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Factors influencing post-acute brain injury rehabilitation treatment outcome

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FACTORS INFLUENCING POST-ACUTE BRAIN INJURY REHABILITATION TREATMENT OUTCOME

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Brain injury has a tremendous effect on the United States. The medical system has a continuum of care available but many of these services are extremely expensive. Despite the effectiveness of residential post-acute brain injury rehabilitation (PABIR) resistance to provide adequate funding remains because of a dearth of randomized controlled trial (RCT) studies demonstrating effectiveness. Some research suggests observational trials are typically more representative of community samples and yield conclusions similar to RCT studies. This study uses a large multi-state naturalistic community-based sample of individuals who received residential PABIR. The purposes of this study were to (1) use logistic regression to identify a model that considered the relationships among the predictor variables to explain treatment outcome for individuals receiving residential PABIR and (2) better understand how self-awareness influences treatment outcome.

The final model contained five independent variables (substance use at time of admit, functioning level at time of admit, change in awareness between discharge and admit, admit before or after 6 months post-injury, and length of stay in the program less than or greater than 2 months). The model was statistically significant, $\chi 2$ (5, N=434) = 194.751, $p < .001$, accounting for 36.2% (Cox & Snell R square) to 61.3% (Nagelkerke R square) of the variance in success rate, and correctly classified 89.4% of cases. Four of the five predictor variables (current substance use, change in awareness, LOS 2 months and TPI 6 months) made statistically

significant contributions to the model. The strongest predictor of successful treatment outcome was change in awareness recording an odds ratio of 29.9 indicating that individuals who improved in self-awareness by at least one level were almost 30 times more likely to be in the successful outcome group, controlling for other factors in the model. Participants were also more likely to be in the successful outcome group if they admitted within 6-months post-injury (5.5x) and stayed longer than 2-months (4.4x). Findings also suggest that active substance use at time of admission did not prevent people from being successful. Importance and implications of these findings are discussed.

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CHAPTER ONE

INTRODUCTION

Each year in the United States an estimated 1.7 million people sustain a traumatic brain injury (TBI). Of those affected, approximately 52,000 die, 275,000 are hospitalized, and 1.365 million are treated and released from an emergency department (Faul, Xu, Wald, & Coronado, 2010). Other research suggests 1.6 – 3.8 million sports- and recreation-related TBIs occur in the United States each year (Langlois, Rutland-Brown, & Wald, 2006). Most of these are mild TBIs that are not treated in a hospital or emergency department. The number of people who sustain a TBI and are not seen in an emergency department is unknown.

Of the estimated 1.7 million people who will sustain a TBI, persons aged 0 to 4 years, 15 to 19 years, and 65 years and older are the age groups most likely to be affected (Faul et al., 2010). In every age group, males are more likely than females to sustain a TBI (Faul et al., 2010) and African-Americans have the highest death rate (Langlois, Rutland-Brown, & Thomas, 2006). The greatest number of TBIs occur in people aged 15–24 (Collins & Dean, 2002; Hardman & Manoukian, 2002).

Falls (35.2%), motor vehicle-traffic crashes (17.3%), events in which the person was struck by or against something or someone (16.5%), and assaults (10%) are the leading causes of TBI. Traumatic brain injury contributes to 30.5% of all injury-related deaths in the United States (Faul et al., 2010). Blasts are a leading cause of TBI for active duty military personnel in war zones (Defense and Veterans Brain Injury Center [DVBIC] as cited in Center for Disease Control, 2010), with an estimated 19% of US military personnel returning from Iraq and Afghanistan reporting a possible TBI (Tanielian & Jaycox, 2008). Brain injury is recognized as a

major public health issue with current estimates of incidence rising at three times the population rate (Faul et al., 2010).

In 1999, Thurman, Alverson, Dunn, Guerrero, and Sniezek estimated there to be 5.3 million Americans needing long-term or life-long help performing activities of daily living (ADL) as a result of a TBI. Research suggests 80,000 to 124,000 individuals per year will sustain a TBI resulting in long-term or permanent disability (Selassie et al., 2003; Thurman et al., 1999). Permanent disability is thought to occur in 10% of mild injuries, 66% of moderate injuries, and 100% of severe injuries (Frey, 2003). Direct medical expenses and indirect costs (e.g., lost productivity) as a result of TBI cost the United States an estimated $60 billion in 2000 (Corso, Finkelstein, Miller, Fiebelkorn, & Zaloshnja, 2006). None of these statistics include the outcomes of the 233,425 medically diagnosed brain injuries in the US military from 2000 through 2011 Quarter 4 (Department of Defense Numbers for Traumatic Brain Injury report, 2012).

Barriers to Evaluating Effectiveness of Rehabilitation Programs

The recovery process following a moderate to severe brain injury usually involves a stay in an intensive care unit. During this process the individual with a brain injury is either in a natural or medically induced coma because of being in a naturally agitated state. After the individual is awake there is often significant disorientation and confusion. Cognitive function is drastically impaired. Once relatively stable, the person with a brain injury is transitioned to a traditional floor. Often the individual will receive cognitive, occupation, and physical therapy. Once medically stable, the individual will either transition to an acute care facility that specializes in brain injury, a nursing home, a psychiatric facility if having major behavior issues,

or home with his or her family. This part of the continuum of care is pretty consistent and predictable. However, the next part of the provision of services is not.

Ideally, an individual would transition into a residential PABIR treatment program. In this capacity, the individual would receive comprehensive treatment to maximize independence. Unfortunately, many individuals struggle to get funded for this level of care. Instead, they exist in a non-rehabilitative setting without purposeful cognitive stimulation. Recovery continues to occur as a product of time but not to the extent that it would if the individual were actively engaged in therapy. Outpatient services are sometimes available on a limited basis depending on need and financial resources. As a result, psychological processes begin to form in an effort to maintain a sense of identity. Sometimes, if the state has a brain injury waiver services and the individual is eligible, funding for residential PABIR treatment becomes an option 6-months or more down the road. By this time, support systems have begun to fall apart, family stress is exacerbating the situation, financial stress is likely, and intervention takes more effort and time, and is potentially less successful.

The nature of the brain results in every brain injury being unique. Additionally, there are a multitude of factors potentially related to treatment outcome after brain injury rehabilitation. Understanding the factors most relevant to treatment outcome is complicated because there are many stages to the recovery process. Certain factors, like length or depth of consciousness, may be extremely relevant during the immediate acute recovery process—the process occurring immediately after the injury before the individual is medically stable—but less relevant during the latter stages of the rehabilitation process (Maas et al., 2010).

Differing relevancy of factors at different stages would be manageable if it were consistent across individuals; unfortunately, because of the uniqueness of each injury, this is not

the case. This presents one of many problems facing researchers investigating the efficacy of brain injury rehabilitation programs. Being cognizant of these problems, the brain injury community formed the Interagency Working Group on Demographics and Clinical Assessment to determine a hierarchy of data elements and outcome measures to allow for easier comparison between studies and meta-analysis (findings published November 2010 in Archives of Physical Medicine and Rehabilitation). Overarching awareness of the aforementioned problems facing researchers investigating the effectiveness of brain injury rehabilitation programs are ethical barriers to conducting randomized control trial studies (RCTs).

Ethical issues are associated with evaluating the general effectiveness of brain injury rehabilitation services because delaying or not providing services is considered a violation of a person's rights (Altman, Swick, Parrot, & Malec, 2010; Malec, 2009). For example, knowing there is a natural recovery window that begins to close following injury and delaying or not providing cognitive therapy to someone for control group purposes who otherwise would benefit from it in a residential program, is often considered a human rights violation. In addition to the ethical issues that interfere with controlled investigation of program effectiveness, when taking into consideration the uniqueness of every injury and the multitude of factors potentially related to treatment outcome, it is virtually impossible to design a study that is both rigorously controlled and generalizable to community populations (Altman et al., 2010; Malec, 2009). To combat the barriers to RCTs research design, brain injury rehabilitation researchers have relied on observational and community-based trials. Comparisons between observational trials and RCTs in clinical medicine revealed patient samples were typically more representative in observational trials and observational trials yielded conclusions similar to RCTs (Concato, Shah, & Horwitz, 2000). These factors led Altman et al. (2010) to suggest that "what large-number naturalistic

community-based observational trials lack in scientific rigor may be offset, to a degree, by the potential to generalize findings to community populations" (p.1698).

Severity of Injury

Traumatic Brain injury severity is classified as either mild, moderate, or severe. Table 1 represents the factors used to classify a traumatic brain injury as cited by the Department of Defense and Department of Veterans Affairs Traumatic Brain Injury Task Force (2008). The abbreviations are AOC – Alteration of consciousness/mental state, LOC – Loss of consciousness, PTA – Post-traumatic amnesia, GCS – Glasgow Coma Scale. Two important points to note are that for the purpose of classification of injury the GCS is measured at or after 24 hours and penetrating injuries that result in a breach of the dura mater do not necessarily adhere to this stratification.

Table 1

Factors Used to Classify Severity of Injury

Mild	**Moderate**	**Severe**
Normal structural imaging	Normal or abnormal structural imaging	Normal or abnormal structural imaging
LOC for 0 – 30 min	LOC 30 min – 24 hrs	LOC > 24 hrs
AOC for a moment – 24 hrs	AOC > 24 hrs	
PTA for 0 – 1 day	PTA for 1 – 7 days	PTA > 7 days
GCS = 13 – 15	GCS = 9 – 12	GCS = 3 – 8

Brain Injury Rehabilitation

Treatment following an injury can vary depending on severity, availability of funding, and limited family and healthcare provider knowledge about brain injury and treatment. The overarching goal of brain injury rehabilitation is to maximize cognitive, physical, and psychosocial functioning while helping the individual emotionally adjust to living with commonly experienced brain injury limitations such as, attention, memory, executive functioning, muscle control, and emotional regulation (Cioe, 2009). An essential component of maximum recovery of function is maintaining a continuum of care—that is to say continued active rehabilitation from moment of injury for as long as needed (ideally at least one plus year) (Choi et al., 1994; Cope & Hall, 1982; Malec, Smigielski, DePompolo & Thompson, 1993; Mani, Miller, Yanasak, & Macciocchi, 2007).

Many moderate and severe injuries involve surgery and almost all require acute (hospital) care until the person is medically stable. However, only a small portion of individuals (about 1/3) receive some form of post-acute (post-hospital) rehabilitation services (Mellick, Gerhart, & Whiteneck, 2003). Depending on where you stand when making the argument, there are several reasons why so few people receive post-acute care. However, within the rehabilitation community, the most common barrier is inadequate funding followed by inadequate availability of specialized treatment providers. The cost of rehabilitation can be substantial (up to $500,000 per year), but measurable gains made can significantly reduce the annual cost of future care (Ashley, Schultz, Bryan, Krynch, & Hays, 1997). Wood, McCrea, Wood, and Merriman (1999) found that six months of neurorehabilitation reduced the cost of 76 patients living in community settings by more than $1.48 million dollars per person over the course of their lifetime. More

recent publications have demonstrated recoupment of initial rehabilitation costs occurring within 24 (Worthington, Mathews, Melia, & Oddy, 2006) to 36 months (Turner-Stokes, 2007).

Residential post-acute brain injury rehabilitation. The purpose of post-acute brain injury rehabilitation (PABIR) (Malec & Basford, 1996) is maximizing independence with activities of daily living and facilitating re-entry into community living (Cioe, 2009; Evans & Jones, 1991; Malec & Basford, 1996). Individuals who are unable to manage independently or do not have adequate support while working toward independence with outpatient therapy require residential PABIR—living at a rehabilitation facility while participating in interdisciplinary rehabilitation.

General residential PABIR procedure. Generally, individuals participating in a comprehensive residential PABIR programs receive multidisciplinary services (e.g., physical therapy, occupational therapy, behavior therapy/counseling, speech therapy, cognitive therapy, case management, rehabilitation therapy, and nursing). Upon arrival, therapists from each of the disciplines evaluate the individual's need for their specific service. After the individual therapy disciplines have completed their evaluations, the clinical team meets to discuss and conceptualize the treatment plan (taking into account individual, family, and clinical goals) in accordance with Commission on Accreditation of Rehabilitation Facilities (CARF) standards. During this conceptualization meeting, the clinical team uses an outcome measurement tool to establish a baseline assessment of independence and functioning. The treatment team also selects several of the outcome measurement content areas and establishes treatment goals based on improvements expected to be made as a result of the residential PABIR services provided.

The clinical team communicates regularly in accordance with CARF standards. The individual continues to receive treatment until the clinical team feels maximum improvement has

occurred, funding is terminated, or the individual/guardian terminates treatment. As the discharge date approaches, the individual's clinical treatment team reconvenes for a discharge meeting. During this meeting, clinicians complete the outcome measurement assessment based on the individual's expected functioning the day after discharge. In re-evaluating the individual with the same outcome assessment based on their current level of functioning, the clinicians are determining to what extent their treatment goals were accomplished. This information is captured in a program evaluation dataset.

Summary of Problem

Brain injury has a tremendous effect on the United States. The rehabilitation system has a continuum of care available but many of these services are extremely expensive. The effectiveness of residential PABIR has been documented in the literature but resistance to provide adequate funding remains because of a dearth of RCT studies demonstrating effectiveness (Altman et al., 2010). Observational trials are typically more representative of community samples and yield conclusions similar to RCTs (Concato et al., 2000). The proposed study will use a large naturalistic community-based sample of individuals who received residential PABIR over the last two decades.

Note: A traumatic brain injury, historically referred to as a head injury, is defined as an alteration in brain function, or other evidence of brain pathology, caused by an external force (Menon, Schwab, Wright, & Maas (2010). Professionals in the brain injury field prefer to use the term acquired brain injury (ABI) in place of traumatic brain injury (TBI) because it is more inclusive. Although ABI is the preferred term when referring to brain injury, TBI is used more often in the literature because these types of injuries are more readily identified in review of medical records and catalogued in data sets. Whenever possible, the term ABI will be used.

However, to maintain the integrity of the cited literature, TBI will be used if that is the term used in the original source.

Factors Related to Treatment Outcome

Determining what constitutes successful treatment outcome can vary depending on who is defining it (expectations of the individual, expectations of the individual's family, expectations of the funder, and expectations of the clinical team) and at what point during the recovery they are being defined. Functional outcomes are those related to an individual's ability to complete activities of daily living and re-enter into community living. The unique nature of every brain injury and thus every recovery from brain injury does not make it prudent to determine success by assessing level of independence with every potential activity of daily living.

Treatment outcome is defined in this study as either successful or unsuccessful. An individual had a successful treatment outcome if, after subtracting each of the items answered on their functional outcome assessment at admission from their functional outcome assessment at discharge, there was an improvement of at least one level in at least four items. This procedure was determined adequate after consensus was achieved during a focus group meeting with this researcher and three distinguished brain injury rehabilitation clinicians, each with 10 or more years of experience with the functional outcome assessment tool. Defining successful and unsuccessful outcome using this procedure resulted in 796 (80.2%) successful and 196 (19.8%) unsuccessful outcomes. A summary of the focus group proceedings is provided in the response variable section of Chapter Three: Methodology.

Many factors may influence functional outcome, among which are: years of education, age of onset, gender, injury severity, associated injuries, functioning at admission to treatment program, type of injury, prior rehabilitation experience, motivation to participate in

rehabilitation, level of awareness, length of stay, family support, substance use, personality, psychological illness, time since injury, socio-economic status, and behavior issues. The goal is to understand how easily identifiable factors at admission to a treatment program (age of onset, years of education, injury severity, substance use at time of admit, functioning upon admission, time since injury at admission, and level of awareness at admission) and clinically supported factors (length of stay and change in awareness) relate to treatment outcome. While many of the factors that influence treatment outcome are not modifiable at the time someone is admitting into treatment, some can be influenced by therapeutic intervention (Shutter & Jallo, 1998) and potentially improve with changes to funding guidelines (Ashley, O'Shanick, & Kreber, 2009).

Included variables. Age of onset, years of education, injury severity, substance use at the time of admission, level of awareness, change in awareness, functioning at time of admission, time since injury at admission, and length of stay are the predictor variables considered for inclusion into the model. These variables were selected because of their intuitive relationship with treatment outcome given clinical brain injury rehabilitation expertise (e.g., the more severe and injury the worse the outcome, the longer it takes to get into treatment the worse the outcome, the shorter the treatment the worse the outcome). Additionally, variables were included because of their relationship to other variables not included in the model or because of clinical experience supporting further investigation of the variable's influence on treatment outcome. Chapter Two: Literature Review provides a detailed explanation about the rationale for choosing the aforementioned predictor variables.

Summary

Brain injury is a significant health issue in the United States. It affects millions of people each year and tens of thousands of those affected have long-term disabilities as a result of their

brain injury. This results in an extreme cost to society. Research has identified many factors related to treatment outcome. However, there are so many factors that it becomes difficult to identify which factors are most relevant. Most of the variables chosen as predictor variables are available at the time someone admits into a NeuroRestorative residential PABIR program. The others are supported by the literature and potentially address two major issues interrelated with residential post-acute care, incentive for funding and effectiveness of treatment.

Age of onset, years of education, injury severity, and substance use at time of admission are variables that exist prior to admission into a residential treatment program. How these variables relate to treatment outcome could support their consideration when trying to secure funding for residential post-acute services. The functioning at admission and time since injury at admission could support the continuum of care argument for more streamlined movement through the phases of rehabilitation, which likely improves treatment outcome and decreases long term cost.

Integrating self-awareness as a variable introduces something currently not, but theoretically able to be, systematically addressed during rehabilitation. Part of the reason it is not addressed is due to the lack of established and supported interventions. However, if when lumped in with the aforementioned variables it accounts for a significant portion of the variance, the benefits of investigating and creating systematic interventions are supported. This makes understanding the role of self-awareness on treatment outcome, after taking into account factors known or expected to be related to treatment outcome, beneficial to treatment program development. Improving treatment programs improves treatment outcomes, which improves the functioning of the individual with an ABI, quality of life for the individual with an ABI and his support system, and cost to society.

Research Questions

The primary purpose of this study is to determine, using an examination of extant data and logistic regression, a model to explain treatment outcome for individuals receiving residential post-acute brain injury rehabilitation, given the following predictor variables: age of onset, years of education, injury severity, substance intoxication at time of admission, self-awareness, functioning at admission, length of stay, and time since injury at admission to treatment program. The secondary purpose of this study is to explore the relationships among the aforementioned predictor variables to determine if a pattern exists among persons receiving residential PABIR.

The following research questions guided this study:

1) Considering other established factors related to treatment outcome, how does self-awareness influence treatment outcome?
2) How do multiple predictor variables interrelate to influence treatment outcome following residential post-acute brain injury rehabilitation?

Analyses

Regression is used to make predictions and gain understanding about the relationship between predictor variables and a response variable. This type of analysis is ideal for evaluating treatment effectiveness when the dependent variable is continuous. A common occurrence that undermines the assumptions underlying regression is multicollinearity – similarity among the predictor variables. Logistic regression is an alternative type of regression that allows for relationships between predictor variables to be considered when evaluating the regression model, which is necessary for this investigation. Logistic regression differs from traditional regression approaches because logistic regression requires use of a dichotomous response variable. In this

study a compromise is made in that treatment outcome is operationalized such that it can exist dichotomously and the inherent similarity between predictor variables can be accounted for in the analysis rather than distracting their relationship with treatment outcome.

Definition of Terms

Acquired Brain Injury (ABI) - any neurological injury (including a TBI) that occurs after birth (e.g., those resulting from heart attack, stroke, airway obstruction, etc.) (National Center on Physical Activity and Disability [NCPAD], 2007)

Age of onset – The age at which individuals with an ABI acquired their brain injury.

Functioning at admission – Functional Area Outcome Menu weighted average score.

Length of stay (LOS) – The length of time in months an individual in admitted to a NeuroRestorative PABIR treatment program.

Injury severity – Mild, Moderate, or Severe (see Table 1 for classification criteria).

Post-Acute Brain Injury Rehabilitation – Any rehabilitation occurring post-hospital (can include residential and outpatient rehabilitation).

Self-awareness – "the capacity to perceive the 'self' in relatively 'objective' terms while maintaining a sense of subjectivity" (Prigatano & Schacter, 1991, p.13).

Substance use at time of admission – Individual is using substances despite medical recommendation to the contrary at the time they are admitting to the rehabilitation program.

Traumatic Brain Injury (TBI) - an alteration in brain function, or other evidence of brain pathology, caused by an external force (Menon et al., 2010)

Time since injury at admission (TPI) – The length of time in months between the date of injury and the date of admission into the program.

Treatment outcome - For the purpose of this study, treatment outcome will be categorized as successful or unsuccessful, determined by the whether or not an individual improves by at least one level on four or more of eight FAOM items.

CHAPTER TWO

LITERATURE REVIEW

There are a multitude of factors potentially related to treatment outcome after rehabilitation from an ABI. Understanding the factors most relevant to treatment outcome is complicated, because there are many stages to the recovery practice. Certain factors, like depth of consciousness, may be extremely relevant during the immediate acute recovery process—the process occurring immediately after the injury before the individual is stable—but less relevant during the latter stages of the rehabilitation process (e.g., outpatient physical therapy services). Differing relevancy of factors at different stages would be manageable if it were consistent across individuals; unfortunately, this is not the case.

This chapter reviews pertinent research literature upon which this study is formed. It begins with an overview of the residential PABIR system, followed by a discussion about treatment outcome and the factors related to treatment outcome, such as severity of injury, type of injury, functioning at admission to treatment program, age of onset, years of education, substance use at time of admission into program, length of stay, and time since injury at admission. Extra consideration was given to level of awareness, a factor related to treatment outcome, because of its relationship with other factors. A summary of key findings synthesizes pertinent literature findings.

Residential Post-Acute Brain Injury Rehabilitation

Frey (2003) estimates permanent disability occurs in 10% of mild injuries, 66% of moderate injuries, and 100% of severe injuries. However, Mellick et al. (2003) estimated that only 1/3 of individuals with ABI receive post-acute rehabilitation services. The Center for Disease Control (2010) estimates there to be 1.7 million TBI per year with 275,000 being

hospitalized and 1.365 million treated and released from the hospital. One can assume that the 275,000 all had moderate/severe injuries and the strong majority of those treated and released from the hospital had mild TBI. A small percentage (5%) of the 1.365 million treated and released had brain injuries classified as moderate in severity. This allows for rough estimates of 400,000 (24% of the total) moderate to severe brain injuries occurring in the United States per year. If one adds the 10% (about 140,000) of mild injuries that result in permanent disability (Frey, 2003) to the estimated 400,000 (24% of total) moderate/severe injuries we can begin to understand who comprises the 1/3 (Mellick et al., 2003) of individuals with ABI who receive post-acute rehabilitation services.

It is important to recognize that PABIR services include any rehabilitation services received by an individual with an ABI after discharge from the hospital (e.g., residential post-acute rehabilitation, outpatient services, and vocational rehabilitation services). Mason (2008) estimated that there are only a few thousand brain injury specialty rehabilitation residential beds in the United States. Conservatively pulling from the literature, there are an estimated 100,000 individuals per year who will have long-term or permanent disability secondary to brain injury. These are the individuals who could most benefit from residential post-acute brain injury rehabilitation.

While the purpose of this study is not to explore the reasons why the United States is poorly prepared to provide services to individuals with ABI, some background information may be beneficial for a general appreciation for the state of brain injury rehabilitation. As would be expected, it is related to money. The cost of rehabilitation can be substantial (up to $500,000 per year) (Ashley et al., 1997). Additionally, the high prevalence of brain injury stresses underfunded public health insurance programs (i.e., Medicaid and Medicare) and the complexity

and chronicity of a brain injury is not adequately covered by private health insurance policies (Ashley et al., 2009; Cioe, Upton, & Hollender, 2010).

Treatment Outcomes

Outcomes vary depending on who is defining them and at what point during the recovery they are being defined. For example, an emergency room trauma surgeon is likely to define successful outcomes in terms of life and death. This criterion would not be relevant at the residential PABIR stage of recovery, where outcomes are focused on functional recovery (Shutter & Jallo, 1998). Functional outcomes are those related to an individual's ability to complete activities of daily living and re-enter into community living (e.g., brushing teeth, preparing meals, toileting, managing money, etc.). The unique nature of every brain injury and thus every recovery from brain injury does not make it prudent to determine success by assessing level of independence with every potential activity of daily living. Instead, in the PABIR setting, a set of outcome goals is determined by clinical staff after their evaluation of the individual's level of functioning at the time of entry into a program. A multi-disciplinary approach is used to address these goals. By setting outcome goals, clinical team members can design their individual treatment approaches to accomplish consistent end-goals.

There are many ways to evaluate treatment outcome. One of the most rigorous methodologies used when evaluating treatment outcome is Analysis of Co-Variance (ANCOVA) with pre-intervention assessment scores are used as the covariate and post-intervention score serve as the dependent variable. This type of evaluation of treatment outcome is most appropriate when evaluating the effectiveness of treatment interventions occurring during rehabilitation. The number of factors inherent to residential post-acute brain injury rehabilitation makes it difficult to evaluate treatment outcome using ANCOVA.

Regression is used to make predictions and gain understanding about the relationship between predictor variables and a response variable. This type of analysis is ideal for evaluating treatment effectiveness when the dependent variable is continuous. A common occurrence that undermines the assumptions underlying regression is multicollinearity – similarity among the predictor variables. Logistic regression is an alternative type of regression that allows for relationships between predictor variables to be considered when evaluating the regression model, which is necessary for this investigation. Logistic regression differs from traditional regression approaches because logistic regression requires use of a dichotomous response variable.

Factors Related to Treatment Outcome

As stated earlier, there are a multitude of factors related to treatment outcome depending on what stage in the process outcome is determined. Many of these factors are not modifiable but some of the other factors can be influenced by therapeutic intervention (Shutter & Jallo, 1998). The purpose of this section is to identify factors related to outcome following ABI to support the selection of several specific variables of interest for this study.

Severity of injury. One of the best predictors of mortality following brain injury is severity of injury (Shutter & Jallo, 1998). Although the World Health Organization criteria determine injury severity by considering length of confusion/disorientation, length of loss of consciousness (LOC), length of post-traumatic amnesia (PTA), and results of structural brain imaging, emergency professionals use the Glasgow Coma Score (GCS) to assess level of consciousness as a determinant of injury severity with a score 13–15 representing mild injury, 9–12 representing moderate injury, and lower than 8 representing severe injury (Teasdale & Jennett, 1974). This makes the GCS a readily available sign of injury severity when reviewing medical records.

Levels of consciousness can change often during the first hours following brain injury. Using the GCS to monitor changes in levels of consciousness remains an important function (Jennett, 2002). Additionally, the GCS is useful when predicting mortality with increase mortality rates the more severe the injury. Even though there was a 40% reduction in mortality following severe brain injury from 1970 to 1980, a review by Marshall et al. (1991) still estimated 30% mortality. This drastically differs from the 0.9% mortality rate of individuals with moderate brain injuries (Stein & Ross, 1992). These research findings support the use of GCS as a determinant of injury severity during the immediate acute treatment of brain injury. However, the validity of GCS predicting functional outcome is slightly less straightforward.

The Traumatic Coma Data Bank (TCDB) reported moderate disability or good recovery in only 16% of patients with severe brain injury (Marshall et al., 1991), whereas 86% of those with moderate injury reported moderate disability or good recovery (Stein & Ross, 1992). Other studies (Diringer & Edwards, 1997; Zafonte et al., 1996) have found limited value of the GCS in predicting functional outcome. Although the relationship between severity of injury and functional outcome is not clear, it correlates with other aspects of brain injury (e.g., type of injury, associated injuries, motivation to participate in rehabilitation, impaired self-awareness, substance use, and behavior issues).

Type of injury. Acquired brain injuries (ABI) can occur many different ways including via a blow or jolt to the head (blunt trauma) or a penetrating head injury, otherwise known as a TBI. Individuals with ABI resulting from penetrating head injuries have higher mortality rates than those with blunt trauma injuries (Aldrich et al., 1992; Levy, Masri, Lavine, & Apuzzo, 1994; Shaffrey et al., 1992). Intuitively, one might presume that the same relationship would exist for functional treatment outcome. However, Zafonte et al. (1997) found no such difference

exists between individuals who acquire a brain injury via blunt vs. penetrating head injury at one year post-injury.

A common injury following a closed head injury is Diffuse Axonal Injury (DAI). This type of injury can greatly affect an individual's potential for improvement. However, Katz and Alexander (1994) found clinical factors used to determine severity (length of PTA, duration of coma, GCS) were the best predictors of outcome from DAI.

Brain injury rehabilitation professionals have historically been pessimistic about marked improvement when working with individuals with anoxic brain injuries—injuries that occur as a result of deprivation of oxygen to the brain. Research (Grosswasser, Cohen, & Costeff, 1989; Schmidt, Drew-Cates, & Dombovy, 1997) has historically found that individuals with anoxic brain injuries have poor outcomes, required more care and longer rehabilitation stays. However, recently Shah, Al-Adawi, Dorvlo, and Burke (2004) found no significant differences in length of stay, Functional Independence Measure (FIM), and cost of stay between a matched sample of individuals with anoxic and TBI.

Associated injuries. The presence of additional systemic injuries in association with a brain injury affects outcome during both the immediate acute phase and functional outcome phase of recovery. Co-occurring injuries increased mortality from 11% to nearly 22% during the immediate acute phase of recovery (Siegel, 1995). Research also suggests associated injuries are associated with long-term outcomes due to problems with psychosocial functioning, memory, attention and learning (Moore, Stambrook, Peters, Cardoso, & Kassum, 1990; Woischneck et al., 1997).

Functioning at admission to treatment program. It seems like injury severity and the presence of associated injury may affect treatment outcome. However, there is significant

within-group variability in both the injury severity and associated injury categories of individuals. Additionally, each person's recovery is unique to their injury and does not necessarily occur in pre-established time intervals. One potential strategy to better address general factors of disability present at time of injury is to use a measure of functioning at time of admission as a predictor variable. Several studies exploring the relationship of functioning at a time of admission into a program suggest it is predictive of long-term employment outcome (Gollaher et al., 1998; Ponsford, Olver, Curran, & Ng, 1995). This suggests functional ratings at a time post-injury may be useful in predicting long-term outcome (Sherer, Bergloff, High Jr., & Nick, 1999).

Age of onset and years of education. Age is an independent predictor of mortality with individuals under the age of 5 (Levin et al., 1992) and over the age of 65 (Kilaru et al., 1996; Vollmer et al., 1991) having the highest mortality rates. Additionally, long-term recovery of function is not common in the elderly (Kilaru et al., 1996) and individuals over age 55 improve at a slower rate than those under age 55 (Cifu et al., 1996). In children with severe brain injury, those under age 7 are more likely to have severe disability than those over the age 8 at time of injury (Asikainen, Kaste, & Sarna, 1996). We know that parts of the brain (pre-frontal cortex) do not complete developing until age 25 (Walsh, 2004) and the ability of the brain to change due to neuroplasticity is a hot topic in neuroscience. Intuitively, individuals with greater cognitive ability pre-injury would be expected to have better outcomes post-injury. Pre-injury education has been shown to predict functional treatment outcome with higher levels of education predicting better outcome (Asikainen et al., 1996; Dikmen, Temkin, & Armsden, 1989; Girard et al., 1996).

Substance use at time of admission. Approximately two-thirds of individuals with TBI have a pre-injury substance abuse history (Corrigan, 1995) and pre-injury alcohol abuse was reported by as many as 79% of TBI patients, which is higher than the general population (Taylor, Kreutzer, Demm, & Meade, 2003). Pre-injury illicit drug use, less prevalent than alcohol abuse, was found in up to 37% of TBI patients (Taylor et al., 2003). Up to three-quarters of TBI survivors are likely to be intoxicated at the time of injury (Corrigan, 1995; Corrigan, Bogner, Mysiw, Clinchot, & Fugate, 2001; Kreutzer, Wehnman, Harris, Burns, & Young, 1991) and one-third report illicit drug use at the time of injury (Wagner, Sasser, Hammond, Wiercisiewski, & Alexander, 2000). Alcohol intoxication at injury is associated with acute complications, longer hospital stays, and poorer discharge status (Corrigan, 1995).

Active substance use is often a barrier to admittance into non-substance use rehabilitation programs. Individuals with substance use issues can present with behaviors that interfere with provision of rehabilitation services. Contrary to the predominant opinion, leading Alcohol and other drugs or abuse (AODA) research suggests it is best to simultaneously address substance use and other disabilities instead of trying to address one while ignoring the other (Koch & Dotson, 2008).

Time since injury at admission. It is widely accepted clinical knowledge that the greatest rate of recovery following brain injury is during the first year with marked improvements continuing to occur at a slower rate over the second year (Choi et al., 1994; Cope & Hall, 1982; DiCowden, *n.d;* High, Jr., Roebuck-Spencer, Sander, Stuchen, & Sherer, 2006; Malec et al., 1993). Improvements can continue to occur after two years post-injury but usually as a result of environmental manipulation and clinical intervention to work with the individual at their level of functioning. This presumption is supported by research like that of Mani, Miller, Yanasak, and

Macciocchi (2007) who found improvements in functional recovery of motor and visual skills over the first year post-injury and Anderson and Catroppa (2005), who found improvements in executive functioning were related to time post-injury in a group of children with severe brain injuries. Time since injury is also relevant because of the relationship between time post-injury and self-awareness.

Length of stay. Research interest in length of stay (LOS) is often related to cost containment. The literature is inconsistent with respect to the relationship between LOS and functional treatment outcome following PABIR but there is agreement that the relationship between LOS and functional outcome is not linear. It is important to establish some meaningful minimum LOS to predict success (Jones & Evans, 1992). Comprehensive Day Treatment Programs have slightly shorter preferred lengths of stay (4 – 7 months) to residential PABIR programs (6 – 9 months). Ruff and Niemann (1990) found individuals with 2-months or less LOS were less successful than those who stayed for the preferred length of stay.

Executive dysfunction. Executive dysfunction is among the most frequently occurring impairments following brain injury. It refers to impaired executive function, which is an umbrella term for many cognitive processes including planning, working memory, attention, problem solving, mental flexibility, initiation, multi-tasking, and so on (Chan, Shum, Toulopoulou, & Chen, 2008). The most widely accepted conceptualizations of executive function is Lezak's model in which volition, planning, purposive action, and effective performance work together to accomplish global executive functioning needs (Lezak, Howieson, & Loring, 2004). Somebody requiring residential PABIR is virtually certain to be exhibiting executive dysfunction. However, the holistic treatment approach provided by most residential PABIR inherently addresses executive dysfunction and improvements correspond to improved

functional outcomes as captured by improved FAOM scores, which represent successful treatment outcome.

Self-awareness. Self-awareness is defined as "the capacity to perceive the 'self' in relatively 'objective' terms while maintaining a sense of subjectivity" (Prigatano & Schacter, 1991, p.13). Individuals with brain injuries often have a disorder of self-awareness, which refers to a person's "inability to recognize deficits or problem circumstances caused by a neurological injury" (Barco, Crosson, Bolesta, Werts, & Stout, 1991, p.129). Awareness may be expressed at various levels ranging from basic perceptual and sensory awareness to sophisticated self-awareness (Stuss, Picton, & Alexander, 2001). Some people dealing with impaired self-awareness (ISA) have intellectual awareness of their behavioral deficits but lack "online" awareness of when a deficit is adversely affecting their performance. This condition, defined as "emergent awareness" significantly impacts a persons' adaptation to life with a head injury (Barco et al., 1991; Crosson, 2000; Crosson et al., 1989).

Brain injury rehabilitation research identifies ISA as a large obstacle during the rehabilitation process. Early ratings of ISA related to measures of functional independence at discharge from rehabilitation hospitals (Sherer et al., 2003). Individuals with brain injuries who have reduced concern about deficits and their consequences often are resistant to treatment and do not engage in rehabilitation (Herbert & Powell, 1989). Fleming and Strong (1995) suggested that self-awareness is more impairing for cognitive and/or socio-emotional aspects of functioning compared to basic activities of daily living (ADLs). Impaired self-awareness (ISA) relates to poorer treatment outcome and compliance (Prigatano, 2005). Also, ISA negatively impacts psychiatric illness (Hoofien, Gilboa, Vakil, & Barak, 2004; Rogers & Read, 2007) and psychosocial functioning (Bach & David, 2006; Ownsworth et al, 2000). There is a positive

relationship between psychosocial functioning and vocational placement success (Upton & Bordieri, 2001; Upton, Bordieri, & Roberts, 2002; Upton, Wadsworth, & Sattley, 2008).

The relationship between time post-injury and awareness is not clearly established in the literature. Some researchers (Allen & Ruff, 1990; Godfrey, Partridge, Knight, & Bishara, 1993; Vanderploeg, Belanger, Duchnick, & Curtiss, 2007) suggest awareness improves with time while others (Prigatano & Altman, 1990; Ranseen, Bohaska, & Schmitt, 1990; Sherer et al., 1999) indicate no relationship between time since injury and awareness in various areas of deficit and chronicity. Impaired self-awareness has been noted to be present several years later (Vanderploeg et al., 2007), seven years post-injury (Oddy, Coughlan, Tyerman, & Jenkins, 1985), and may be permanent for some individuals with ABI (Prigatano, 1999).

Impaired self-awareness is an important factor in determining subjective well-being in persons with ABI (Evans, Sherer, Nick, Richardson, & Yablon, 2005), and thus a need to address family perceptions has developed to maximize therapeutic alliance and productivity status at discharge (Sherer, Hart, Whyte, Nick, & Yablon, 2005). Although many factors contribute to the distress experienced by significant others—neurobehavioral sequelae, fear of seizures, the physical demands of caring for the patient—the most consistently cited correlate with significant other distress is the presence of residual cognitive and behavioral deficits (Douglas & Spellacy,1996; Wallace et al., 1998). Given the relationship between ISA and the rehabilitation process and the consequences for individuals with ABI and their families if ISA persists after discharge from rehabilitation, understanding the role of self-awareness on treatment outcome is essential to program development.

Summary of Key Findings

The population of interest in this study is individuals with ABI receiving residential post-acute brain injury rehabilitation. This population seems the most appropriate for this type of investigation because residential post-acute brain injury rehabilitation is often the last rehabilitation setting that allows for clinical manipulation of the environment to support clinical initiatives. For the purpose of this study, successful treatment outcome is determined by the number of improvements made by one level on eight FAOM items. Individuals who improve in at least four of eight items are considered successful. While this method of operationalizing treatment outcome is not ideal, it is necessary when using logistic regression analyses.

Given the population of individuals receiving residential PABIR are most likely to have moderate and severe injuries, it seems relevant to include it as a factor when investigating the relationship between factors at admission to a treatment program and successful treatment outcome. While type of injury does relate to mortality rates during the immediate phase of the recovery process, effects related to type of injury concerning functional outcome are subsumed under the effects of injury severity. Associated injuries are related to outcome during the immediate and functional recovery phases of rehabilitation. The nature of residential post-acute brain injury rehabilitation supports use of strategies to maximize independent functioning. Although associated injuries will be present in a portion of the study sample, if included the variable could only be coded as present or not present, which does not accurately reflect the range of impairment that may or may not be present as a result of the associated injury. A weighted average FAOM score at admission will be used as a predictor variable.

The age of an individual when acquiring a brain injury relates to outcome during the immediate and functional recovery phases of rehabilitation for the very young and very old.

Although most of the sample individuals will not fall into one of the major categories documented to be most affected by age of onset as a predictor variable, it is worthwhile investigating the relationship to increase understanding about the role of this variable in brain injury recovery. Years of education is related to age of onset and is thus relevant for consideration during the model building variable selection process.

The NeuroRestorative data set tracks substance use history and current substance use. While it is important to consider the effects of substance use history because of its relationship to acute outcome, current substance use is preferred because it is a barrier to admission for many rehabilitation programs and current research suggests it is important to simultaneously address substance use and other disabilities instead of addressing each separately. For this reason it is important to consider active substance use at time of admission as a predictor of functional outcome.

There is a relationship between recovery and time post injury, especially in the moderate/severe brain injury population. Unfortunately, there is no consistency across time among brain injuries. This makes it uninformative to compare the recovery of one individual with a brain injury to another individual with a brain injury at any like time. That being said, the rate of change seems to be related to the length of time post-injury. To better understand the relationships among the predictor variables, it is essential to consider time since injury at admission to the program to account for the potential relationship between time post-injury and recovery made during the treatment program.

Most of the variables explored have been un-modifiable characteristics of individuals with ABI at the time they admit into a treatment program. However, both self-awareness and length of stay can theoretically be addressed during the course of the treatment program. Unlike

other areas addressed during rehabilitation (e.g., use of hands, speech, orientation, depression, etc.), techniques to improve self-awareness are not well-established. Given the relationship between self-awareness and the rehabilitation process and the consequences for individuals with ABI and their families if ISA persists after discharge from rehabilitation, understanding the role of ISA on treatment outcome is essential to treatment program development. Likewise understanding the role of length of stay, especially when taking into account other potentially relevant predictor variables, is important for supporting advocacy for increased lengths of stay to improve treatment outcome.

CHAPTER THREE

METHODOLOGY

This study was approved by the Southern Illinois University Institutional Review Board (IRB) and NeuroRestorative Risk Review committee. A model-building approach was used using logistic regression design of extant data to explain treatment outcome given predictor factors supported by a review of the literature and clinical experience. The logistic regression model uses multiple predictor variables that can be "categorical or continuous, allow for polynomial terms or interactions between predictors, permit user-driven entry decisions or iterative methods, and provide model fit diagnostics and residual analyses" (O'Connell & Amico, 2010, p. 221). Statistical Package for the Social Services (SPSS) software version 17 was used for the analysis. The findings from this study increase understanding about factors influencing residential PABIR treatment outcome and have the potential to guide program development.

Instrumentation

Functional outcome data collected using the Functional Area Outcomes Menu (FAOM; see Appendix A to review the full instrument) (Braunling-McMorrow & Tompkins, 1994; Braunling-McMorrow & Neumann, 1999). When used for adults, the FAOM consists of the following 10 content areas: residential status, level of independence, behavioral and emotional status, level of community participation, level of awareness, vocation/higher education/structured productive activity, involvement in vocation or education, level of self-managed health, intimacy/relationships, and quality of life. The FAOM uses a 5 point (1-5) Likert-type scale, where higher scores reflect greater independence and higher functioning. Maximum level of functioning is reflected by a FAOM total score close to 50 (score of 5 across all 10 areas) (see Table 2 for a quick reference guide for scoring the FAOM).

Table 2

Quick Reference Guide for Scoring the FAOM

	Residential Status	Level of Independence	Behavioral and Emotional Status	Community Participation	Level of Awareness	Vocational Endeavors	Educational Endeavors	Involvement In Vocation or Education	Level of Self Managed Health	Intimacy Relationships	Quality of Life
5 Maximum	At Home and Independent	Completely Independent 17-24 hours per day	Self manages with no assistance	Productive activities daily	Anticipatory awareness, can consistently plan ahead	Competitive employment	Regular classroom	Full-time participation	Self initiates medical routines	Mutually satisfying relationship intimacy and friends	High quality of life
4	Home or apartment with support	Independ. 9-16 hours per day.	Self manages with occasional assistance	Productive activities, but not daily	Emergent awareness, may sometimes plan ahead	Non-competitive or supported employment	Classroom with formal support	3/4 time participation	Requires direction guidance for complex medical	Reports relationship with friends or intimate > 1 time/wk	Person is often happy
3 Intermediate	Congregate living Staff available 24/hrs day.	Independ. 5-8 hours per day.	Self manages with daily assistance	Errands and leisure activities weekly	Intellectual awareness, inconsistently initiates strategies	Sheltered or specialized employment	Self contained classroom& regular classroom	1/2 time participation	Manages basic medical once prompted	Casual relationship, activities out of home at least 1 time/wk	Generally happy exhibits problems dealing with day to day
2	Post-Acute rehab setting	Independ. Up to 4 hrs. per day.	Minimally responsive to external intervention	Errands, leisure activities one time per week or more	Identifies skill and difficulties once prompted	Avocational program	Self contained classroom only	1/4 time participation	No self management skills of medical routines	Interacts with others only for basic needs	Person is rarely happy. Difficulty with day to day issues
1 Minimum	Institutional setting	Requires 24 hours assistance	Actively resists externally manged interventions	No community participation	Cannot identify any skill or difficulties	No participation	No participation	No participation	Resistant to medical interventions	No contact or actively resists contact	Person is consistently unhappy or miserable

Braunling-McMorrow, Tompkins, and Neumann (1996). Center for Comprehensive Services, Inc. Mentor ABI

The FAOM was developed through the analysis of outcome types "typically expected or promised by industry consensus" (Braunling-McMorrow & Tompkins, 1994, p. 3) in addition to what the test developers had found in their history. The FAOM assesses several different aspects of community functioning and parts of the FAOM (i.e., Level of Independence/Assistance, Level of Community Participation, and Level of Awareness) are directly related to professional literature such as the Supervision Rating Scale (Boake, 1996), Community Integration Questionnaire (Willer, Rosenthal, Kreutzer, Gordon, & Rempel, 2003), and the Pyramid Model of self-awareness (Crosson et al., 1989).

Content measured by each FAOM item. The level ratings of the *residential status* item on the FAOM measures the level of autonomy of each participant in their residential setting. The level ratings of the *level of independence/assistance* item represent the ability of an individual to remain independent of assistance in four hour blocks. Conceptually, increased level of independence translates into greater opportunity for the caregiver to work outside the home. The level ratings of the *behavioral and emotional status* item represent an individuals' ability to self-regulate behaviors and emotions without depending on external structural supports. This does not mean that individuals are not able to utilize external supports (e.g., counseling services) but rather the level of structural supports needed for the individual to manager his/her behavior and emotions on a daily basis.

The levels ratings of the *level of community participation* item represent the amount of community inclusions regardless of whether or not support is needed. Conceptually, assistance is disregarded as it is often necessary due to physical or cognitive difficulties as a result of the injury. The levels rating of *level of awareness* item is based on observable and measurable behaviors that reflect the ability to understand and predict performance. The level ratings for the

v*ocation/higher education/structured productive activity* item represent points along the range of participation in meaningful activities and the support needed. Rating levels represent culturally expected norms. The *involvement in vocation or education* item is designed to complement the Vocation/Higher education/Structured productive activity item. The intention is to reflect changes in level of involvement (e.g. moving from ¼ time to ½ time employment), which represent meaningful progress toward independence.

The level ratings for the *level of self-managed health* item reflect the degree to which individuals accept and manage their medical routines. Conceptually, the ability to make and keep doctor's appointments, recognize symptoms requiring medical attention, and take medications as prescribed directly relate to independence. The level ratings for the *intimacy/relationships* item are designed to represent the type and quality of relationships between individuals and others with respect to type of relationship, frequency of contact, and satisfaction with these relationships. The level ratings of the q*uality of life* item reflect the average range of an individuals' representation of their quality of life. This item considers the common highs and lows or life, especially during rehabilitation, by considering the consistency of the response and providing examples of observable representations of quality of life (e.g., "life is good").

Reliability and validity. Although efforts had been made to validate the FAOM by comparing it to other similarly used ratings scales (e.g., Mayo-Portland Adaptability Index (MPAI)), the assessment methods used by each of the assessments for the content areas made it impossible to accurately compare the two assessments (D. Braunling-McMorrow, personal communication, February 9, 2009). Inter-rater reliability is regularly measured by comparing individual clinician completed FAOM scores to clinical team completed FAOM scores. The

latest resulted in a coefficient of .64 (M. Gould, personal communication, May 6, 2011). McMorrow, Braunling-McMorrow, & Smith (1998) validated the FAOM and, despite limited validity and reliability studies, the FAOM has been accepted by multiple peer-reviewed journals (*Brain Injury* and *Journal of Rehabilitation Outcome Measurement*) who have published research studies (Braunling-McMorrow, Dollinger, Gould, Neumann, & Heiligenthal, 2010; Hensold, Guercio, Grubbs, Upton, & Faw, 2006) that use the FAOM as the measurement tool.

Setting

NeuroRestorative Carbondale, formerly the Center for Comprehensive Services, was the first community-based residential PABIR program in the country. Located in the central Midwest, it provides residential PABIR services to individuals with primarily moderate and severe brain injuries. NeuroRestorative Carbondale has multiple programs including those designed for individuals with psychiatric and behavioral sequelae usually considered treatment resistant, and it accepts all forms of funding. The residential PABIR services provided by NeuroRestorative Carbondale have been shown to result in significant functional gain (Braunling-McMorrow et al., 2010).

NeuroRestorative Carbondale's model has been replicated throughout the United States. The data used for this project represent 12 sites in seven states and before elimination of cases due to missing data or statistical outliers totaled 1509 individuals who received residential PABIR services over the last twenty years, which certainly qualifies as a large naturalistic community-based sample. This type of large naturalistic community-based sample offers the opportunity to generalize findings far beyond that of a RCT or even typical community-based sample project.

NeuroRestorative residential PABIR procedure. This section generally describes the procedure in place during collection of these data (August 1991 – June 2011). Individuals participating in NeuroRestorative residential PABIR programs receive multidisciplinary services (physical therapy, occupational therapy, behavior therapy/counseling, speech therapy, cognitive therapy, case management, rehabilitation therapy, and nursing). Upon arrival, therapists from each of the disciplines evaluate the individual's need for their specific service. After the individual therapy disciplines have completed their evaluations, the clinical team meets to discuss and conceptualize the treatment plan (taking into account individual, family, and clinical goals) in accordance with Commission on Accreditation of Rehabilitation Facilities (CARF) standards. During this conceptualization meeting, the clinical team completes the Functional Area Outcome Menu (FAOM) (Braunling-McMorrow & Tompkins, 1994; Braunling-McMorrow & Neumann, 1999) to establish a baseline assessment of independence and functioning in 10 content areas (additional information about the FAOM will be presented later in the proposal). The treatment team also selects several of the FAOM content areas and establishes treatment goals based on improvements expected to be made as a result of the residential PABIR services provided.

The clinical team communicates regularly in accordance with CARF standards. The individual continues to receive treatment until the clinical team feels maximum improvement has occurred, funding is terminated, or the individual/guardian terminates treatment. As the discharge date approaches, the individual's clinical treatment team reconvenes for a discharge meeting. During this meeting, clinicians complete another FAOM based on the individual's expected functioning the day after discharge (this is done because some items on the FAOM are affected by the type of living arrangements offered during treatment compared to those after

discharge). In re-evaluating the individual with the FAOM based on their current level of functioning, the clinicians are determining to what extent their treatment goals were accomplished. This information is captured in the NeuroRestorative program evaluation dataset.

Sampling Procedure

Determining adequate sample size necessary for reliable estimation of model coefficients in a logistic regression study can be challenging because of (a) base rate or response probability within the population of interest (rareness of the event), (b) difference in sample size between the two response categories (success versus failure), (c) number of observations per covariate pattern (sparseness of the data), (d) the type of covariates included in the model (continuous versus categorical), and (e) the expected number of events per covariate (O'Connell & Amico, 2010). Additionally, the case to variable ratio influences the number of covariate patterns and likelihood of small numbers of cases in response group pairs.

Hosmer and Lemeshow (2000) recommended the sample size of the smallest response group be at least as large as $10(p + 1)$, where p is the number of predictors in the model. The proposed study included seven predictors, which would require a minimum of 80 cases in the smallest response in accordance with Hosmer and Lemeshow. The initial data set had 1103 subjects and the smaller response set (unsuccessful) had 240 cases, thus meeting the minimum requirement. The preliminary final model, with only five predictors, had 196 cases in the smaller response group (unsuccessful), meeting Hosmer and Lemeshow's minimum requirement. After completing the model-building process, as guided by Hosmer and Lemeshow's 5-step process (explained in detail later in this chapter) the final model with five predictors had 71 cases in the smaller response set (unsuccessful). 71 exceeds the minimum requirement of $10(p + 1)$, where p is the number of predictors in the model [$p = 5$, $10(5+1) = 60 < 71$].

Response Variable

The uniqueness of each injury and each rehabilitation plan results in variability in treatment goals. In this study, the response variable is treatment outcome with either successful (1) or unsuccessful (0) as dichotomous options, employing artificial dichotomization based on the number of improvements by at least one level for 8 FAOM items. Artificial dichotomization of response variables is not the ideal method in most areas of inquiry (O'Connell & Amico, 2010). In the case of this response variable, a focus group was used to determine the best method to quantify treatment outcome as a dichotomous variable.

Focus group. Three clinicians, each with 10+ years of experience using the FAOM, agreed to meet via conference call to determine a method for quantifying treatment outcome into a dichotomous variable. The clinicians were the department supervisors from the Speech Language department, Occupation Therapy department, and Counseling department. The conference call began with a brief explanation of the study and a summary of committee discussion from my prospectus.

The first part of the discussion was determining whether or not to use change in individual items or change in total FAOM score to represent treatment outcome. The determination was made to use change in individual items in place of change in total FAOM scores. Each focus group participant could site multiple examples of cases where someone's success could be misrepresented by large changes in single items or several small changes with a decrease that offset the meaningful changes.

The second part of the discussion focused on identifying which of the 10 items should be considered for inclusion. The focus group unequivocally agreed that all of the first five FAOM items (residential status, level of independence, behavioral and emotional status, level of

community participation, and level of awareness) should be included. After some discussion, the determination was to not include the vocation/higher education/structured productive activity and involvement in vocation or education items. Reasons for not including these items included the following: skew in distribution of answers because the item is rated based on expected functioning the day after discharge and many of these item activities require a transition period, inaccurate representation of change because of skewed distribution, nature of improvements better captured by other items given the influence of the skewed distribution.

Level of self-managed health, item 7, was generally considered worthy for inclusion. There was some concern about not being able to observe the behaviors assessed at the higher rating levels, but consensus was that it should be included because of the relationship between level of self-managed health and independence. There was rather extensive discussion about whether or not to include the last two items, intimacy/relationships and quality of life. Although each of these items has observable and measurable guidelines for ratings, the focus group felt that, in their experience, there was often subjective input based on individual clinician perception. Eventually, the focus group consensus was to include these items because final FAOM ratings were the result of an interdisciplinary team interaction and represented the consensus of the clinical team. As a result of this portion of the discussion, 8 of the 10 FAOM items were determined worthy of inclusion in attempting to quantify treatment outcome.

The final part of the focus group discussion focused on determining how to measure change in the eight FAOM items in order to distinguish between successful and unsuccessful treatment outcome. For program evaluation purposes, case managers were trained to mark a discharge as successful if at least half of the treatment goals established during the admission process using the ten items from the FAOM were met. Meeting a treatment goal meant

achieving the predicted level of functioning made during the admission interdisciplinary team meeting. Using this as a guide, discussion focused on establishing the amount of improvement needed in each of the items and the number of improvements needed at the established amount in order to distinguish successful from unsuccessful treatment outcome.

The final decision was that an improvement of at least one level (e.g., rating of 2 at admission and rating of 3 at discharge) on at least four of the eight FAOM items represented a successful discharge. There are inherent limitations in artificially dichotomizing a response variable. However, using a focus group as explained above incorporates the input of highly experienced clinicians with numerous years using the tool. The consensus of the focus group represents a determination of successful outcome by individuals who possess extensive knowledge about both brain injury rehabilitation and the FAOM assessment tool. This supports the determination of success based on this dichotomization as an effective method given the inherent differences among individuals with ABI and their treatment plans.

Predictor Variables

The following variables are identified as predictor variables based on a literature review and clinical experience: *age of onset, years of education, injury severity, substance use at time of admission, level of awareness/change in awareness, functioning at admission, length of stay, and time since injury at admission*. Although the literature supports the use of these variables as predictor variables, a careful model-building approach using univariate analyses between the predictor and outcome variables was used to support inclusion (Hosmer & Lemeshow, 2000). This section describes the variables as they existed in the original data set. The actual predictor variable selection process is described in detail in Chapter Four: Results.

Age of onset. This study is only interested in those who were 18 years or older at the time of admission. The literature describes peaks in specific age groups but not necessarily in the adult population. Age of onset (N = 983) data range from 16 – 77 with *M* =33.67, SD = 13.875 is considered continuous and was used as such during the predictor variable selection process.

Years of education. Years of education data (N = 146) was originally categorized as less than 12 years, 13-14 years, 15-16 years, 16 or more years. As Table 3 shows, there were not enough cases in the 15-16 years or 16 or more years' categories to warrant them being separate categories. Instead, the 13-14 years, 15-16 years and 16 or more years' categories were collapsed into one category, 12 or more years. This dichotomous split resulted in 81(55.5%) with less than 12 years of education and 65(45.5%) with 12 or more years of education. This variable was considered dichotomous when used during the predictor variable selection process.

Table 3

Education Level Categories as Coded in Original Dataset.

Characteristic	N	Valid percentage
Years of Education:		
< 12 years	81	55.5
13-14 years	45	30.8
15-16 years	14	9.6
16+ years	6	4.1
Total	146	100%

Injury severity. Injury severity was coded in the original data set as mild, moderate, and severe. Generally, the population served by residential PABIR programs is those in the moderate

to severe range. Table 4 represents the breakdown of injury severity in the original data set. Injury severity was coded as a categorical variable during the predictor variable selection process.

Table 4

Injury Severity as Coded in Original Dataset

Characteristic	N	Percentage	Valid Percentage
Injury Severity:			
Mild	119	8.2	9.7
Moderate	120	8.3	9.8
Severe	963	67.7	80.4
Missing	230	15.8	
Total	1452	100%	100%

Substance use at time of admission. This variable is coded in the original data set as either "Yes" when an individual was a substance user at the time of admission or "No" if the individual was not a substance user at the time of admission. The responses for this question were gathered during an intake evaluation interview with any substance use considered "Yes". For the purpose of analysis, No = 1, Yes = 0 because 1 represents the direction of interest in that the opinion suggests someone who has a substance use issue is more likely to not have a successful treatment outcome.

Level of awareness/Change in awareness. Level of awareness at admission to a residential PABIR program is assessed by item 5 on the FAOM. It integrates the Pyramid Model of self-awareness (Crosson et al., 1989) conceptualization of awareness existing at hierarchical levels (refer to Chapter 3: Instrumentation or Appendix A for additional clarification) with higher scores representing better awareness. The ordinal nature of the variable does not affect its use as

a predictor variable, only the interpretation of the findings. Level of awareness was coded as a categorical variable with cases originally rated as 5 (n = 12) and 4 (n = 29) compiled into cases rated 3 (n = 266) (see Table 5).

Table 5

Admission Level of Awareness Rating as Coded in Original Dataset

Characteristic	N	Percentage	Valid Percentage
Level of Awareness:			
1	525	36.2	38.2
2	544	37.5	39.5
3	307	21.1	22.3
Missing	76	5.2	
Total	1452	100%	100%

The rationale behind using level of awareness at admission was to investigate if individuals with better awareness are more likely to have a successful outcome. However, this line of thinking does not take into consideration the improvement in awareness that can occur during the rehabilitation process. Evaluating the relationship between the amount of change in awareness and treatment outcome may be a more appropriate evaluation. Change in awareness (N = 1508) is considered a continuous variable with a range of -2 to 4, *M* = 1.12, SD = 1.036 (see Table 6 for distribution of scores).

Functioning at admission. When the full FAOM is used it provides a functioning score range of 10 (very low) to 50 (very high). These scores represent an individual's functioning at time of measurement (in this case admission). As already discussed, 2 of the 10 FAOM items were eliminated as part of the focus group determination of a quantifiable method of determining

successful treatment outcome. All cases with missing data on items 1-5 were eliminated from the data set. However, there were several with missing data in items 6, 7, and 8. Eliminating these cases from the data set was not prudent. Instead, a weighted average was calculated by adding all the values of the completed items and dividing it by the number of items answered. The Functioning at Admission variable (N = 1508) ranged from 1 – 4.75 with *M = 2.036* and SD = .641 was considered a continuous variable during the predictor variable selection process.

Table 6

Change in Awareness as Coded in Original Dataset.

Characteristic	N	Valid Percentage
Injury Severity:		
-2	10	0.7
-1	61	4.0
0	338	22.4
1	557	36.9
2	416	27.6
3	116	7.7
4	10	0.7
Total	1508	100%

Length of stay. The relationship between length of stay and treatment outcome in the PABIR setting is not very well established. Conceptually, it seems faulty to expect there to be a linear relationship between length of stay and treatment outcome. Descriptive statistics of length of stay (in months) from the original data set (N = 1508) with a range of .033 to 51 and *M* = 6.08, SD = 6.17. Because of the relationship between the mean and standard deviation as well as the

skewed distribution, the mean was not the optimal measure of central tendency. Additionally, the intention of including a length of stay variable was to distinguish between those who had lengths of stays less than what would be expected or suggested. To identify a potential cut-point visual binning transformation was completed using SPSS software. Cut-points were established at the quartiles with the 1st quartile cut-point being 2.23. A cut-point at 2-months was established with 0 representing cases with lengths of stays less than or equal to 2 months and 1 representing cases with lengths of stays greater than 2 months. It was considered a dichotomous variable during the predictor variable selection process.

Time since injury at admission. The function of time on recovery and on level of awareness was explored in the literature review. Including time since injury provides perspective to the potential relationship among predictor variables and between predictor variables and the response variable. Time since injury is a continuous variable but does not have a linear relationship with treatment outcome. In the data set cleaned of outliers, the variable time since injury (N = 983) ranged from 0.1 – 111 months with M = 15.63, SD = 20.72. Because of the large standard deviation and skewed distribution, the median (6.5) is a better measure of central tendency. An artificial dichotomization at 6-months better represented the meaning of including time since injury as a predictor variable in that it established a data-driven point of comparison (Malec & Basford, 1996). During the predictor variable selection process time since injury measured in months was entered as a dichotomous variable with 0 representing those admitted for residential PABIR at or before 6-months post injury and 1 representing those who admitted after 6-months post injury (see Table 7 for the name, description, and type of each variable).

Procedure

All of the data needed for this study were already coded for program evaluation purposes.

Table 7

Name, Description, and Type of Variables

Name	Description	Type of variable
Gender	Male (1) or Female (0)	Demographic, Nominal (dichotomous)
Location of Program	What state the NeuroRestorative program is in	Demographic, Nominal (categorical)
Age at Admit	Age of person with ABI when admitted to residential PABIR program	Demographic, Continuous (interval)
Injury Severity	Severe (2) or Moderate (1)	Demographic, Ordinal (dichotomous)
Substance History	Presence (1) or absence (0) of historical substance use issues at time of admission.	Demographic, Nominal (dichotomous)
Education Level	Years of education at time of admission with <12 years (0) and ≥ 12 yrs (1)	Predictor, Nominal (dichotomous)
Age at Injury	Age of person with ABI when (s)he acquired their brain injury	Predictor, Continuous (interval)
Time post injury	Latency between date of injury and date of admission into residential PABIR program. Split into two categories with ≤6-months (0), >6-months (1).	Predictor, Nominal (dichotomous)
Substance Use at time of admit	Participant is actively using substance at the time of admission (1) or not actively using at the time of admission (0) as determined by records obtained at admission	Predictor, Nominal (dichotomous)
Length of Stay	Length of stay in residential PABIR. Split into two categories with ≤2-months (0), >2-months (1).	Predictor, Nominal (dichotomous)
Functioning at time of admit	Total FAOM score for the 8 selected items divided by the number of items answered (creating a weighted average)	Predictor, Continuous (interval)
Level of awareness	FAOM Level of Awareness score at admission as determined by interdisciplinary treatment team	Predictor, Ordinal (categorical)
Change in Awareness	Difference between discharge and admission level of awareness ratings.	Predictor, Continuous (interval)
Treatment Outcome	Successful (1) or Unsuccessful (0) as determined by number of treatment goals predicted during initial IDT meeting	Criterion, Nominal (dichotomous)

After receiving approval from the appropriate risk and human subjects committee, the NeuroRestorative program evaluation team provided these data from their database. Record review was not necessary as prior research studies had identified and filled much of the previously missing data. Using Microsoft Excel, the set was reviewed and cleaned, then identifiable information was removed. The original file with identifiable information was password protected and kept in a password protected folder to prevent access by others but still allow me to reference it for data verification purposes. SPSS software was used for analyses. These data were only accessible by the researcher and committee members who completed the NeuroRestorative research associate agreement. The file with unidentifiable information was kept on a password protected computer. These data were returned to NeuroRestorative upon completion of the project.

Research Questions and Analyses

The proposed study uses logistic regression analysis design to explain treatment outcome by considering seven predictor variables. A logistic regression is a type of generalized linear models used to predict the probability of success (response probability) conditional on one or multiple predictors (O'Connell & Amico, 2010). In addition to predicting the response probability, a logistic regression model helps identify relationships among predictors and allows for model-fit diagnostics.

The following research questions guided this study:

1) Considering other established factors related to treatment outcome, how does self-awareness influence treatment outcome?
2) How do multiple predictor variables interrelate to influence treatment outcome following residential post-acute brain injury rehabilitation?

Analyses. Regression is used to make predictions and gain understanding about the relationship between predictor variables and a response variable. This type of analysis is ideal for evaluating treatment effectiveness when the dependent variable is continuous. A common occurrence that undermines the assumptions underlying regression is multicollinearity – similarity among the predictor variables. Logistic regression is an alternative type of regression that allows for relationships between predictor variables to be considered when evaluating the regression model, which is necessary for this investigation. Logistic regression differs from traditional regression approaches because logistic regression requires use of a dichotomous response variable. In this study a compromise is made in that treatment outcome is operationalized such that it can exist dichotomously so that the inherent similarity between predictor variables can be accounted for in the analysis rather than negatively influencing their relationship with treatment outcome.

Assumptions of logistic regression. Using a logistic regression requires the response variable be binary. Kerlinger and Lee (2000) used 'successful or not successful' as an example of when use of a logistic regression design is the appropriate analytic approach, supporting use of logistic regression design as the appropriate analytic approach for this study. The logistic regression requires the response variable be appropriately coded with 1 representing the desired outcome. It is also important to properly fit the regression model, which requires including only meaningful variables. A detailed description of the model-building process using the Hosmer and Lemeshow (2000) variable selection process is provided in Chapter Four: Results. The Hosmer and Lemeshow approach was chosen in place of using a stepwise method to estimate the logistic regression because it is important to consider clinical appropriateness and refit the model

with previously excluded variables when trying to create a generalizable model (Hosmer & Lemeshow, 2000).

A logistic regression requires each predictor variable be independent of the other predictor variables (no multicollinearity). This is problematic with these predictor variables because of the nature of the investigation. Fortunately, logistic regression allows for the option to account for these effects (e.g., interaction, mediating, modifying) of the predictor variables in the analysis of the model if necessary. To reduce Type I error when using a logistic regression, it is important for there to be a linear relationship between the continuous predictor variables and the log odds—a quotient comparing the probability of success to the probability of failure. Finally, adequate sample size must be met. A detailed explanation about the steps taken to assure an adequate sample size was provided earlier in the methods section.

CHAPTER FOUR

RESULTS

This chapter reviews the predictor variable selection process, model fit procedures, and presents the final model. Hosmer and Lemeshow's (2000) model building approach was used and will be referenced throughout. Demographic variables describe the sample so as to provide a reference guide for generalization.

Variable Selection

Hosmer and Lemeshow (2000) suggest starting the selection process with a careful univariate analysis of each variable. They recommend including in the multivariable analysis any variable with a *p*-value < 0.25 based on the work of Mickey and Greenland (1989). The rational for such a high *p*-value is that often a traditional level (0.05) eliminates variables that are clinically important and may be statistically significant when included with other relevant predictor variables. While including variables with such high *p*-values increases the chances of including questionable variables, care in determining why the variable is relevant and systematically evaluating its relevance throughout the model building process is likely to correctly identify the variable's relevance.

Education Level. The first variable evaluated for inclusion in the multivariable model was years of education, coded edlevel. After consolidating the variable into two categories (<12 yrs and ≥12 yrs), univariate analyses were run. Results of the univariate logistic regression analyses were not significant, χ^2 (1, N = 206) = .295, p = .587 suggesting neither individuals with less than 12 years or 12 years or more of education were more likely to have successful treatment outcome. Given this information, years of education was eliminated from the pool of variables considered for the multivariable model.

Severity of injury. The second variable evaluated for inclusion in the multivariable model was severity of injury. Descriptive analyses reflected 80% of the sample had a severe injury with 10% having a moderate injury and 10% having a mild injury. Univariate analyses were run with severity of injury coded as a categorical variable. Results of the univariate logistic regression analyses were not significant, χ^2 (2, N = 1222) = .206, p = .902. Neither mild p = .903, moderate p = .660, nor severe p = .707 injury severity were significant predictors of treatment outcome. This seems inconsistent with the reviewed literature (Marshall et al., 1991; Shutter & Jallo, 1998; Stein & Ross, 1992), which covers the full span of injuries but do not necessarily consider functional outcome. The level of care provided in the residential PABIR setting is focused on functional outcome and most appropriate for persons with severe and moderate injuries. Other literature (Diringer & Edwards, 1997; Zafonte et al., 1996) suggests severity of injury is not good predictor of functional outcome. The determination was made to delete all cases with missing severity of injury data (n = 230) and mild severity of injury (n = 119).

Level of awareness at admission. The third variable evaluated for inclusion in the multivariable model was level of awareness at admission, coded AdmitLvl_awrns. After the variable was consolidated into three categories (as discussed in Chapter Three: Methodology) univariate analyses were run. Results of univariate logistic regression analyses were significant, χ^2 (2, N = 1103) = 24.973, $p < .001$. Closer investigation of the results showed a significant relationship between treatment outcome for both individuals with very low levels of awareness (rating of 1) and very high levels of awareness (ratings of 3, 4, and 5). While these findings were relevant and somewhat consistent with the study hypothesis, they did not encompass the concept behind evaluating the effect of awareness on treatment outcome. Further consolidation of the

variable was not possible. In re-evaluating the intent of investigating awareness, it seemed the better measure was the effect of change in awareness during the course of rehabilitation on treatment outcome. By measuring the change in awareness the direct relationship between awareness and treatment outcome was being evaluated. However, awareness is one of the items used to determine whether or not an individual's outcome was successful. Additional steps were taken to demonstrate the predictor variable (change in awareness) was independent of the other FAOM difference variables.

Change in awareness. Prior to demonstrating change in awareness was independent the other FAOM difference variables it was important to assess whether or not it met criteria for inclusion in the multivariable model. Univariate analyses were run with change in awareness coded as a continuous variable. Results of the univariate logistic regression analysis were significant, χ^2 (1, N = 1103) = 307.491, $p < .001$. The next step was demonstrating change in awareness was independent of the other FAOM difference variables by evaluating how it compared to the other FAOM item difference scores. Multivariable logistic regression with the eight FAOM items difference scores as predictor variables and treatment outcome as the dependent variable provided a reference for comparison of each FAOM item taking into account the influence of the other FAOM items (see Table 8 for results).

Change in level of awareness had the third highest Wald statistic behind level of independence and quality of life. Given the stated purpose of residential PABIR is increased independence and improved quality of life these findings are consistent with expectations. These analyses demonstrate the worthiness of change in awareness being included in the multivariable model. To establish the change in awareness variable is independent of the dependent variable (treatment outcome) Pearson Correlation analyses were run. There was a moderate correlation

(.540) between change in awareness and treatment outcome, which is not high enough to suggest a lack of independence between the change in awareness and treatment outcome variables.

Table 8

Logistic Regression Showing Order of Relevancy of 8 FAOM Difference Scores

	B	S.E.	Wald	df	*p*	Odds Ratio
ResStat	.665	.136	24.083	1	.000	1.945
LvlIndpndnce	1.651	.242	46.545	1	.000	5.214
Behav	1.317	.226	34.002	1	.000	3.733
ComAccess	.896	.170	27.883	1	.000	2.450
LvlAwnrs	1.517	.254	35.701	1	.000	4.561
Health	1.572	.267	34.725	1	.000	4.815
Intimacy	1.211	.227	28.511	1	.000	3.357
QoL	1.242	.203	37.270	1	.000	3.463
Constant	-4.817	.511	88.824	1	.000	.008

Age at onset. The next variable evaluated for entry into the multivariable model was age at onset. The literature did not provide a clear relationship between age at onset and treatment outcome with respect to PABIR. Univariate analyses were run with severity of injury coded as a continuous variable. Results of univariate logistic regression analyses were not significant, χ^2 (1, N = 1103) = 1.140, p = .286, Wald = 1.127, statistic was p = .288. Although this failed to meet the minimum suggested standard of p = .25, the potential clinical relevance, especially given the exclusion of years of education caused me to consider it worthy for inclusion in the multivariable model.

Time post injury. Time post injury in months was the next variable evaluated for entry into the multivariable model. Univariate analyses were run with time post injury coded as a

continuous variable. Results of univariate logistic regression analyses were significant, χ^2 (1, N = 1103) = 8.130, p = .004. Time post injury was included in the multivariable model.

Functioning at admission. Functioning at admission, labeled FunctAtAdmit, was the next variable evaluated for inclusion in the multivariable model. Univariate analyses were run with functioning at admit coded as a continuous variable. Results of univariate logistic regression analyses were significant, χ^2 (1, N = 1103) = 51.007, p < .001. Functioning at admission was included in the multivariable model.

Length of stay. Length of stay in months was the next variable evaluated for inclusion in the multivariable model. Univariate analyses were run with length of stay in months coded as a continuous variable. Results of univariate logistic regression analyses were not significant, χ^2 (1, N = 1103) = 1.329, p = .249, Wald = 1.374, p = .241. However, length of stay in months met the standard of p = .25 for inclusion in the multivariable model.

Substance use at time of admission. The final variable evaluated for inclusion in the multivariable model was whether or not the participant was actively using substances at the time of admission, coded subcrnt. Univariate analyses were run with subcrnt entered as a dichotomous variable with 0 = Yes and 1 = No as the predominant opinion suggests someone without a substance use issue is more likely to be successful. Results of univariate logistic regression analyses were not significant, χ^2 (1, N = 513) = 1.165, p = .280, Wald = 1.106, p = .293.

As discussed in Chapter One and Chapter Two, active substance use is often a barrier to admission into many non-substance use rehabilitation programs. Individuals with substance use issues can present with behaviors that interfere with provision of rehabilitation services and the predominant opinion had been that the substance use issue needed to be addressed before the

other disability need could be rehabilitated. Current alcohol and other drugs or abuse (AODA) research suggests it is best to simultaneously address substance use and other disabilities instead of trying to address one while ignoring the other (Koch & Dotson, 2008). Given all of these clinical reasons, despite failing to meet the $p = .25$ criteria, the clinical relevance of active substance use as a barrier to admission made it worthy for inclusion in the multivariable model.

Multivariable model. Variables that met statistical or clinical criteria for inclusion in the multivariable model were age at onset, substance use at admission, time post injury (months), functioning at admission, length of stay (months), and change in awareness. Multivariable logistic regression analyses were run with age at onset, time post injury (months), functioning at admission, length of stay (months), and change in awareness coded as continuous variables and substance use at admission coded dichotomously. Results of multivariable logistic regression analyses were significant, χ^2 (6, N = 513) = 127.001, $p < .001$ (see Table 9 for the results of the initial multivariable model). Hosmer and Lemeshow (2000) suggest using an examination of the Wald statistic and a comparison of each estimated coefficient from the multivariable model to the model containing only that variable. Variables should be deleted, added, and verified until all of the seemingly important variables are included and those excluded are done so for clinical or statistical reasons.

Prior to making decisions about inclusion or exclusion of variables it was important to verify the minimum number of cases in the smallest response group met the $10(p+1)$ criteria. In this regression, $10(6+1) = 70 < 105$ (number of unsuccessful outcomes), thus meeting the sample size criteria. The initial set of decisions based on the multivariable model results is to eliminate age at onset as a predictor variable. When coded as a continuous variable, age at onset is not appropriate for use in the multivariable model. The literature establishes a decrease in treatment

Table 9

Initial Multivariable Logistic Regression Model

	B	S.E.	Wald	Df	*p*	Odds Ratio	95% C.I. for Odds Ratio	
							Lower	Upper
AgeAtOnset	-.007	.0100	.580	1	.446	.990	.970	1.010
subcrnt(1)	-.593	.37	2.610	1	.106	1.81	.880	3.720
TPImonths	-.003	.002	1.520	1	.218	.997	.993	1.000
FunctAtAdmit	-.474	.200	5.480	1	.019	.620	.420	.930
LOSmonths	-.026	.020	1.890	1	.170	.980	.940	1.010
ChngInAwrns	1.538	.180	69.890	1	.000	4.66	3.250	6.680
Constant	1.780	.670	6.970	1	.008	5.93		

success when individuals are 55 years or older. However, this data set has less than 8% at or above age 55 making the division of the continuous variable into two groups unwise. Despite the dramatic effect inclusion of substance use at admission has on the size of the data set (elimination of 53.5% of cases), when included the minimum size of the smallest response set is met and its clinical relevance makes it important to keep. Both the time post injury (TPI) and length of stay (LOS) variables had noticeable changes in their Wald statistic and level of significance when entered into the multivariable model. Further analysis was needed to identify outliers and better define the purpose of including these variables.

Re-examination of TPI and LOS variables. To evaluate the shape and utilization of the TPI and LOS variables descriptive analyses were run (see Table 10). The difference between the Means and Medians drew my attention to the minimum and maximum values. These values resulted in a range far too large suggesting the need to investigate for outliers.

Table 10

Descriptive Statistics for TPI and LOS

Statistic	TPI (months)	LOS (months)
Mean	26.8	6.257
Median	7.56	4.333
Minimum	0.1	0.1
Maximum	383.33	51.1

Total N = 1103

Investigation of outliers using box plots is shown in Figure 1. Cases outside the horizontal line above the box represent outliers. After re-examining the variables and their distributions, the decision was made to delete from the data set all individuals with TPI > 10 years (120 months) and all individuals with LOS > 2 years (24 months), both parameters help to eliminate unique cases to those typically receiving residential PABIR.

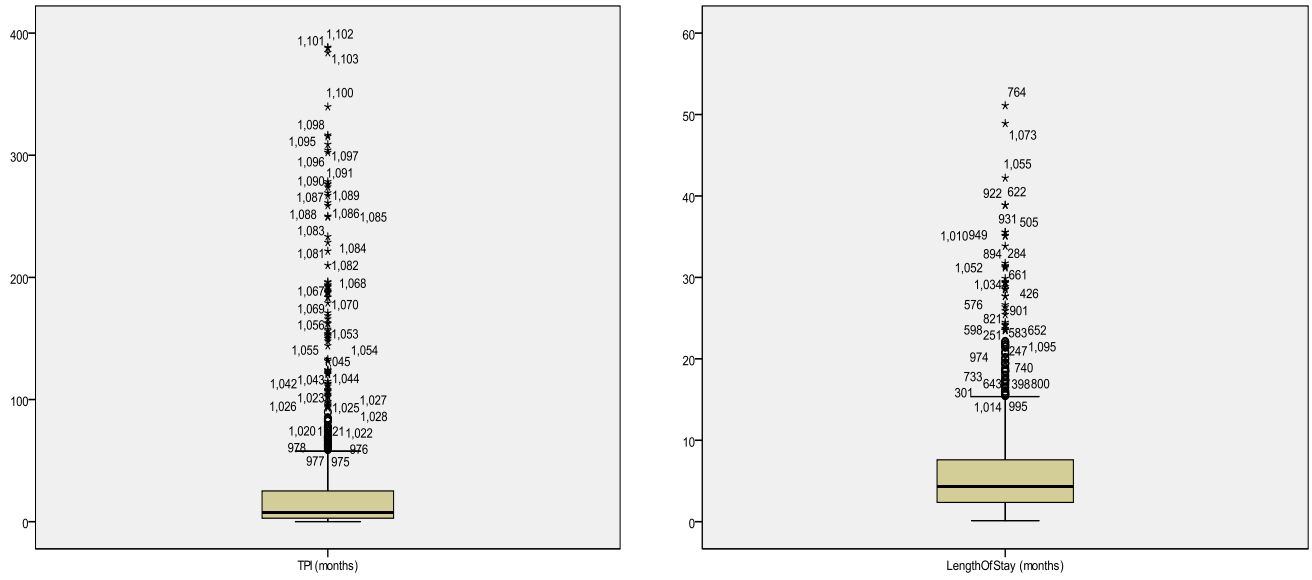

Figure 1: Box plots depicting outliers for TPI and LOS variables

After re-examining TPI and LOS and deleting outliers, it was important to reconsider the appropriateness of each of these variables being considered continuous. Given the literature and the results of the multivariable analyses, it seemed worthy to consider creating dichotomous variables based on clinical and statistically meaningful cut-points. Using the visual binning transformation procedures TPI and LOS were split into dichotomous variables. Previous literature (Braunling-McMorrow et al., 2010) had used TPI cut-points of 6-months and 1-year. Because the median for TPI after reduction in outliers was 6.5, it was decided to set 6-months as the cut point with those admitting 6-months or less post-injury coded as 0 and those admitting longer than 6-months post-injury coded as 1.

Previous literature (Jones & Evans, 1992; Ruff & Niemann, 1990) concerning length of stay was inconsistent but suggested a minimum length of stay necessary to be successful. Seeking to establish a point at which an unsuccessful outcome becomes a successful outcome, the first quartile 2.2 months was a logical place to look. For the ease of description and consistent with Ruff and Niemann (1990), 2-months was used as a cut-point with those remaining in treatment for 2-months or less being coded as 0 and those with lengths of stay greater than 2-months being coded as 1.

Preliminary model with TPI and LOS as dichotomous variables. Variables included in this analysis were substance use at time of admission (subcrnt), functioning at admission (FunctAtAdmit), change in awareness (ChngInAwarns), time since injury in months dichotomously split at 6-months (TPI6months), and length of stay dichotomously split at 2-months (LOS2months). Results of multivariable logistic regression analyses were significant, χ^2 (5, N = 461) = 132.286, $p < .001$, indicating the model was able to distinguish between

individuals who were and were not successful (see Table 11 for the preliminary main effects model results).

Table 11

Preliminary Main Effects Logistic Regression Model

	B	S.E.	Wald	df	*p*	Odds Ratio	95% C.I. for Odds Ratio	
							Lower	Upper
subcrnt(1)	-.930	.420	4.840	1	.028	2.530	1.110	5.800
FunctAtAdmit	-.260	.220	1.370	1	.241	.770	.500	1.190
ChngInAwrns	1.730	.210	66.50	1	.000	5.650	3.720	8.560
TPI6months(1)	-.895	.340	6.940	1	.008	.410	.210	.7950
LOS2months(1)	.510	.340	2.310	1	.129	1.670	.860	3.220
Constant	.930	.550	2.840	1	.092	2.540		

Note: (1) reflects the variable is a categorical variable with the reference group listed first.

Evaluating collinearity among predictor variables. At this point Hosmer and Lemeshow (2000) recommend exploring any potential relationships among variables in the model. If an interaction is identified, systematic removal and inclusion of each variable in the equation and a comparison of the Wald and significance values of the variables in those models is required. Pearson Correlation analyses and collinearity statistics obtained through traditional multivariable linear regression analyses can be used to evaluate the relationships among the predictor variables.

The Pearson Correlation table (see Table 12) reflects no moderate or strong correlations among the predictor variables. The lack of a strong correlation suggests there is no interaction among the predictor variables. Collinearity statistics provide two values: Tolerance – *how much*

the variability of the independent variable is not explained by the other independent variable and VIF (Variance Inflation Factor) – *the inverse of the tolerance*. A tolerance value that is very small (less than .10) or a VIF value that is very high (value above 10) indicates likelihood of multicollinearity. Collinearity statistics evaluating the potential for multicollinearity among the predictor variables do not suggest reason for concern (see Table 13).

Table 12

Pearson Correlations for Predictor Variables (N = 434)

	subcrnt	TPI6	FunctAdmt	LOS2	ChngAwrns
subcrnt	1.000				
TPI6months	-.161	1.000			
FunctAtAdmit	-.130	.318	1.000		
LOS2months	.010	.201	-.086	1.000	
ChngInAwrns	.019	-.249	-.212	-.013	1.000

Table 13

Collinearity Statistics for Predictor Variables

	Tolerance	VIF
Subcrnt	.965	1.036
TPI6months	.799	1.251
FunctAtAdmit	.852	1.173
LOS2months	.933	1.072
ChngInAwrns	.917	1.091

Elimination of cases. Procedure is to investigate the SPSS casewise list output and investigate all cases with standardized regression values greater than |2.5|. Accuracy of the data should be determined and elimination or exclusion of cases should follow (Pallant, 2010). After several deletions and re-runs of the analysis, 27 cases were removed leaving N = 434.

Final Model

This model contains five independent variables (substance use at time of admit, functioning level at time of admit, change in awareness between discharge and admit, admit before or after 6 months post-injury, length of stay in the program less than or greater than 2 months). The goal was to assess the influence of these factors on whether or not someone would be successful in a residential PABIR program.

Sample characteristics. The sample is consistent with the expected sample of a community integration residential post-acute brain injury rehabilitation program (see Table 14). Eighty-five percent of the sample had severe injuries and 76.7% of were male. Age at onset ranged from 16 to 77 with *M* = 35.1, SD = 14.01 and age at admission ranging from 18 to 77 and *M* = 36.58, SD = 13.684. A smaller sample (N = 132) had available education data with 55.3% having less than 12 years of education.

Time post-injury at admission ranged from 0.5 to 110.93 with *M* = 17.75, SD = 22.32 and 41.9% admitting within the first 6-months post-injury. Length of stay ranged from .13 months to 23.53 months with *M* = 5.78, SD = 4.86 and 24% staying for 2 or less months. Forty-six percent of the sample had a history of substance use but only 15.7% were actively using at the time of admission. Functioning at admission, coded as a weighted average, ranged from 1 – 4.375 with *M* = 2.017, SD = 0.628. Admission levels of awareness were relatively evenly dispersed with 39.4% having poor awareness (rating level of 1), 36.6% having moderate awareness (rating level of 2), and 24% having good to great awareness (rating levels of 3, 4, and 5). Change in awareness ranged from -2 to 3 with *M* = 1.0, SD = 0.945.

Table 14

Sample Characteristics

Characteristic	N	Percentage	Valid Percentage	Range	Mean	Std.Dev
Gender	434					
Female	101	23.3				
Male	333	76.7				
Severity	434					
Moderate	63	14.5				
Severe	371	85.5				
AgeAtOnset	434			16 - 77	35.1	14.01
AgeAtAdmit	434			17 - 77	36.6	13.68
TPI (months)	434			.5 - 110.9	17.8	22.32
≤6mon	182	41.9				
>6mon	252	58.1				
FunctAtAdmit	434			1 - 4.38	2.02	.628
Education Level	132	30.4				
<12 yrs	73	16.8	55.3			
=>12 yrs	59	13.6	44.7			
Missing	302	69.6				
SubHistory	434	98.6				
Yes	197	45.4	46.0			
No	231	53.2	54.0			
Missing	6	1.4				
SubCrnt	434					
Yes	68	15.7				
No	366	84.3				

Table 14 continued

Characteristic	N	Percentage	Valid Percentage	Range	Mean	Std.Dev
ChngInAwrns	434			-2 - 3	1.00	.945
Admit Awarnes	434					
1	171	39.4				
2	159	36.6				
3	104	24.0				
LOS(months)	434			.13 - 23.5	5.78	4.86
≤2mon	104	24.0				
>2mon	330	76.0				
Program State						
Virginia	6	1.4				
Illinois	282	65.0				
Tennessee	14	3.2				
Kentucky	60	13.8				
Florida	54	12.4				
Mass.	17	3.9				
Maine	1	.2				
Treatment Outcome (Response Variable)						
Unsuccessful	71	16.4				
Successful	363	83.6				

Model characteristics. The full model containing all predictors was statistically significant, $\chi 2$ (5, N=434) = 194.751, $p < .001$, indicating the model was able to distinguish between individuals who were and were not successful. The model as a whole explained between 36.2% (Cox & Snell R square) to 61.3% (Nagelkerke R square) of the variance in success rate, and correctly classified 89.4% of cases. Four of the five predictor variables (current

substance use, change in awareness, LOS 2 months and TPI 6 months) made statistically significant contributions to the model (see Table 15).

Table 15

Logistic Regression Representing Factors that Influence Treatment Outcome

	B	S.E.	Wald	df	Sig.	Odds Ratio	95% C.I. for Odds Ratio Lower	Upper
subcrnt(1)	-1.790	.620	8.470	1	.004	5.988*	1.786*	20.000*
TPI6months(1)	-1.710	.500	11.870	1	.001	5.495*	2.083*	14.286*
FunctAtAdmit	.0540	.280	.036	1	.850	1.060	.610	1.840
LOS2months(1)	1.470	.460	10.330	1	.001	4.360	1.780	10.690
ChngInAwrns	3.400	.450	56.130	1	.000	29.920	12.300	72.790
Constant	1.920	.930	4.240	1	.039	6.790		

Note: "*" indicates inversion of odds ratio

The strongest predictor of successful treatment outcome was change in awareness recording an odds ratio of 29.9 indicating that those who's awareness improved by at least one level were nearly 30 times more likely be in the successful treatment outcome group, controlling for other factors in the model. Additionally, persons who admitted into PABIR within six months post-injury were nearly 5.5 times more likely to be in the successful treatment group than those who admitted after 6 months post-injury, controlling for other factors in the model. Those who stayed in the rehabilitation program longer than 2 months were nearly 4.4 times more likely to be in the successful treatment outcome group than those who stayed for 2 months or less, controlling for other factors in the model. The data also suggests that active substance use at

time of admission does not prevent people from being successful, controlling for other factors in the model.

Relationships among predictor variables. As hypothesizes, there were several relationships between the predictor variables that influenced the covariate patterns (see Figure 2). A systematic analysis of all the relationships between all of the predictor variables provided some insight into the likely behavior of the substance use and functioning at admission variables.

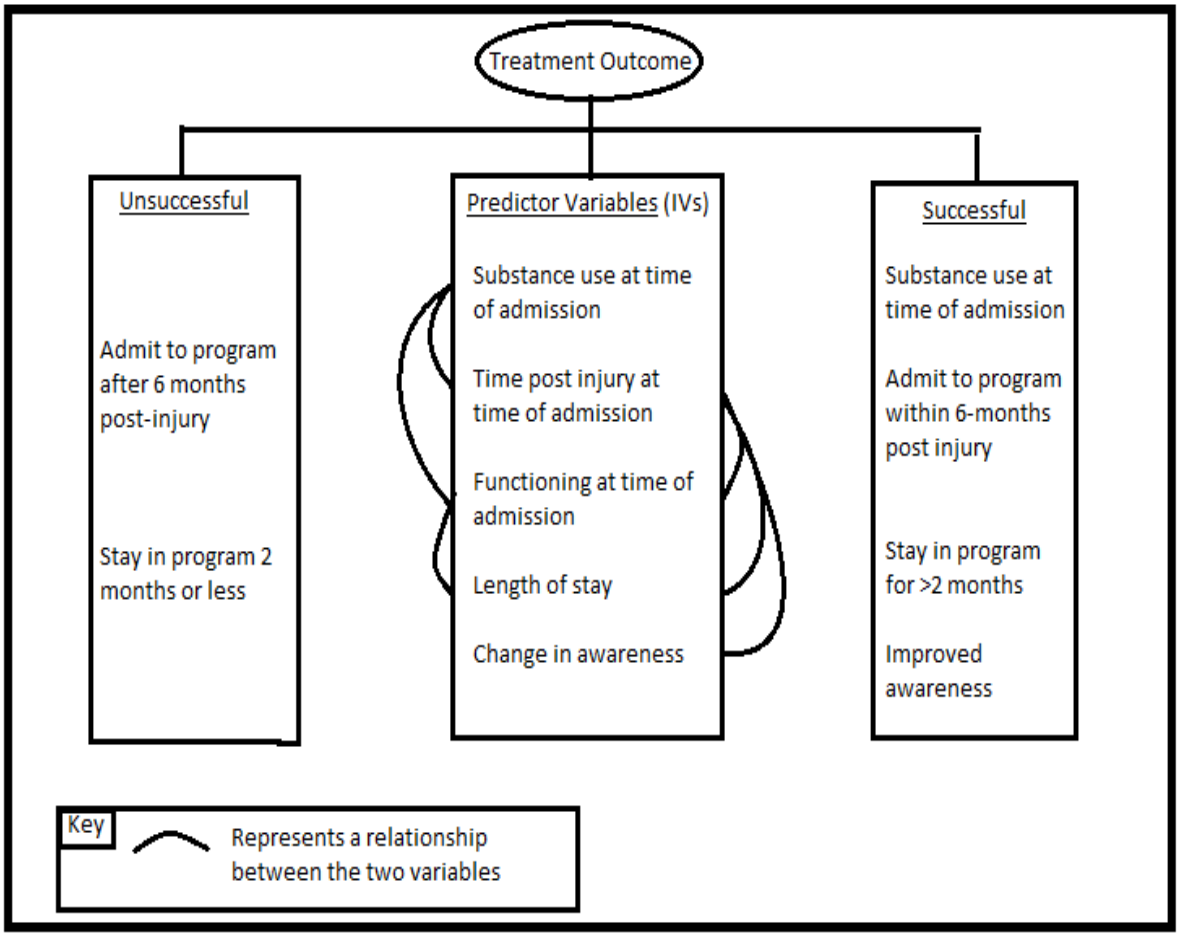

Figure 2: Relationships between/among predictor and response variable

Seventy-six percent of those who were actively using at the time of admission admitted into PABIR 6-months or later from their date of injury. Individuals who were actively using at the time of admission were significantly more likely to be higher functioning, t (432) = 2.716, p = .007. Individuals who entered the rehabilitation program within the first 6-months were significantly more likely to be lower functioning, t (432) = -6.974, $p < .001$. Individuals who admitted into treatment after 6-months post injury were 29.2% more likely to remain in treatment longer than 2-months. Individuals who admitted prior to 6-months post-injury were significantly more likely to have improved awareness, t (432) = 5.351, $p < .001$. There was no significant relationship between change in awareness and whether or not someone stayed longer than 2-months, t (432) = .266, $p < .790$.

CHAPTER FIVE

CONCLUSIONS AND DISCUSSION

This chapter provides a review of the results presented in chapter four, interpretation of the findings given the established literature, discussion about the relevance of these findings in the field, exploration of the studies strengths and challenges, and thoughts about future directions for this line of research.

Sample Characteristics

The sample is consistent with the expected sample of a residential PABIR program. Most (85.5%) of the sample had severe brain injuries and were male (76.7%). The average age at onset was 35 and average age at admission was 36.58. More than half of the sample did not complete 12 years of education but there was missing data (70% of sample) for this variable.

The average amount of time it took for participants to admit into the treatment program was almost 18 months with almost 42% admitting within the first 6-months post-injury. The average length of stay was just shy of 6 months with 24% staying for 2 or less months; typical recommended lengths of stay are 6 – 9 months. Forty-six percent of the sample had a history of substance use but only 15.7% were actively using at the time of admission. The average level of functioning at admission was 2.017 (out of 5). Admit levels of awareness were relatively evenly dispersed with 39.4% having poor awareness (rating level of 1), 36.6% having moderate awareness (rating level of 2), and 24% having good – great awareness (rating levels of 3, 4, and 5). The average change in awareness was 1.0.

Model Characteristics

Treatment outcome was primarily successful n = 363 (83.6%). However, unsuccessful outcomes n = 71 (16.4%) exceeded the minimum 60 cases needed for adequate sample size with

five predictor variables. The model was able to correctly predict 89.4% of the cases and correctly classify 95.9% of the successful treatment outcomes (sensitivity). The model did not do as well (64.8%) classifying individuals who were not successful (specificity). Of the people predicted to be successful, the model accurately picked 93.2% of them (positive predictive value). Of those predicted to be unsuccessful, the model accurately picked 68.7% of them (negative predictive value).

Research Question One

Considering other established factors related to treatment outcome, how does self-awareness influence treatment outcome? Research question one sought to understand how awareness influenced treatment outcome, taking into consideration other factors related to treatment outcome. The initial thinking was that level of awareness at admission would explain treatment outcome. However, the findings were that those with really poor levels of awareness and good levels of awareness explained treatment outcome but those with moderate levels of awareness did not. While this partially answered research question one it was not sufficient. A better measure of the influence of awareness on treatment outcome was the amount of change that occurred during treatment. Measuring awareness in this capacity was more in line with the research relating impaired self-awareness to treatment outcome and awareness to therapeutic rapport and treatment outcome (Herbert & Powell, 1989; Prigatano, 2005; Sherer et al., 2003).

My hypothesis was that improvement in awareness would increase the likelihood of successful treatment outcome. This hypothesis was supported with change in awareness being the most significant predictor variable. Such that, individuals who improved by at least one level of awareness were nearly 30 times more likely to be in the successful treatment outcome group, controlling for other factors in the model.

Research Question Two

How do multiple predictor variables interrelate to influence treatment outcome following residential post-acute brain injury rehabilitation? Research question two sought to understand how multiple predictor variables relate to influence treatment outcome following residential PABIR. The rationale behind this research question was there are many potential predictor variables available prior to someone admitting into a treatment program and even more after an individual admits into treatment. The concern was that similarity among these variables would lead to multicollinearity, which would violate an assumption of the analysis and the generalizability of the findings. The final model depicts significance for four of five predictors taking into the account of each of the other predictors. Despite the relationships between the predictor variables that influenced the functioning at admission variable, there were no multicollinearity violations and all other variables included in the model were significant predictors of treatment outcome.

Discussion

Having a large data set and operationalizing the dependent variable as a dichotomous variable allowed for the use of logistic regression. Using the literature as a guide (Braunling-McMorrow et al., 2010; Jones & Evans, 1992; Malec & Basford, 1996; Ruff & Niemann, 1990) it was possible to dichotomize several continuous variables into clinically relevant dichotomous variables. Using logistic regression allowed for inclusion of both continuous and categorical variables in the model. Odds ratios depicting the relationship between the categorical variables and the dependent variable provided a clear comparison of distinct groups differentiated at clinically relevant cut-points (Pallant, 2010). The relationship between awareness and treatment outcome supports increased attention on evidence based integration of awareness interventions.

Unfortunately, the literature is sparse with experiments addressing this need and an established consistent intervention has yet to be published (Cheng & Man, 2006; Goverover, Johnston, Toglia, & Deluca, 2007).

Although level of functioning at admission was not a significant predictor of treatment outcome, the behavior of the variable caused deeper analysis of the relationships among the predictor variables. The results of these investigations depict possible reasons why level of functioning at admission was not significant as well as relationships among known predictors of treatment outcome that are supported by clinical input. For example, those who were actively using at the time of admission were significantly more likely to be higher functioning. Clinically, an individual must be able to independently access or arrange for acquiring substances in order to be actively using. Many people who are low functioning probably do not have the ability to acquire substances. Consistent with the relationship between level of functioning and substance use, a vast majority of those who were actively using at the time of admission admitted 6-months or later. While this could be construed to support the argument against early provision of services because of natural recovery clinically, it more appropriately reflects the increased likelihood of those who do make progress to turn to substance use as a coping mechanism because of an inability to return to their previous level of functioning, which is associated with not receiving services.

Expectedly, one would expect level of functioning to be lower in those admitting into treatment earlier. While a non-brain injury specialist might expect a shorter length of stay for those who admit after 6-months (because of progress already made due to the natural recovery process), the data are that those who admitted into treatment 6-months or later were 29.2% more likely to remain in treatment longer than 2-months. This is consistent with Ashley and Persel

(1999) findings of shorter lengths of stay for those who admitted prior to 6 months post injury compared to those who admitted 6-18 months or 18 months post injury. These data support the brain injury specialist argument for a continuum of services and earlier admission into treatment. By admitting someone into treatment earlier you are able to maintain and amplify the momentum of the natural recovery process occurring at the fastest rate (during the first six months) leading to better goals attainment, better treatment outcome, higher level of functioning, and decreased long-term cost.

With respect to awareness, those who admitted prior to 6-months post-injury were significantly more likely to have improved awareness. Clinically, it is easier to demonstrate the need for services when the need for services is great and before defense mechanisms are established to protect the identity. The literature (Bach & David, 2006; Barco et al., 1991; Crosson, 2000; Crosson et al., 1989; Douglas & Spellacy, 1996; Herbert & Powell, 1989; Hoofien, Gilboa, Vakil, & Barak, 2004; Ownsworth et al., 2000; Rogers & Read, 2007; Wallace et al., 1998) addresses the difficulty of differentiating between psychological denial, a natural part of the recovery process, and impaired self-awareness. Someone admitted to a program within 6-months post-injury will likely be making tremendous progress. Theoretically, this progress makes it easier to accept limitations because prior barriers are no longer present. Hypothetically, the process of overcoming barriers may make it easier to acknowledge current barriers. The ability to acknowledge current barriers coincides with the ability and willingness to acknowledge deficits (awareness) and, because of the ability/willingness to acknowledge deficits improvements in awareness are made. Consistent with the literature that impaired self-awareness can be long lasting (Oddy, Coughlan, Tyerman, & Jenkins, 1985; Prigatano, 1999; Prigatano & Altman, 1990; Ranseen, Bohaska, & Schmitt, 1990; Sherer et al., 1999; Vanderploeg et al.,

2007), there was no significant relationship between change in awareness and whether or not someone stayed longer than 2-months.

Active substance use as a barrier to admission into brain injury rehabilitation facilities cannot continue to occur. Despite being a barrier to provision of services given the historically prevailing opinion that substance use issues must be addressed prior to other rehabilitation issues, leading Alcohol and other drugs or abuse (AODA) research suggests it is best to simultaneously address substance use and other disabilities instead of trying to address one while ignoring the other (Koch & Dotson, 2008). Brain injury rehabilitation is a rehabilitation process and the underlying philosophy of rehabilitation established by the Rehabilitation Act of 1973 is to serve the most severely disabled. Substance use treatment facilities are not designed to work with persons with brain injuries because the behaviors exhibited reflect "non-compliance" and are not accepted (Koch & Dotson, 2008). Many brain injury rehabilitation programs do not have adequate programming or knowledge to provide some level of substance use treatment (Taylor et al., 2003).

Whether it is the hiring of someone with substance use disorder treatment experience and training them to understand and work with the brain injury population, coordinating or collaborating with a local substance use disorder facility, or addressing potential substance use issues during treatment to prevent future co-existing disabilities, there are opportunities to integrate substance use treatment into brain injury rehabilitation treatment. These data support the potential for successful outcomes for persons actively using at the time of admission when proper programming is in place. The benefits of increasing independence and decreasing the risk of substance use following discharge during the same rehabilitation stay are many.

Strengths and Challenges

This study explains the influence of easily identifiable factors on treatment outcome, which can be used to improve funding for services. Additionally, the influence of awareness improvements on treatment outcomes supports increased attention paid to awareness improvement interventions as integral parts of residential PABIR programming. The data set includes cases from eight different states across the Midwest, Northeast, and Southeast over a 16 year time period. All of the programs that provided data except all forms of funding providing an excellent sample of those affected by brain injury.

While these are strengths of the study, there are also several challenges. Many changes were made during the data analysis part of the project. While this could have been expected given the model-building process proposed to the dissertation committee, changes made after project proposal are limitations. The changes made include redefining the substance use variable from substance use at time of injury to active substance use at time of admission. This change was needed because of the type of data gathered (Yes or No for substance use history or substance use current). All that could be reliably gathered from the data was whether or not the individual was actively using at the time of admission. The relevance of this variable is well-established but it varied from what was proposed to the committee.

The awareness variable included in the multivariable model was changed. Initially, level of awareness at admission was the predictor variable but after univariate analyses revealed inconsistency across the levels of awareness an alternative method of assessment was used. It is reasonable to consider change in awareness a more appropriate method of evaluating the relationship between awareness and treatment outcome and it was mistaken to not have it be the

proposed method of evaluating the relationship. However, it is a change from what was proposed to the committee and should be considered a limitation.

Several of the variables proposed to the committee as predictor variables (age of onset and injury severity) did not have a strong enough relationship with treatment outcome during the variable selection process to be included in the multivariable analyses. While changes to the injury severity variable helped improve the generalizability of the findings by better representing the population of those who usually receive residential PABIR, the lack of a linear relationship between age of onset and lack of literary guidance for categorization of the variable (other than 55 or older which was not adequately represented by the data set) required the elimination of age of onset as a predictor variable. Additionally, education level was not included in the multivariable model, which is a weakness given literature (Asikainen et al., 1996; Dikmen, Temkin, & Armsden, 1989; Girard, et al., 1996) supporting a relationship between pre-injury education and treatment outcome. Length of stay was not considered in my prospectus but suggested for inclusion by my committee.

There were likely procedural inconsistencies across the multiple treatment sites. The potential for non-clinician-recommended termination of services skewing the data is problematic. Unfortunately, given the challenges associated with securing funding for adequate lengths of stay in residential PABIR programs (Ashley et al., 2009; Cioe et al., 2010), clinician recommended termination of services may not represent the majority of termination cause.

While the final sample is 30% of the acquired (1452) cases in the data sets, the primary reason for having a sample less than 1/3 the original sample size is the inclusion of the substance use at time of admission variable. For this reason, it may be more appropriate to consider the smaller sample more like the smaller population of persons who met criteria instead of a small

percentage of the potential data pool. As discussed throughout, the predominating opinion was that substance use needed to be addressed prior to other issues. For this reason, NeuroRestorative did not begin collecting data about substance use until the end of calendar year 1999, and even then it was not consistently recorded until after 2001. Even with the reduced sample size, the minimum amount of required cases in the smallest response group with five predictor variables (60) was exceeded. There is a far greater portion of successful outcomes, which affects the case to variable ratio (see Table 16). Despite this, inclusion of the substance use variable has a far more positive than negative influence.

Table 16

Case to Variable Ratio Table for Categorical Predictor and Response Variables

	TPI		LOS		SubCrnt	
	≤6mon	>6mon	≤2mon	>2mon	Yes	No
Unsuccessful	14	57	23	48	7	64
Successful	168	195	81	282	61	302

The variables selected do not include all of the variables demonstrated to relate to treatment outcome. The intention was to balance appropriateness with entirety by including variables known to be strongly associated with other predictor variables not included. However, these attempts may also influence the conclusion validity and strength of the model. Finally, there are many factors that occur during the treatment process that may influence treatment outcome. Accurately identifying and including these factors is virtually impossible, which may cause some to call into question the utility of this investigation. However, it seems more logical

to use the information available to better understand the problem then to fail to attempt because there are too many unknowns.

Future Directions

The argument for improved provision of PABIR services began long before this research project and is likely to continue for long after. There is a glimmer of hope that the Health Care Reform Act will mandate some level of coverage as part of the minimally acceptable benefits package (History of the Passage of the March 2010 Health Care Reform Laws as cited at ProCon.org, 2011). Inclusion of minimum provision of services will increase the availability of funding for many persons who would otherwise not be able to receive services. This study seems to support the benefits of maintaining a continuum of care to maximize outcomes. While this research demonstrates the ability for persons with active substance use to benefit from brain injury rehabilitation therapy, this is a topic in need of greater attention. There seems to be a need in the brain injury community to establish a treatment approach for identifying the likelihood of returning to substance use upon discharge and appropriately treating at each level, establish acceptable standards for mild, moderate, and severe substance use (as is done with the general population), and build relationships with local substance use treatment providers to educate and support their populations of many persons who may have undiagnosed brain injuries or a history of brain injury.

The findings concerning the relationship between self-awareness and treatment outcome support the relationship between self-awareness and therapeutic rapport and treatment outcome (Prigatano, 2005; Sherer et al., 2003; Sherer et al., 2005). Unfortunately, the absence of a clear, concise intervention for improving self-awareness remains frustrating for clinicians who regularly face this barrier to treatment success. Developing a self-awareness treatment

intervention is a major need in the field and the importance of addressing it is highlighted by these research findings. Randomized Controlled Trial (RCT) research to identify and perpetuate an awareness improving intervention or systematic integration could significantly improve treatment outcomes.

Finally, this research is only possible because of the foresight of NeuroRestorative's leadership in the creation of the FAOM assessment, integration of the assessment into treatment planning, and inclusion of variables like current substance use as part of their evaluation process. These decisions resulted in a large dataset that allowed for this type of statistical model-building approach. As the field moves toward a unified measure of treatment outcome with the Mayo-Portland Adaptability Index – 4 (MPAI-4), it is critical we gather relevant data to support future large-scale analytic investigations of the factors that contribute to treatment outcome.

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APPENDICES

Functional Area (FA) Outcomes Menu

Each of the following categories contain a hierarchical five-point scale, or menu, of possible levels of functioning ranked in order from the greatest level of functioning to the least level of functioning. For each category please mark the individual's appropriate level of functioning AS OBSERVED according to the following protocol:

- *Plan of Care (POC): current status of the individual at the time of POC*
- *Admission Status: current status of the individual the day BEFORE the individual admits to CCS (as determined the first two weeks of the admission/evaluation period)*
- *Transfer: status of the individual on the day AFTER the individual transfers*
- *Discharge Status: status of the individual on the day AFTER the individual leaves CCS*
- *Follow-up: current status of the individual at the time of designated follow-up periods*

*Only one level should be marked for each category. If it appears that the individual is functioning in more than one level please mark the least level within the hierarchy (i.e., do not give the individual the "benefit of the doubt"). **NOTE**: The two categories, "Vocation / Higher Education / Productive Activity" and "Educational Status" are mutually exclusive. Each individual will be assessed in only one of these two categories based upon the following criteria: (1) if the individual is an adult he/she will be assessed in "Vocation / Higher Education / Productive Activity;" (2) if the individual is a child or adolescent he/she will be assessed in "Educational Status." Following these two categories is a separate category, "Level of Involvement in Vocation / Productive Activity / Education ," that EVERY individual should be assessed, regardless of whether he/she is an adult, adolescent, or child.*

Residential Status:

__ 5. Individual resides in a home or apartment with no live-in support. This may include an individual who lives with others but does not receive assistance or support from them, or an individual who receives occasional assistance or support from family/friend(s)/staff but does not live with them.

__ 4. Individual resides in a transitional group living arrangement, MENTOR home or in a home/apartment with available residential family/friend(s)/staff who provide consistent support as needed.

__ 3. Individual resides in a congregate group living arrangement (i.e., staff available 24 hours per day) with all or partial residential assistance as needed. This includes long-term supported living placement.

__ 2. Individual resides in a post-acute residential rehabilitation setting.

__ 1. Individual resides in a hospital or institutional setting (acute or sub-acute), including a nursing home.

Level of Independence / Assistance:

__ 5. Individual is completely independent. He/she is independent on a regular daily basis in all tasks including money management, grocery shopping, banking, laundry, etc. *(or 17-24 hours)

__ 4. Individual is independent 9-16 hours per day but he/she requires intermittent assistance in such tasks as, money management, grocery shopping, banking, laundry, etc.

__ 3. Individual is independent 5-8 hours per day including participation in in-home or community activities.

__ 2. Individual is independent up to 4 hours per day, including participation in in-home or community activities.

__ 1. Individual is not independent. He/she requires 24-hour assistance and/or distant supervision.

DBM and ST, 1994
Revised DBM and TN, 1999
CLNCL 048 10/01/03

Functional Area (FA) Outcomes Menu

Reminder: *Each of the following categories contain a hierarchical five-point scale, or menu, of possible levels of functioning ranked in order from the greatest level of functioning to the least level of functioning. For each category please mark the appropriate level that the individual being assessed is currently functioning. Only one level should be marked for each category. If it appears that the individual is functioning in more than one level, please mark the least level within the hierarchy.*

Behavioral / Emotional Status:

__ 5. Individual self-manages his/her behavior\emotional status during difficult life situations without organized assistance from others.

__ 4. Individual self-manages his/her behavior\emotional status during difficult life situations with occasional (i.e., weekly) assistance from others or with minimal environmental manipulation.

__ 3. Individual requires ongoing (i.e., daily) assistance for behavior\emotional status from others or environmental manipulations in order to self-manage behaviors in difficult life situations.

__ 2. Individual is minimally responsive to externally managed interventions that are intended to minimize the frequency and intensity of behaviors\emotional status in difficult life situations.

__ 1. Individual actively resists externally managed interventions, or actively resists interventions that are intended to minimize the frequency and intensity of behaviors\emotional status in difficult life situations.

Level of Community Participation: (WITH or WITHOUT assistance)[1]

__ 5. Individual either participates in an out-of-home employment position, school activity, or productive activity such as organized church or activity, bowling league, or club on a daily basis.

__ 4. Individual either participates in an out-of-home employment position, school activity or productive activity such as organized church, Alcoholics Anonymous (AA), volunteer work or out-patient therapy meetings, or club one time per week or more, but not on a daily basis.

__ 3. Individual participates in functional errands outside of his/her home, such as grocery shopping, laundry, or banking, AS WELL AS leisure activities one time per week or more, but individual does not participate in organized activity or employment.

__ 2. Individual only participates in functional errands such as grocery shopping, laundry, banking …one time per week or more.

__ 1. Individual does not participate in employment, school attendance, functional errands nor leisure activities outside of his/her home.

[1] adapted from Willer, Rosenthal, Kruetzer, Gordon, and Rempel. Community Integration Questionnaire (1993).

Functional Area (FA) Outcomes Menu

Reminder: *Each of the following categories contain a hierarchical five-point scale, or menu, of possible levels of functioning ranked in order from the greatest level of functioning to the least level of functioning. For each category please mark the appropriate level that the individual being assessed is currently functioning. Only one level should be marked for each category. If it appears that the individual is functioning in more than one level, please mark the least level within the hierarchy.*

Level of Awareness:

__ 5. Anticipatory awareness: Individual demonstrates awareness of his/her ability/difficulties by consistently planning ahead.

__ 4. Emergent awareness: Individual demonstrates some awareness of how his/her ability/difficulties impact their day to day by consistently providing or initiating effective strategies. He/she may also sometimes plan ahead for situations or stimuli.

__ 3. Intellectual awareness: Individual demonstrates intellectual knowledge of how to compensate for abilities/difficulties, but not how it impacts his/her day to day. Person may initiate effective strategies, but inconsistently.

__ 2. Individual can identify or acknowledge difficulties/deficits once prompted.

__ 1. Individual does not accurately and/or consistently identify any skill or deficit areas.

NOTE: *Please assess the individual in only one of the following two categories based upon the aforementioned criteria. Do not assess an individual in both of the next two categories.*

Vocation / Higher Education / Structured Productive Activity (adults ONLY):

__ 5. Individual is competitively employed with a competitive wage and a regular work place, enrolled in a competitive degree-oriented academic program with a regular classroom (without organized assistance), or tends to homemaker responsibilities-taking care of family & home so that it does not require paid service.

__ 4. Individual is employed in a noncompetitive formally structured position with consistent on-the-job supervision or assistance (e.g., "job coach") and receives either competitive or commensurate wages, enrolled in a supported degree oriented academic program, attends vocational training with the goal of competitive employment, tends to homemaking responsibilities with consistent full- or part-time supervision/assistance, or performs consistent non-paid volunteer responsibilities one time per week or more.

__ 3. Individual is employed in a noncompetitive therapeutic work environment (e.g., "sheltered workshop" or supported community placement) one time per week or more at a commensurate wage or is enrolled in an academic program that is not degree oriented and may require specialized instruction.

__ 2. Individual participates in an avocational program one time per week or more with no wages where his/her socialization and activity needs are met (e.g., "day activity" program, productive activity program).

__ 1. Individual does not participate in vocational, educational, or structured productive activities one time per week or more.

Functional Area (FA) Outcomes Menu

NOTE: *Please assess the individual in either the previous category or else the following category based upon the aforementioned criteria. Do not assess an individual in both the previous AND the following categories.*

Educational Status: (adolescents or children ONLY)

__ 5. Individual attends a regular classroom with informal support, including preschool and G.E.D. classes, **or has successfully completed high school or G.E.D. classes.**

__ 4. Individual attends a classroom with formal related services (i.e., I.E.P. or 504 Plan) including "special education," attends G.E.D. classes with specialized instruction including assistance from a tutor either within or outside of the G.E.D. classroom, or attends a preschool classroom with specialized services.

__ 3. Individual has been placed in a self-contained resource environment and participates in some regular classes.

__ 2. Individual has either been placed in a self-contained resource environment, attends a private school that has been tuitioned out by the public school system, or receives home-bound educational services and does not participate in any regular classes.

__ 1. Individual does not participate in educational services or endeavors.

NOTE: *Please assess ALL individuals in the following category, regardless of adult, adolescent, or child status.*

Level of Involvement in Vocation / Productive Activity / Education:

__ 5. Full-time participation or more: Individual is involved in more than 30 hours per week of vocational or productive activity endeavors, enrolled in a full-time equivalent vocational training or adult education program (e.g., college, G.E.D., etc.), or is involved in more than 22.5 hours per week of educational endeavors.

__ 4. 3/4-time participation: Individual is involved in more than 20 hours per week but equal to or less than 30 hours per week of vocational or productive activity endeavors, enrolled in a 3/4-time equivalent vocational training or adult education program (e.g., college, G.E.D., etc.), or is involved in more than 15 hours per week but equal to or less than 22.5 hours per week of educational endeavors.

__ 3. 1/2-time participation: Individual is involved in more than 10 hours per week but equal to or less than 20 hours per week of vocational or productive activity endeavors, enrolled in a 1/2-time equivalent vocational training or adult education program (e.g., college, G.E.D., etc.), or is involved in more than 7.5 hour per week but equal to or less than 15 hours per week of educational endeavors.

__ 2. 1/4-time participation: Individual is involved in up to 10 hours per week of vocational or productive activity endeavors, enrolled in a 1/4-time equivalent vocational training or adult education program (e.g., college, G.E.D., etc.), or is involved in up to 7.5 hours per week of educational endeavors.

__ 1. no participation

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Functional Area (FA) Outcomes Menu

Level of Self Managed Health

__5. Self initiates all medical routines, anticipates medical issues, identifies early symptomology, may use organized self directed/or compensatory strategies; ie. knows to call doctor or call for assistance, knows how to self medicate…

__4. Can do basic daily medical routines with or without compensatory strategies, but needs direction/guidance for more complex medical issues; ie. may need help with appointments, diabetes management, medicine stocks…

__3. Can manage basic daily medical routines once prompted or initiated by someone.

__2. No self management skills of medical routines. Is passively compliant with medical routines established by others.

__1. Resistant to medical routines/interventions.

Intimacy/Relationships

__5. Has a mutually satisfying relationship with significant other in their life and several friends, (can include co-workers away from work or organized setting) more than 1 time per week with this person(s).

__4. Has satisfying intimate relationship(s) or reports relationships with friends, (can include co-workers away from work or organized setting) more than 1 time per week with this person(s).

__3. Has casual relationships with friends (non-family, and can include co-workers away from work or organized setting), and engages in activities in or out of home at least 1 time per week with this person(s).

__2. Interacts only with family (including spouse), or others (ie. an attendant, caretaker…) for meeting basic needs and social contacts.

__1. No contact, or actively resists contact with others.

Global Quality of Life Scale

__5. Person is consistently happy and enjoys a high quality of life. "Life is good."

__4. Person is often happy and usually able to deal with day to day issues in living. "Life is basically ok."

__3. Person is occasionally happy and generally exhibits problems in dealing with day to day issues in life. "Things could be better."

__2. Person is rarely happy and has a difficult time dealing with basic day to day issues in life. "Things could be a lot better."

__1. Person is consistently unhappy and miserable and unable to manage simplest day to day issues. "Life is awful."

Gmail

Nicholas Cioe <njcioe@gmail.com>

FW: Permission to print FAOM as an appendix

2 messages

Cioe, Nick <Nick.Cioe@thementornetwork.com>
To: "njcioe@gmail.com" <njcioe@gmail.com>

Mon, Nov 15, 2010 at 11:44 AM

From: McMorrow, Debbie
Sent: Monday, November 15, 2010 10:22 AM
To: Cioe, Nick
Subject: RE: Permission to print FAOM as an appendix

Sorry Nick, yes, it is to give you permission and let me know if the editor requires a signed document. I will be in the office next week.

Here you go,

And thanks for the review on the report template

From: Cioe, Nick
Sent: Monday, November 15, 2010 10:04 AM
To: McMorrow, Debbie
Subject: RE: Permission to print FAOM as an appendix

Thanks...but I never received the first part of your e-mail. I assume it said I did have your permission; is that correct? Is it easier for me to ask Mindy for a copy of the grid?

Nick

p.s. I am trying to review the report template today but if I don't I will do it tomorrow and get back to you.

From: McMorrow, Debbie
Sent: Monday, November 15, 2010 9:55 AM
To: Cioe, Nick
Subject: RE: Permission to print FAOM as an appendix

Oops also meant to mention that you could use the short form of the FAOM that we used in our most recent Brain Injury publication, the grid.

From: Cioe, Nick
Sent: Friday, November 12, 2010 4:01 PM
To: McMorrow, Debbie
Subject: Permission to print FAOM as an appendix

Hi Deb,

Risk just finished reviewing a manuscript to be submitted for publication from the data set used for my Thesis (the manuscript that you were aware about and had spoken with Dr. Upton about). I wanted to include the FAOM as an appendix but the journal editor requested I receive your permission to reprint it. Is this something you would be willing to give?

Thanks,

Nick

ShortFAOM.doc
47K

Nicholas Cioe <njcioe@gmail.com> **Wed, Nov 17, 2010 at 12:08 AM**
To: Bill Crimando <crimando@siu.edu>

Hi Dr. Crimando,

Below is the e-mail chain between me and Dr. McMorrow (creator of the FAOM instrument references in the

manuscript I sumbitted to you). She is giving me permission to use both the FAOM and the short FAOM grid. I do not think the short FAOM grid suffices to meet the questions raised by the reviewer so I suggest the full FAOM. I am attaching both so you can review and provide feedback. Please let me know if additional information is required.

Thanks,
Nick

[Quoted text hidden]

2 attachments

ShortFAOM.doc
47K

Appendix A (FAOM Discharge and F-U).docx
24K

VITA

Graduate School
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Nicholas J. Cioe

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College of the Holy Cross
Bachelor of Arts, Psychology, May 2005

Southern Illinois University Carbondale
Master of Science, Rehabilitation Counseling, August 2009

Special Honors and Awards:

Certified Rehabilitation Counselor (CRC)

Reviewer for the Vocational Evaluator and Career Assessment Professional Journal

Trainer for NeuroRestorative utilization of the Mayo Portland Adaptability Index-4 (MPAI-4)

Recipient of the annual 2008 Guy A. Renzaglia Scholarship Award

2nd prize 11th Annual Brown University Medical School Research Symposium on Mental Health Sciences

Student Rehabilitation Association (Secretary 2008, President-elect 2009, President 2009)

Dissertation:

Factors Influencing Post-Acute Brain Injury Rehabilitation Treatment Outcome

Major Professor: Thomas D. Upton

Publications:

Upton, T. D., Alaw, R., Cioe, N. J. (2011). Duty to warn vs. duty to protect confidentiality: Ethical and legal considerations relative to individuals with AIDS/HIV. *Journal of Applied Rehabilitation Counseling, 42*(1).

Cioe, N. J., Bordieri, J., & Musgrave, J. R. (2010). Validity of the O*NET Ability Profiler for use in comprehensive vocational evaluations. *Vocational Evaluation and Career Assessment Professionals, 6*(1), 37-48.

Cioe, N. J. & Upton, T. D. (2010). The Historical Context and Importance of Private Vocational Rehabilitation. In: *Private Rehabilitation: Evolving Opportunities*. Ed. T. D. Upton. Linn Creek, MO: Aspen Professional Services.

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Conferences:

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Cioe, N. J. *Understanding What it Feels Like to Live with a Brain Injury: Helping improve relationships one interaction at a time* (Presentation). 10th Annual Statewide BI Conference, Warwick, RI. March 25, 2011.

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