: traumatic brain injury (TBI); then patient ages of 18 to 64 years; and finally moderate TBI criteria of GCS 9 to 12.

The purpose of the pilot study was to identify feasibility issues in regards to using a large, national dataset and to address those concerns with the following pilot questions (PQ):

PQ1: Can moderate TBI patients (incidents in the 2010 NSP database) be identified based on Glasgow Coma Scale score of 9 to 12?

PQ2: Is there sufficient variability in post-acute care discharge of moderate TBI patients?

PQ3: Is there sufficient number of patients to adequately power the study and answer the research questions?

PQ4: Is there an acceptable percentage of missing, 10% or less, in the selected variables of interest included in the 2010 NSP data for evaluation in the study?

The 2010 NSP dataset contains 161,087 traumatic patient incidents from a total of 100 level I and level II trauma centers. The NSP data was retrieved from NTDB[®] contributing facilities (N=90) as well as non-contributing facilities (N=10). The study criteria were applied to the data with the pilot study questions answered as follows:

PQ1 was addressed and satisfied with successful classification of moderate TBI patients using the GCS score of 9 to 12 with N=1,776 patients identified between the ages of 18-64 years in the NSP data as well as showing a sufficient number of patients to adequately power the study per PQ3.

However, further analysis after the Pilot Study revealed a number (N=737) of TBI patients were missing severity classification. Additional moderate classification measures, AIS scores of the head 3 and 4, were implemented for the full study when the GCS score was unavailable. This resulted with N=2,087 moderate TBI patients identified as illustrated in figure 1 of the sampling process.

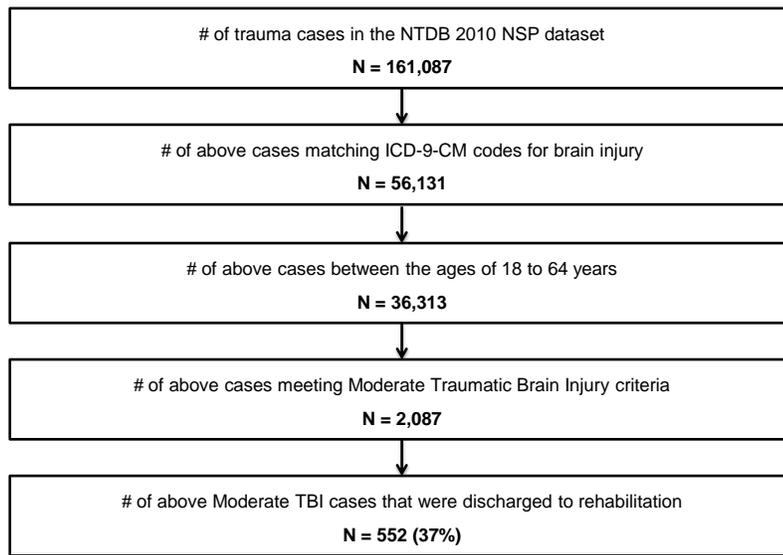


Figure 1. Sampling Process

PQ2 was also addressed in the sampling process Figure 1 based on identification of moderate TBI patients and the percentage (37%) discharged to rehabilitation (N=552) or not discharged to rehabilitation (N=960) or 63%. These numbers were based on the original pilot study findings of N=1,685 minus the rehabilitation exclusion criteria of: 1) patient expired (n=78); 2) patient left against medical advice (AMA)/self discharge (n=49); 3) missing/not known/not recorded (n=46); and prior to the addition of ICD-9-CM 959.01. This confirmed that there was variability in the discharge destination of the moderate brain injured patients.

Per PQ4, variables were analyzed for missing data as reported in Table 7 and found to be at acceptable levels for this analysis. Initially the work industry variable was proposed for the study. Due to missing data, the work-related injury variable was collapsed to a yes/no variable. The study variables were evaluated individually based on their importance to the study proposal and the outcome variable as described in the missing data proposal section that follows.

Table 7. Missing Variable Percentages

Variable	% Missing Data*	Variable	% Missing Data*
Setting – Level of Care Designation:		Injury Severity :	
Level I Trauma Centers	0	ISS	5
Level II Trauma Centers	0	GCS	0
		AIS	0
Outcome – Discharge Disposition:		Injury Mechanism:	
Rehabilitation	3	MVC	0
Not Rehabilitation	3	Non-MVC	0
		Trauma Type	
<u>Predictors:</u>		Blunt	0
Age (18 to 64 years old)	0	Penetrating	0
Sex		Primary Payment Source	11
Male	0	Length of Stay (in days)	0.6
Female	0	Work-Related Injury	
Race/Ethnicity	3	Yes	12
Region	0	No	12

* All proportions calculated using total Moderate TBI Patients; ages 18 to 64; (N= 2,087) as denominator.

Missing Data

Missing data are a pervasive problem in using secondary data because almost all standard statistical methods presume that every case has information on all the variables to be included in the analysis. Missing data can result in significant bias because the characteristics of patients or hospitals with missing information may be different than those with full data reporting. The proportion of missing data varies across data elements in the NTDB[®] and the NSP datasets, making it important to decide how to deal with missing data when doing analyses. In most cases, the data are not missing at random and analyses, therefore, are subject to bias if missing data are ignored. Results may be misleading when excluding all observations with missing data.

The NTDB[®] has two important field values in regards to missing data. There is the Not Applicable (NA) field when data requested is not applicable to the patient; or the Not Known/Not Recorded (NK/NR) field that applies when no value was recorded for the patient. This documents that there was an attempt to obtain the information but it was unknown by all parties or the information was missing at the time of documentation (ACS, 2007).

Therefore for this study, variables were examined individually and patterns of missing data were evaluated. Important missing data issues were brought to the researcher's attention in the pilot study phase. Although the original pilot study sampling process revealed a total of 1,685 moderate TBI incidents (or patients) meeting the study criteria of GCS 9 to 12; addition of ICD-9-CM 959.01 and further analysis of the data revealed 737 incidents (patients) missing TBI severity classification entirely. An

additional TBI classification method was used based on prior research including where initial moderate TBI classification was based on GCS 9 to 12; then AIS of the head scores of 3 and 4 were used to classify moderate TBI if the GCS score was unavailable. After this expanded criteria, incidents (patients) with AIS moderate TBI classification were added to the sample for a total N=2,087.

An important next step was to evaluate the missing data patterns for GCS. The objective of the analysis was to understand whether patients with GCS information available differ from patients who are missing GCS information. The main outcome of discharge destination was compared for incidents with complete vs. missing GCS to understand how discharge disposition differs if GCS data are missing. Furthermore, demographics and injury severity were compared among patients for whom GCS was not reported vs. their counterparts with GCS information available. For example, patients with no motor activity related to spinal cord injuries may be more likely to have missing GCS information in the database.

Description of the moderate TBI patient (RQ1) included all outcomes; whereas discharge to rehabilitation predictors (RQ2) included all outcomes except when the patient expired; left AMA, discontinued care, or was missing discharge data. The before mentioned outcomes were classified as not discharged to rehabilitation. In the pilot study evaluation of missing data, discharge destination revealed 3% missing data. Further analysis of the main outcome variable of discharge to rehabilitation was required to look at missing data patterns. Patient factors, such as injury severity and demographics, were compared while looking for significant patterns in patients who have incomplete

information for discharge disposition. These comparisons and evaluations advised the investigator on how to treat missing data.

Power Analysis

Statistical power considerations for this study were conducted based on two study objectives. The first aim (RQ1) of this study was to describe the demographics, injury characteristics, and financial characteristics of patients suffering from TBI of moderate severity. Descriptive statistics were calculated for both the crude sample and the nationally representative weighted sample of the NSP. Counts and proportions were presented for categorical variables. The precision of the descriptive estimates in the pilot study analysis indicated that the initial available sample size was more than sufficient to describe the population of interest. For example, in the initial pilot data of 1,685 incidents with moderate GCS, weighted proportions and 95% confidence intervals were estimated to be: GCS 9, 21% (18-25%); GCS 10, 22% (19-25%); GCS 11, 27% (24-31%); GCS 12, 30% (26-33). The main outcome variable, discharge to rehabilitation was estimated in the following weighted proportions and 95% confidence intervals in the initial pilot study sample of N=1,685: Rehabilitation 52% (48-56%); Home with no services (no rehabilitation) 37% (33-41%). Precision levels of weighted estimates were evaluated by inspecting 95% confidence intervals and were found to be sufficient to meet research question 1 (RQ1).

Multiple logistic regression models were calculated to evaluate research question 2 (RQ2): to identify the predictors of descriptive, clinical, and financial characteristics on discharge destination in the moderate TBI population. Sample size was evaluated using

PowerLog, developed for Stata statistical software, based on methodology of Agresti (1996) and Hsieh (1998) (Agresti, 1996; Hsieh, Bloch, & Larsen, 1998). Assumptions were based on estimates obtained from the pilot study (N=1,685). Injury severity score was selected as the primary predictor variable for sample size evaluation, as the investigators expected that higher overall injury severity score would be positively associated with discharge to rehabilitation. In the pilot study, the estimated probability of discharge to rehabilitation for patients with mean ISS score (17) was 34%, and the probability of discharge to rehabilitation for patients with mean + 1 standard deviation ISS (28) was 54%. Assuming alpha (type I error rate) = 0.05, sample size and power relationships were estimated per Figure 2: Power & Sample Size.

The R-squared values were estimated at three different levels to characterize the range of possible correlation among covariates. Results of the full multiple regression model (with all covariates represented) in the pilot study indicated that the R-squared value between the primary predictor (ISS) and other model covariates was 0.22. Expanding the population to include moderate TBI using additional criteria is not expected to dramatically increase this relatively low R-squared. Using available estimates from the pilot study, the required sample size to achieve 90% power was 166, less than 10% of the initial pilot study sample size (N=1,685). However, even if the final study model correlation among covariates increases to a very high level (R-squared = 0.9), the available sample size in the pilot study (N=1,685) was estimated to be sufficient for multiple logistic regression models with power > 90% as illustrated in Figure 2.

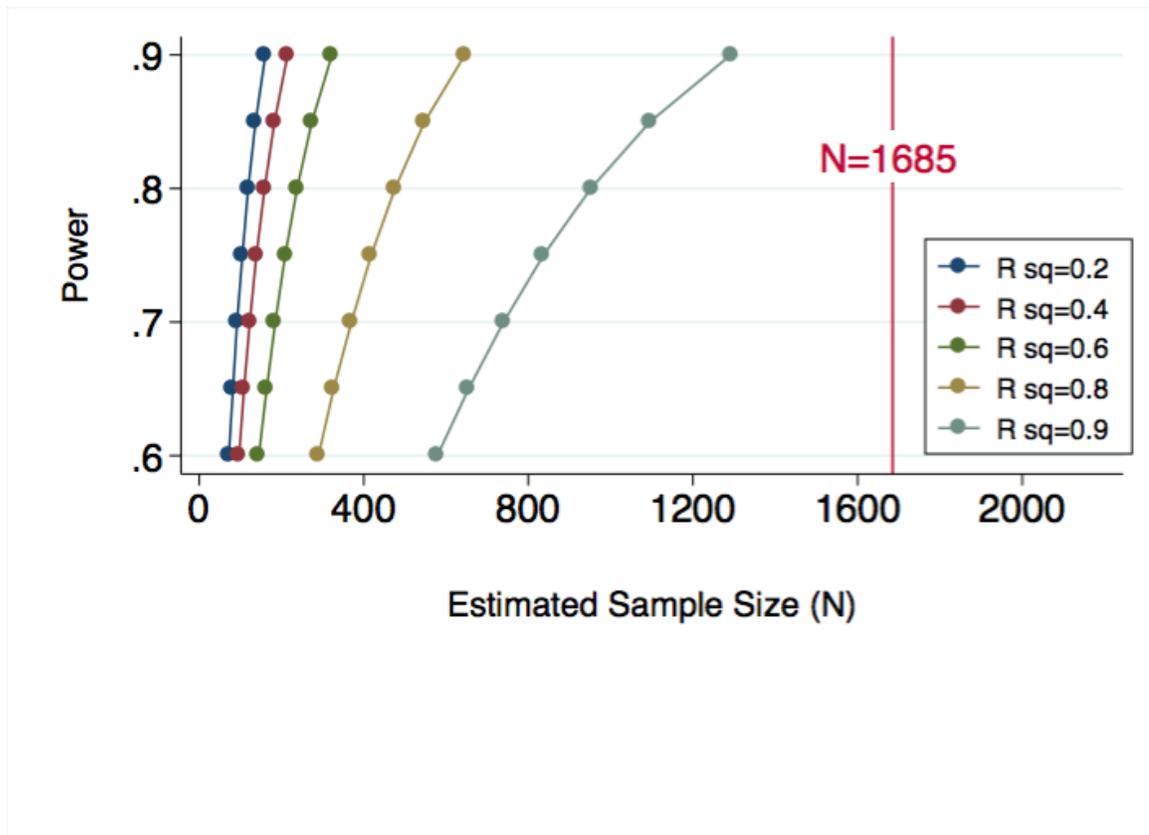


Figure 2. Power and Sample Size

Achieving stability in the parameter estimates requires a sufficient number of cases per predictor in the model. Recommendations for sample size range from 10 to 20 cases per predictor (Polit, D.F., 2010). Based on the initial pilot study sample size results (N=1,685) and 12 variables or predictors, this analysis consist of 140 cases per predictor. This exceeds the 10 cases per predictor recommendation and gives stability. Maximum

likelihood estimation relies on large-sample asymptotic normality, which means that the stability of the estimates declines when the sample size is inadequate in relation to the number of predictors (Polit, 2010). Given the broader inclusion criteria for defining moderate TBI including AIS of the head scores of 3 and 4, the increased sample size (N=2,087) was more than sufficient for RQ2.

Analysis Plan

As per the pilot study, the proposal was submitted online via IRB.net to the Office of Research Integrity and Assurance (ORIA) at George Mason University (GMU) for review for a full study using the same de-identified data from the NSP 2010 dataset and an approval with a determination of exempt status was received from the university ORIA. All analyses were conducted using the statistical software program Stata[®] version 13 (College Station, TX). The discharge destination variable was coded into a dichotomous variable (discharged to rehabilitation or not) for each subject. Discharged to rehabilitation included patients discharged or transferred to short term general hospitals as inpatient; intermediate care facilities; home with organized home health; skilled nursing facilities; hospice care; or another type of rehabilitation or long-term care facility. Criterion for significance for all statistical tests was set at $p < 0.05$ (type I error). A series of descriptive statistical analyses were completed to describe demographic and injury variables by assessing frequencies and proportions. Multiple logistic regression, backward stepwise selection, modeling was used to answer the predictors of discharge destination.

Research question 1 was to describe the moderate brain injured patient. A series of descriptive statistics were used to identify the demographic characteristics, such as age, sex, race/ethnicity, and region of care; clinical characteristics, including the injury severity, injury mechanism, and trauma type; and financial characteristics including primary payment source, length of acute care stay, and work-related injury or not; of the moderate traumatic brain injured patient treated at level I and II trauma centers for each discharge disposition group. Univariate comparisons of variables with the outcome variable of discharge destination were conducted using Chi-square test for categorical variables with significant variables included in multivariate models.

Research question 2 was to determine predictors of discharge of the moderate TBI patient to rehabilitation. Discharge destination was collapsed into yes (discharged to rehabilitation) or no (not discharged to rehabilitation). Bivariate comparisons were made of the demographic (age, sex, race/ethnicity, and region); clinical (injury severity, injury mechanism, and trauma type); and financial (primary payment source, length of acute care stay, and work-related injury) variables, for those discharged to rehabilitation and those who were not. Multivariate logistic regression modeling was used to calculate odds of association between discharge disposition and the predictors. Each predictor variable was modeled independently. With the use of backward elimination stepwise method, all of the variables were initially included in the model. Then the least significant variable was removed and the significance of the other variables reevaluated based on the new model. This process was continued until only statistically significant variables remained

in the model. This modeling was completed on both the raw data and the weighted data for comparison.

Logistic regression is most commonly used to model the relationship between a binary outcome variable and a set of predictors (Hosmer, 1999). The goal of a logistic regression model is to estimate the probability of an event. There are several important issues related to the use of logistic regression. First, there is the issue of the ratio of cases to variables included in the analysis. Several problems may occur if too few cases relative to the number of predictor variables exist in the data. Second, logistic regression relies on the goodness-of-fit test as a means of assessing the fit of the model to the data. If any of the cells have expected frequencies that are too small, the analysis may have little power. Third, logistic regression is sensitive to high correlations among predictor variables. These issues or assumptions were considered and evaluated during analyses.

Limitations and Methodological Considerations

The NTDB[®] is becoming an increasingly representative sample of hospitals caring for the injured; however there remain several limitations to this study. This study used data from the NTDB[®] that integrates data originally collected by trauma registrars using many different trauma registry software programs. As such, the data are only as reliable as the clinicians who are coding for the diagnosis. Therefore, the first limitation is related to coding variations. For example, the number of International Classification of Disease 9th Revision Clinical Modification (ICD-9-CM) diagnoses that can be entered into the registry may vary across trauma registry software. To reduce the bias caused by

miscoding, the ACS COT has cleaned the NTDB[®] dataset by eliminating certain data that are out-of-range or invalid (ACS, 2007).

Another limitation relates to the fact that the NTDB[®] is not a population-based dataset. Although the NTDB[®] includes data of over a million injured cases, it may not be representative of all US trauma cases. The data have been submitted voluntarily from hospitals that have shown a commitment to monitoring and improving the care of injured patients, so it is possible that the characteristics of patients who present to hospitals that do not participate in the NTDB[®] may differ somehow from those who present to hospitals that contribute to the NTDB[®] (ACS, 2007). That is, the hospitals have not been systematically selected to represent the varied injured populations.

Third, many of the variables used in severity scoring (ISS, GCS, AIS) are subject to measurement error. This may further bias or affect the precision of any estimated difference between hospitals based on variation in equipment or those performing and recording the measurement. Most inaccuracy in calculating the injury severity can be related to missing data. Most trauma registries can automatically derive the ISS from the AIS method or the ICD-9-CM conversion (Lucas et al., 2001). If information necessary for calculation of ISS is missing, the ISS may not be accurate. Lucas et al. (2001) found that severity scores were calculated differently depending on the registry software used by trauma centers. Although GCS is the most widely used measure or classification of injury severity (i.e., mild, moderate, severe), the pilot study results provided evidence that the use of GCS alone in classifying moderate was not sufficient and that additional

definitions of moderate TBI severity, including AIS of the head scores of 3 and 4 were needed.

Finally, information bias may exist. Information bias refers to an apparent difference between two groups that is actually caused by a difference in the data available to compare them (ACS, 2007). Very few fields are absolutely required by NTDB[®] and differences in the proportion of cases with missing data may be responsible for apparent differences among trauma centers. The quality of data available in trauma registries can have a significant impact on the value of the information obtained. To reduce the impact of information bias on this study, only level I and II trauma centers were analyzed. Seemingly due to better training of data extractors, level I and II trauma centers report fewer missing data points to NTDB[®] and more complete collection for their trauma registries.

Human Subjects Consideration

Exempt status was granted by the university Office of Research Integrity and Assurance (ORIA) for the pilot study conducted to test feasibility of the NSP 2010 dataset in answering the proposed research questions and the full study itself.

Confidentiality of the database was maintained throughout the course of the study with data kept on a secure laptop accessible only with the researcher's private password.

There are no conceivable risks associated with this research. This proposal involves the use of preexisting de-identified data and does not involve direct human subjects research. Measures were taken to ensure that the de-identified data were stored on secured hard drives and data will be destroyed at the conclusion of this project. All

researchers and consultants involved in this study abided by HIPPA rules and regulations to ensure subjects rights to privacy and confidentiality.

There are also no anticipated benefits to subjects in this study. However, it is possible that patients and health professionals could benefit from the results of this study in the future. Future benefits of identifying factors associated with discharge destination could aid in improving resource utilization and planning at the hospital level. The results could also provide invaluable data for patient and family counseling. The goal of this project is to provide the best information on the description of the moderate brain injured patient and the predictors of discharge from acute care to rehabilitation.

CHAPTER FOUR: RESULTS

The outcome measure of discharge disposition with a binary outcome of rehabilitation vs. no rehabilitation showed that 65% of moderate TBI patients were discharged home (N=1205) with no services compared to only 35% (N=644) being discharged to rehabilitation. Similar to research that has examined combinations of mild, moderate, and severe TBI patients, results showed that discharge decisions for the moderately injured were based on factors besides clinical need and included demographic and financial characteristics. Also similar to prior research across the TBI severity spectrum was that moderate TBI patients were most often male, non-Hispanic white, treated at trauma centers in the South, had sustained blunt injuries that were not MVC related and had injury severity scores of GCS of 12 and AIS of head score of 4. Most of the injuries were not work-related, were covered by private insurance, and were admitted to acute care fewer than 2 days. While almost 4% of the moderate TBI patients expired prior to acute care discharge, another 2.9% left against medical advice. Multivariate logistic regression models resulted in seven significant predictors of discharge with LOS > 13 days being 22 times more likely to go to rehabilitation, Medicare coverage 4.5 times the odds, higher injury severity increased the odds, patients treated in the Midwest were 2.6 times, and the 55 to 64 age group were twice as often discharged to rehabilitation.

CHAPTER FIVE: DISCUSSION

To our knowledge, this is the first paper to investigate a moderate TBI sample of patients exclusively in regards to discharge disposition. Compared to prior research that has examined combinations of mild, moderate, and severe patients, results were similar in that discharge decisions appear to be based on issues beyond clinical need and include demographic and financial factors. Although the moderate TBI sample appeared older than prior studies, it could have been influenced by the age inclusion criteria of 18 to 64 years that was intended to prevent any influence of government insurance programs for the young or elderly. Future research could be expanded to all ages to increase the generalizability. Pertinent variables, such as co-morbid conditions, were not available in this retrospective data and may have been influential on the outcome. Missing data can also be an issue with retrospective data and was addressed in this study with case deletion and formation of missing categories. This study also did not take into account the varied levels of rehabilitation received upon discharge but relied on the belief that continued care was more beneficial than home with no services. Future research related to these limitations is warranted. In addition to agreeing with previous research in this area, this study contributes to the brain injury science by describing characteristics of the moderate TBI patient exclusively.

APPENDIX I

American College of Surgeons



August 29, 2013

Sandra Rogers
George Mason University
10830 W. 1st Street
Fairfax, VA 22030

Dear Ms. Rogers,

Thank you for purchasing the **National Trauma Data Bank (NTDB) 2010 National Sample Program (NSP)** research data set. Permission from the American College of Surgeons Committee on Trauma (ACS COT) for the use of your dissertation titled, "Description of the Moderate Brain Injured Patient and Predictors of Discharge to Acute Rehabilitation," is thereby granted according to the terms below:

1. Treat the information received from The American College of Surgeons, Committee on Trauma as non-public health data. The data will never be used as a basis for legal, administrative or other actions that can directly affect an individual whose medical or personal information is included in a case in the data.
2. Agree that all information received under the provisions of this Agreement may only be used for the purposes described herein; i.e., advocacy, medical education, patient education, or other trauma care-related activities supported by not-for-profit organizations.
3. Agree that all Information derived from the NTDB from The American College of Surgeons, Committee on Trauma shall remain the full and copyrighted property of The American College of Surgeons, Committee on Trauma and shall be so noted in educational material, website presentations, and publications.
4. Represent that The American College of Surgeons, Committee on Trauma is not responsible for any ancillary or derivative works based on the original Data, Text, Tables, or Figures.
5. Indemnify The American College of Surgeons, Committee on Trauma from any and all liability, loss, or damage suffered as a result of claims, demands, costs, or judgments arising out of the failure of Requester or those acting in connection with Requester to conform to and obey the provisions set forth in this Agreement.
6. Notify The American College of Surgeons, Committee on Trauma of any use of the Data, Text, Tables, or Figures that have been used or resulted in related technology



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312/202-5155 • FAX: 312/202-5005

APPENDIX II



Office of Research Integrity and Assurance

Research Hall, 4400 University Drive, MS 6D5, Fairfax, Virginia 22030
Phone: 703-993-5445; Fax: 703-993-9590

DATE: November 15, 2013

TO: Kathy Richards, PhD
FROM: George Mason University IRB

Project Title: [538774-1] Description of the Moderate Brain Injured Patient and Predictors of Discharge to Acute Rehabilitation

SUBMISSION TYPE: New Project

ACTION: DETERMINATION OF EXEMPT STATUS
DECISION DATE: November 15, 2013

REVIEW CATEGORY: Exemption category #4

Thank you for your submission of New Project materials for this project. The Office of Research Integrity & Assurance (ORIA) has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

Please remember that all research must be conducted as described in the submitted materials.

Please note that any revision to previously approved materials must be submitted to the ORIA prior to initiation. Please use the appropriate revision forms for this procedure.

If you have any questions, please contact Bess Dieffenbach at 703-993-4121 or edieffen@gmu.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within George Mason University IRB's records.

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BIOGRAPHY

Sandra Rogers graduated from Estill County High School, Ravenna, Kentucky, in 1982. She received her Associate Degree in Nursing in 1987 and her Bachelor of Science in Nursing in 1993, both from Eastern Kentucky University. She was employed as a critical care registered nurse in several university-based teaching hospitals for over 20 years and received her Master of Business Administration with a healthcare focus from the University of North Florida in 2003. She received a Graduate Certificate in Nursing Education from George Mason University in 2010 and was awarded funding through Project RN, a CareFirst program that funds scholarships for nurses seeking advanced degrees to become nurse educators, to continue her doctorate education. Other supporter's of Sandra's doctoral education include Sigma Theta Tau International and a dissertation completion grant through George Mason University.

EDUCATION

2010 - 2014	PhD, George Mason University, College of Health and Human Services, Fairfax, VA
2009 - 2010	Graduate Certificate, Nursing Education George Mason University, School of Nursing, Fairfax, VA
2001 - 2003	MBA, University of North Florida, Jacksonville, FL
1991 - 1993	BSN, Eastern Kentucky University, Richmond, KY
1985 - 1987	ADN, Eastern Kentucky University, Richmond, KY

EMPLOYMENT

2011 - 2013	George Mason University School of Nursing Graduate Research Assistant
2009 - 2011	George Mason University School of Nursing Adjunct Nursing Faculty
2007 - 2009	Recruitment Specialist Inc., Towson, MD Project Director / Director of Nurse Recruitment

2000 - 2006	University of Florida & Shands Hospital, Jacksonville, FL Registered Nurse, Trauma/Surgical Intensive Care Unit
2003 - 2004	Professional Placement Resources, Jacksonville, Florida Nurse Manager, International Division
1999 - 2000	Travcorp, Boston, Massachusetts Traveling Registered Nurse
1991 - 1999	University of Kentucky Medical Center Registered Nurse, Trauma Intensive Care & Emergency Department
1989 - 1991	University Community Hospital, Tampa, Florida Registered Nurse, Emergency Department
1987 - 1989	Clark Regional Medical Center, Winchester, Kentucky Registered Nurse, Emergency Department & Medical/Surgical

PROFESSIONAL ACTIVITIES AND MEMBERSHIPS

Organizations:	Sigma Theta Tau, School of Nursing Honor Society Society of Trauma Nurses Beta Gamma Sigma, Business School Honor Society Healthcare Financial Management Association Toastmasters International Association of Critical Care Nurses Emergency Nurses Association (served as regional treasurer)
Certifications:	Advanced Trauma Life Support Course Coordinator Basic Life Support Course Instructor Advanced Cardiac Life Support certification Basic Life Support certification
Honors:	Dissertation Completion Grant, GMU, 2013 CareFirst Nursing Education Fellowship Award, GMU, 2011 Scholarship, HFMA, University of North Florida, 2002 Dean's List, University of North Florida 2001-2003 Dean's List, Eastern Kentucky University, 1985-1987 Clinical Nursing Student of the Year, Eastern KY University, 1987

COMMUNITY SERVICE

Volunteer: RN Volunteer, Jeanie Schmidt Free Clinic, Herndon, Virginia

POSTER PRESENTATIONS

- November, 2013 Rogers, S and Richards, KC (2013, November). NURS 998: Dissertation Proposal Development of Description of the Moderate Brain Injured Patient and Predictors of Discharge to Rehabilitation. Poster presented at the 2013 Sigma Theta Tau International 42nd Biennial Convention, Indianapolis, IN.
- September, 2012 Rogers, S and Gill, J (2012, September). NURS 930: The Relationship between Health-Related Quality of Life and Inflammation in Women with PTSD. Poster presented at the 2012 National State of the Science Congress on Nursing Research, Washington, DC.
- March, 2012 Rogers, S and Gill, J (2012, March). NURS 930: The Relationship between Health-Related Quality of Life and Inflammation in Women with PTSD. Poster presented at the 2012 College of Health and Human Services Research Day, George Mason University, Fairfax, VA.