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Exploring the Outcomes of Rehabilitative Care for Veterans and Service Members Treated For A Disorder Of Consciousness In The VHA Emerging Conciousness Program

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EXPLORING THE OUTCOMES OF REHABILITATIVE CARE FOR VETERANS & SERVICE MEMBERS TREATED FOR A DISORDER OF CONSCIOUSNESS IN THE VHA EMERGING CONSCIOUSNESS PROGRAM

A dissertation in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University

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Abstract

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Over the past several years, there has been an influx in patients being treated for polytraumatic injuries within the Veterans Health Administration (VHA), largely due to the wars in Afghanistan and Iraq, but also due to advances in life sustaining medical interventions. The polytrauma population includes veterans who have sustained a severe traumatic or non-traumatic brain injury, and a significant loss in cognitive and physical functioning, referred to as a disorder of consciousness. The purpose of the current study was to explore factors related to successful emergence from a disorder of consciousness, using a sample of veterans who were treated at one of the five VA polytrauma rehabilitation center (PRC) sites in an Emerging Consciousness (EC) Program. Participants (*N* = 70) included both combat and non-combat active duty military personnel and veterans who sustained either a severe traumatic brain injury or anoxic brain injury, and were considered to have a disorder of consciousness at the time of their admission to the EC program. Patient information was retrospectively collected from electronic medical records, and included demographic data, medical information, and scores on the Functional

Independence Measure (FIM), Rappaport Coma Near Coma (CNC) Scale, and the JFK Coma Recovery Scale- Revised (CRS-R). In addition, Receiver Operator Characteristic Models (ROC) were utilized to explore "cut scores" for predicting emergence using the CNC and CRS-R. Results showed that age is a significant factor in changes in FIM scores over time, but it did not predict time to emerge or emergence itself. In addition, for the CNC, scores at intake tended to be a better predictor of emergence, while week three scores on the CRS-R were more accurate in determining whether someone would emerge or not. Exploratory analyses also showed a difference in discharge location after treatment based on a patient's age. Finally, significant variance in initial scores on the CNC was seen for Caucasians, when compared to other ethnic groups. Limitations are explored, along with implications and recommendations for future research and clinical practice.

Exploring the Outcomes of Rehabilitative Care for Veterans & Services Members Treated for a Disorder of Consciousness in the VHA Emerging Consciousness Program

Background and Significance

With the onset of Operations Enduring Freedom, Iraqi Freedom, and Operation New Dawn, both the military and the Department of Veteran's Affairs have had to re-formulate the type of care they offer to service members. In particular, there have been an astonishingly high number of polytrauma injuries from the conflicts in Iraq and Afghanistan, where service members are not only surviving what might have been fatal events in previous wars, but are then requiring intensive rehabilitative care. This phenomena has largely been linked to the use of unconventional warfare techniques by insurgents, including the use of improvised explosive devices (IEDs), but has also been linked to advances in body armor being used in theater (Okie, 2005). Traumatic brain injuries due to the primary and secondary effects of blast exposure became a common occurrence during these wars, and these injuries often come with secondary wounds such as spinal cord injuries, amputations, bone fractures, and burns (Friedemann-Sanchez, Sayer, & Pickett, 2008). In response, the Department of Veteran's Affairs began what is now called the Polytrauma System of Care (Sigford, 2008; PSC). Although the VA has been offering treatment for traumatic brain injuries for several decades, it wasn't until 2005 that the Veterans Health Administration (VHA) formerly designated four existing VA Traumatic Brain Injury (TBI) treatment facilities as Polytrauma Rehabilitation Centers (PRCs), with a fifth being added in 2013, to assist in the care and rehabilitation of service members who are suffering from traumatic and non-traumatic brain injuries, and other co-occurring medical and psychological disorders. The locations of the five PRCs include the VA Palo Alto Health Care System in Palo Alto, California, the VA Medical Center in Minneapolis, Minnesota, the James A. Haley VA

Medical Center in Tampa, Florida, Hunter Holmes McGuire VA Medical Center in Richmond, Virginia, and the most recent addition, the South Texas Veterans Health Care System in San Antonio, Texas. These specialized treatment centers use a multi-disciplinary team approach to care for veterans suffering from polytrauma injuries, with a focus on rehabilitating the service member or veteran with both their physical and cognitive well-being (Sigford, 2008). Included in the Polytrauma Rehabilitation Centers is a program designed to meet the needs of individuals who have sustained a disorder of consciousness (DOC) due to the severity of their brain injury. This program is referred to as the Emerging Consciousness (EC) program (McNamee, Howe, Nakase-Richardson, & Peterson, 2012), and will be the focus of the current study.

Purpose

Formally founded in 2007, the VHA-EC programs specialize in rehabilitation services to promote the recovery of neurological functioning for those suffering from brain injuries related to both traumatic and non-traumatic incidents (McNamee et al., 2012). There are several unique aspects of the VHAs-EC programs in terms of rehabilitation and long-term recovery for the patients, and these will be explored in detail in coming chapters. As with polytrauma injuries, patients with disorders of consciousness have been receiving treatment in VA facilities for several years. The dynamics of post 9/11 warfare, including improved body armor and expedited access to medical care, resulted in an influx of brain injury survivors. In response, the VHA created a specialty 90-day rehabilitation program as a part of the larger polytrauma network of care (Cifu et al., 2009; McNamee et al., 2012).

Being a relatively new program, researchers have just begun to explore correlates and predictors of successful outcomes for patients treated in the VA's EC program. Thus, the purpose of this study is to identify the factors associated with improved outcomes for veterans and service members who have been treated in an EC program at one of the five PRCs in the U.S. The intent of identifying such factors may provide clinicians and researchers alike with information to improve the experience of EC patients undergoing rehabilitation.

In the following pages, I will first provide a brief overview of the types of brain injuries commonly treated in VA polytrauma rehabilitation settings, specifically focusing on those seen in the emerging consciousness programs. This brief overview will include TBIs, brain injury due to stroke, and anoxic and hypoxic brain injuries. After exploring the background of these types of acquired brain injuries, I will explore the different disorders of consciousness (DOCs) that can result from severe head trauma.

The second part of the literature review will include an outline of the VA's Polytrauma System of Care (PSC), including the makeup of the Polytrauma Rehabilitation Centers (PRCs) approach to treatment, and for the purposes of this study, a detailed description of the Emerging Consciousness Program (ECP), including the rehabilitative care offered for patients with severe brain injuries and disordered consciousness. Current research on factors influencing the recovery of patients with disordered consciousness will also be explored, specifically looking at different mechanisms of brain injury, and changes in functionality over time.

In the third part of the review, I will explore several of the common measures that are used to assess progress and outcomes during the rehabilitation of EC patients. The chapter will conclude with a summation of the author's research questions and hypotheses, as they relate to the literature review and the current study.

Review of the Literature

Traumatic Brain Injuries: Etiology and Diagnosis

According to the Defense and Veterans Brain Injury Center (DVBIC), as of May of 2015, over 300,000 service members had received a medical diagnosis of TBI since 2000. Unlike previous conflicts (for reasons noted above) head wounds and neck injuries account for a significantly higher proportion of the injuries that have been seen in OEF, OIF, and OND, especially when compared to previous engagements like World War II and Korea (Owens et al., 2008). However, a majority of TBIs for service members occur out of theater through incidents such as falls, motor vehicle accidents, or recreation activities (DVBIC, 2015), which is especially true as the troop levels in Iraq and Afghanistan have steadily declined over the past few years.

Traumatic brain injuries can be thought of as any instance where an external force impedes upon or disrupts the regular function of the brain (National Institute of Neurological Disorders and Stroke, 2015; NINDS). This can occur through penetration of the brain (referred to as an open injury) where an object penetrates the skull and damages the brain. TBIs can also occur through closed head injuries, where damage to the brain is caused by sudden force without penetration of the skull (NINDS, 2015). Brain injuries are referred to as focal when the damage is relegated to one area of the brain, or diffuse, when several areas are impacted (Vital, 2002). In the case of military-related TBI, blast-related brain injuries have been found to be more common than other types of brain injuries in OEF and OIF veterans (Okie, 2005; Hoge, et al., 2008). Blast injuries occur when an explosion caused by an improvised explosive device (IED), or other device (grenade, motor vehicle explosion, etc.) results in a sudden change in atmospheric pressure, creating a forceful blast that varies depending on the magnitude of the explosion. The blast waves produced by this sudden shift in air pressure can impact vital organs, namely those that are air filled, such as the lungs, inner ear, or bowels. This is referred to as primary blast exposure (Okie, 2005; Taber, Warden, & Hurley, 2006). The specific impact that primary blast exposures have on brain functioning have yet to be conclusively explicated, although some human and animal studies have demonstrated that changes in brain structure, particularly to the cerebellum and brain stem, can result from these types of injuries(Bauman et al., 2013; Goldstein et al., 2012; MacDonald et al., 2009). More recently, researchers conducted a post-mortem examination of human brains that had been exposed to several forms of brain injury, including primary blast exposure. Their findings showed distinct differences in the anatomical structure of those individuals who had been exposed to at least one blast related event, including a notation of changes in primary structures in the brain responsible for some of the more notable symptoms that are seen in TBI patients, such as the prefrontal cortex, hypothalamus, and the amygdala (Shively et al., 2016).

A second type of injury that can occur from blast exposure is referred to as secondary blast exposure. This includes damage to the body that occurs as a result of objects put into motion by the force of the explosion, to include fragments that may have been embedded in an improvised bomb, or other shrapnel (Taber, Warden, & Hurley, 2006). This type of injury would include a TBI sustained due to penetrating head trauma from material put into motion by a blast (DePalma, Burris, Champion, & Hodgson, 2005). A third type of injury that occurs as a result of an improvised explosive device or other explosion is referred to as a tertiary blast injury, which is when a person is forcefully moved or put into motion due to the sheer force of the blast, and then comes into contact with an object (Taber, Warden, & Hurley, 2006). The final type of injury that can occur as a result of an explosion is a quartanery blast injury, which encompasses all other injuries sustained that cannot be categorized as primary, secondary, or tertiary. Quaternary blast injuries can include burns due to chemical or heat exposure as a result of the blast, complications due to radiation exposure, or long-term conditions resulting from inhalation of toxic substances released during the precipitating explosion (DePalma et al., 2005). Thus, blast injuries provide several mechanisms by which a person might sustain a TBI, both penetrating and other.

According to Okie (2005), TBIs can lead to the destruction of synaptic connections in the brain that begins shortly after the injury occurs, and continues for hours or days to follow. The destruction of these synaptic terminals can be seen as the force behind the behavioral deficits noted post-TBI. Other complicating factors include brain swelling, which can lead to tissue damage, as well as hemorrhages and contusions (NINDS, 2015; Okie, 2005). White matter lesions can impact the ability of the brain to properly transfer information from one cortical region of the brain to another, which may also impact behavior and processing (Riggio & Wong, 2009). Thus, especially in the case of penetrating TBIs or depressed skull fractures where fragments of the skull can damage brain tissue, the location of the injury plays a significant role in the corresponding physiological and behavioral functioning post-injury (NINDS, 2015; Riggio & Wong, 2009). Brain bleeds, also called hematomas, can also produce significant damage after a TBI (NINDS, 2015). Another possible byproduct of TBI is anoxia, which is the absence of oxygen being circulated to the brain that in turn leads to neuronal cell death (Vital, 2002). Although anoxia can take place as a secondary effect of a TBI, it is a mechanism of injury that occurs in several other major health episodes such as heart attacks, drownings, and blood loss (Vital, 2002). For the purpose of this paper, brain injury due to anoxia will be examined separately from those injuries classified as a TBI, although it is important to note that the two are not always distinct from each other. That is, one can experience a TBI with anoxia, and vice versa, but not all TBIs result from or include anoxia or brain cell death due to lack of oxygen (NINDS, 2015).

Immediate side effects of TBI involve some form of alteration of consciousness, including confusion and disorientation directly after the event occurs (NINDS, 2015; Okie, 2005). Memory loss or posttraumatic amnesia (PTA) is a common side effect, and can include loss of memory for events leading up to, or after the injury has occurred. Both memory loss and posttraumatic amnesia are used in the diagnosis of TBI, and classification of TBI severity (Vital, 2002). Other common effects of a TBI include neurological disruptions such as vision problems, and loss of balance (Taber & Hurley, 2009), as well as cognitive difficulties such as problems with concentration, attention, and mood (Vital, 2002).

As has been demonstrated, TBI is not a single diagnosis, but rather a range of conditions with specific levels of classifications. Non-penetrating TBI's are classified as mild, moderate, or severe based on specific symptoms that occur just after the onset of the injury. These factors commonly include duration of loss of consciousness, extent of alteration of consciousness, and scores on the Glasgow Coma Scale (GCS; Oakey, 2005; Taber & Hurley, 2009). The Glasgow Coma Scale is a 15-point scale that measures three elements of responsivity in an individual suffering from a brain injury: motor response, verbal response, and eye opening. Scores range from 3 to 15, with lower scores indicating a more severe brain injury (Teasdale & Jennett, 1974). The GCS has been noted as one of the most widely used scales for assessing the prognosis and severity of brain injuries (Bordini, Luiz, Fernandes, Arruda, & Teive, 2010) although it has been criticized for the lack of acuity in cases of mild traumatic brain injuries (Helmick, Parkinson, Chandler, & Warden, 2007). The interrater reliability of the measure has largely been classified in the adequate range, when assessing agreement between raters utilizing the GCS in an emergency department setting (Fischer et al., 2010; Gill et al., 2004)

Table 1

Glasgow Coma Scale (GCS)

BEHAVIOR	RESPONSE	SCORE
Eye Opening	Spontaneously	4
	To Speech	3
	To Pain	2
	No response	1
Best Verbal Response	Orientation to time, place, and person.	5
	Confused	4
	Inappropriate words	3
	Incomprehensible sounds	2
	No response	1
Best motor response	Obey commands	6
	Purposeful movement to painful stimulus	5
	Withdraws from pain	4
	Abnormal (spastic) flexion, decorticate posture	3
	Extensor (rigid) response, decerebrate posture	2
	No response	1

Note: Table adapted from: Teasdale, G., & Jennett, B. (1974). Assessment of coma and impairment of consciousness: A practical scale. *Lancet*, *2*, 81-84.

Mild TBI's are classified as those that involve a loss of consciousness for 0 to 30 minutes, with disorientation that lasts for less than 24 hours. Other criteria include posttraumatic amnesia that lasts from 0-1 day, and a GCS score of 14-15 (Taber & Hurley, 2009). Mild TBIs are often described as concussions, and are diagnosed at a significantly higher rate than any of the other types of TBI. For example, according to DVBIC, Mild TBIs makeup 82.4% of all TBIs diagnoses in service members since 2000, while severe and penetrating TBIs makeup approximately 2.5% (DVBIC, 2015). Moderate TBIs are those that involve loss of consciousness for at least 30 minutes or more, not surpassing 24 hours, and less than 24 hours of disorientation.

Posttraumatic amnesia can exceed one day, but not surpass 7 days for a diagnosis of Moderate TBI, and GCS scores range between 9 to 13. Severe TBIs require a loss of consciousness and alteration of consciousness that each extend beyond 24 hours. Severe TBIs include the experience of posttraumatic amnesia for at least a 7-day period and a GCS rating of 3-8 (Taber & Hurley, 2009). In the case of moderate and severe TBIs, damage to the brain may be seen in magnetic resonance images (MRIs; Okie, 2005), although this is not always the case. Complicating the diagnosis of TBI severity is the lack of conclusive data that may be available for patients, especially those who sustained initial injuries in a combat zone. Additionally, due to the prevalence of disorientation or posttraumatic amnesia (PTA), this data is also difficult to come by through patient self-report, and so caution must be used in determining TBI severity for those patients who are lacking formal records of the injury and events following.

Table 2.

Diagnostic Criteria for Traumatic Brain Injury (TBI) Severity

Severity	**Glasgow Coma Scale Score**	**Loss of Consciousness**	**Posttraumatic Stress Amnesia**
Mild	14-15	<1 hour	<24 hours
Moderate	9-13	1-24 hours	24 hours to < 7 days
Severe	3-8	>24 hours	7 days or more

Note: Adapted from Helmick, K. M., Parkinson, G. W., Chandler, L. A., & Warden, D. L. (2007). Mild traumatic brain injury in wartime. *Federal Practitioner*, 58-65.

The impact of traumatic brain injuries depends largely upon their severity, and can range from short-term cognitive and physical damage, to long-lasting deficits. In the case of mild TBI, symptoms might include headaches, lethargy, disrupted sleep patterns, and difficulties with concentration, attention, and thinking. Those suffering from a moderate to severe TBI may also endure posttraumatic seizures, vomiting, nausea, prolonged loss of consciousness, slurred speech, and feelings of numbness in the extremities (Vital, 2002). Cognitively, those with a mild or moderate TBI diagnosis may see significant changes in their ability to carry out “higher level” processes of thinking, an impairment of “executive functioning” in the brain. This might include disruptions in one’s ability to think abstractly, plan, problem solve, and the use of sound judgement. Brain injuries of this nature can also impact basic functioning in speech and language, hindering communication due to the development of aphasia (difficulty in understanding both written and spoken language). Sensory processing is also affected by TBIs, and can include tinnitus, changes in sense of smell and taste, and visual processing difficulties such as light sensitivity (NINDS, 2015). Behavioral problems may also be an issue after the occurrence of a TBI, and can include impulsivity, aggression, anger, and difficulty regulating emotions (Okie, 2005). As has been noted, the long-term effects of TBIs vary depending on the nature and severity of the injury. Optimal recovery time for those with a TBI ranges from 6-months to one year. For those with moderate to severe TBIs, symptoms may linger for several years, and the accumulation of additional injuries to the brain increase the risk for ongoing side effects (NINDS, 2015; Okie, 2005).

Non-Trauma Acquired Brain Injuries: Stroke

Although more common in VA rehabilitation settings, TBIs are not the only form of acquired brain injuries treated in emerging consciousness (EC) programs. Stroke and anoxic brain injuries are two other mechanisms of injury that can lead to a disorder of consciousness. According to the NINDS (2014), a stroke is the result of sudden interruption of blood flow to the brain due to a blocked blood vessel, called an ischemic stroke. This results in the death of brain cells, called ischemia, which then leads to a replacement of fluid filled cavities in the brain, known as brain infraction. Blood clots occur either through “free-roaming” clots that typically form in the heart (referred to as an embolus), or through stenosis, which is the narrowing of the arteries due to a buildup of fat and cholesterol, called plaque. Ischemic strokes account for approximately 80% of all strokes (NINDS, 2014).

Stroke can also occur as the result of bleeding in the brain due to a burst blood vessel, referred to as a hemorrhagic stroke. Typically, neurons are protected by a blood-brain barrier that is intended to regulate which elements of the blood pass through to the neurons from the cerebral capillaries. In the case of a hemorrhagic stroke, blood spills into the brain tissue, impacting the neurochemical balance. This can occur in several ways, including through an aneurysm, where thin artery walls become weak over time and burst, leading to bleeding in the brain, or when arteries become full with plaque, and the artery walls break and become unable to maintain the structure needed to hold the blood in place (NINDS, 2014).

Strokes are notable for symptoms such as sudden paralysis or numbness to the face or extremities, particularly on one side of the body. Other signs include disorientation, slurred speech, difficulty seeing, dizziness, or severe headaches with no known cause. Diagnosis of a stroke event is typically conducted through the use of computed tomography (CT) scans of the brain. These scans help to indicate what type of stroke occurred, and identify whether a foreign body, such as a tumor, is causing the observed symptoms. Magnetic resonance imaging (MRI) can also be used to elucidate sudden and small changes in brain tissue that typically occur after a stroke (NINDS, 2014)

According to the Centers for Disease Control and Prevention (CDC) stroke is the 5th leading cause of death in the U.S., and accounts for a significant number of disabilities in the adult population. Stroke can occur at any age, but the likelihood of a stroke occurring increases with age (CDC, 2015). Some of the "unmodifiable" risk factors include older age, heredity (family history of strokes), and ethnic identification, such as African American ancestry. Men tend to experience strokes at a higher rate than women, but women are more likely to die from a stroke. Some modifiable risk factors for stroke include hypertension, diabetes, and heart disease. Lifestyle factors such as cigarette smoking, alcohol consumption, and illicit drug use can also increase the risk of a stroke event (American Academy of Family Physicians, AAFP; 2015). Head or neck injuries can also lead to strokes, as in the case of a TBI (CDC, 2015; NINDS, 2014). Thus, as in the case of anoxic brain injuries, strokes can be both a cause of a brain injury in and of themselves, or a secondary event to another mechanism of injury (such as a TBI).

Many of the signs of stroke are similar to the resulting physiological and cognitive damages that can occur as a result of this health event. Depending on the extent of damage and area of the brain that was compromised, stroke can lead to paralysis, difficulty in executive functioning (attention, planning, learning, judgement, etc.), memory impairment, speech and language deficits, problems with emotion regulation, and impaired physical functioning affecting activities of daily living (ADLs), among others (AAFP, 2015; NINDS, 2014).

Anoxic Brain Injuries

Another type of brain injury that is seen in patients being treated through one of the VA's EC programs is anoxic brain injury. According to NINDS (2014), anoxic brain injuries occur when the oxygen source to the brain is stopped completely, or is significant reduced. This is also referred to as hypoxic-anoxic injury (HAI) and cerebral hypoxia, both of which indicate a decrease in the level of oxygen going to the brain (Family Caregiver Alliance, 2004; NINDS, 2014). There are four main types or mechanisms of anoxic brain injury. The first is anemic anoxia, where oxygen is not being properly transported through the blood stream to the brain. A number of factors can lead to this condition, including chronic anemia (persistent low levels of hemoglobin or red blood cells), acute hemorrhaging (severe bleeding), or poisoning from carbon monoxide (NINDS, 2014). The second mechanism that typically causes anoxic brain injury is called toxic anoxia, where some type of toxin in the body prevents oxygen from being carried to the brain through one's blood. A third type of anoxia is called stagnant anoxia. This involves an internal medical condition that in some way restricts or completely stops oxygen from reaching the brain through the blood. This is also referred to as hypoischemic injury (HII), and includes conditions such as cardiac arrest, stroke, near-drownings, asphyxia, etc. (Family Caregiver Alliance, 2004). Finally, anoxic anoxia occurs when there is a lack of oxygen in the air for the body and brain to thrive. This typically only occurs at very high altitudes. In instances of loss of oxygen to the brain, cell death can begin as early as four minutes, and permanent brain damage can be seen after five. Long-term depletion of oxygen in the brain can lead to disorders of consciousness, brain death, and death. (Family Caregiver Alliance, 2004; NINDS, 2014). There are several ways to diagnose anoxic or hypoxic brain injuries aside from physical examination and medical history. Blood tests can be conducted to determine the level of oxygen in the blood. Computed tomography (CT) scans, or MRIs can be used to exam the brain and any abnormalities that would be indicative of an anoxic brain injury. Electroencephalograms (EEGs) can also be used to capture brain activity, and the presence of seizures (NINDS, 2014).

The symptoms of an anoxia vary depending on the severity of the injury, or how long an individual received little or no oxygen to the brain. Symptoms of mild anoxic brain injury include difficulty with concentration, judgement, memory, and motor coordination. In cases of severe anoxic brain injury, both cognitive and physical impairments can ensue for days, weeks, months, and in the most severe cases, several years (NINDS, 2014). Anderson and Arciniegas

(2010) conducted a literature review on hypoxic-ischemic brain injuries (HI-BI) in order to better assess the sequelae for this type of medical event. The authors indicated that most cases of HI-BI tend to result in a form of comatose after the initiating event, although the range of severity of the loss of consciousness can vary, and subsequently impact recovery (as seen in traumatic brain injuries and stroke). For those who regain consciousness, and no longer reside in a comatose state, cognitive impairments were found to be common, including difficulties with attention and processing, memory, and executive functioning (Anderson & Arciniegas, 2010).

The prognosis for recovery in an individual who has sustained a brain injury due to loss of oxygen is dependent upon a number of factors, including the extent of the severity of the original injury (time without sufficient oxygen travelling to the brain), and the length of time spent in an unconscious state (NINDS, 2014). Thus, an individual who lost consciousness for a short period of time would likely have a faster and better recovery than someone suffering from an anoxic brain injury that entered a minimally conscious state. In addition, anoxia caused by a toxin can have varying long-term effects depending on the toxin involved. For example, in the case of carbon monoxide, residual damage from the toxin can be seen days and even weeks after the initial event (NINDS, 2014).

Disorders of Consciousness (DOC)

As noted, in severe cases of brain injury, it is not uncommon for individuals to sustain brief and at times prolonged loss of consciousness. Recently, researchers have set out to define specific criteria for the different levels of consciousness, based on more objective criteria than what has been seen and used in the medical field in the past. Advances in modern medicine, particularly in life-saving resuscitation techniques after brain injury events, have led to an increase in survival rates in cases of severe brain injury. When loss of consciousness does not result in brain death, patients may go through a progression of stages of consciousness over several weeks or months, sometimes fully regaining both awareness and arousal (Gosseries et al., 2011). These stages of consciousness have been categorized into four subsets of DOCs, and will be explored below.

DOCs can be described as a disruption in the levels of arousal and awareness for an individual who has sustained loss of consciousness as a result of a brain injury. Arousal (also called wakefulness) is often measured through the presence of spontaneous or stimulus-induced eye opening, or other reflexive actions in a patient, and commonly related to level of alertness (Ganter, Bodart, Laureys, & Demertzi, 2013; Gosseries et al., 2011;). Awareness is much more complex, and is often viewed as the level of "conscious perception" individuals have about both their environment and themselves post-injury. It encompasses cognitive abilities and behavioral intentions, as well as orientation to time, place, situation, and self (Gosseries et al. 2011).

The first and most severe type of DOC is coma. Patients are said to be in a comatose state when there is an absence of responsiveness and wakefulness, even in the case of intense stimulation (Plum & Posner, 1980). Comatose patients may demonstrate reflexive responses to pain, but are unable to follow commands or produce verbal or non-verbal voluntary responses. They do not have sleep-wake cycles, and typically present with reduced autonomous functioning, such as lowered ability to regulate breathing and body temperature (Gosseries et al., 2011; Laureys, 2005). Comatose states are time limited, in that a coma is only considered after loss of consciousness has lasted for at least one hour. Patients in a comatose state typically regain some level of consciousness, unless they suffer complete brain death, which is considered the absence of life-sustaining neurological function (Laureys, 2005).

Vegetative state (also referred to as unwakefulness syndrome, UWS) includes wakefulness without awareness or insight into one's self or their surroundings (Bernat, 2006). Individuals in this state are able to open their eyes, but have no purposeful control of their basic motor, visual, or auditory functions, aside from natural reflexes (Bruno, Laureys, & Demertzi, 2013). Clinical features of individuals in a vegetative state (VS) include the presence of sleep-wake cycles, cranial nerve reflexes, and the preservation of brainstem autonomic and hypothalamic functioning, such as regulation of breathing and body temperature. Patients with this level of consciousness still do require intensive medical and nursing care to survive, but demonstrate spontaneous abilities to breathe independently for short periods of time. The vegetative or unwakeful state is characterized by an inability to follow commands or interact with others. Verbal expression is not present, nor is the ability to comprehend language. Patients in this state do not have basic cognitive functioning that would allow them to think, feel, or perceive, thus demonstrating a lack of awareness (Bernat, 2006; Multi-Society Task Force on PVS, 1994). This can be irreversible, but some patients see either partial or full recovery over time (Laureys, 2005). In most cases, a diagnosis of irreversible, or permanent vegetative state (PVS) is not made until at least 3 months post-injury for non-traumatic cases, and after 12 months for traumatic brain injuries (Multi-Society Task Force on PVS, 1994). However, current recommendations are to avoid using terms such as "permanent" or "persistent" for diagnostic purposes, and instead to include the duration and cause of the condition when diagnosing to avoid misrepresentation of a patient's prognosis (Bernat, 2006; Laureys, 2005).

In some rare cases where brainstem lesions have been sustained, patients may fully regain consciousness but are otherwise totally paralyzed and unable to produce much, if any voluntary responses to stimuli. This condition is referred to as locked-in syndrome (American Congress of

Rehabilitation Medicine, 1995; ACRM) and is often difficult to distinguish from a disorder of consciousness (Bruno et al. 2009). Patients diagnosed with locked-in-syndrome are cognitively aware of both themselves, their environment, and have full sensory capacity, but are unable to use speech or limb movements to communicate due to very limited motor functioning (Laureys, 2005). For many patients with this diagnosis, their primary means of communication comes in the form of vertical or lateral eye movements, or blinking (ACRM, 1995). Since patients with locked-in-syndrome regain the two signature diagnostic components of a disorder of consciousness (awareness and wakefulness) after sustaining a brain injury and enduring a comatose state, it is not necessarily classified as an actual disorder of consciousness (Bernat, 2006), but instead as a possible outcome of a severe head injury.

Patients who begin to exhibit behaviors that indicate they are cognitively aware of their surroundings and themselves, and thus no longer fit the categorization as being in a vegetative state, are considered to be minimally conscious (ACRM, 1995). The minimally conscious state (MCS) is considered when patients begin to exhibit purposeful behaviors that are distinguishable from pure reflexes. Behaviors may be inconsistent, and they may not be "functional" behaviors, but they should be reproducible when considering whether a patient has entered into a MCS (Giacino et al., 2002). Diagnosis of MCS includes the ability of the patient to produce "meaningful" or "purposeful" behaviors in reaction to external stimuli. The diagnostic criteria includes following simple commands, accurate response to yes/no question, vocalization in response to a question, intelligible verbalization, reaching for objects, handling objects in a way that is appropriate for their size and shape, appropriate emotional reactions to external cues, and sustained fixation on faces or other stimuli (Giacino et al., 2002). Patients with a MCS diagnosis at the onset of rehabilitation therapy have been found to have a better prognosis for functional recovery and recovery of consciousness, when compared to those in a coma or vegetative/unwakeful state (Giacino et al., 2002; Godbolt et al., 2013; Katz, Polyak, Coughlan, Nichols, & Roche, 2009).

Table 3

Disorders of Consciousness: Definition, Diagnostic Characteristics

Condition	**Consciousness**	**Sleep & Wake Patterns**	**Motor Function**	**Auditory Function**	**Visual Function**	**Communication**
Coma	None	Absent	Reflex and postural responses only	None	None	None
Vegetative State (VS)	None	Present	Postures or withdraws to noxious stimuli; Occasional non-purposeful movement	Startle; Brief orienting to sound	Startle; Brief visual fixation	Startle; Brief visual fixation
Minimally Conscious State (MCS)	Partial	Present	Localizes to noxious stimuli; Reaches for objects; Holds or touches objects in a manner that accommodate the size and shape	Localizes to sound location; Inconsistent command following	Sustained visual fixation; Sustained visual pursuit	Sustained visual fixation; Sustained visual pursuit

Adapted from Giacino, J. T., et al. (2002). The minimally conscious state: Definition and diagnostic criteria. *Neurology*, *58*, 349-353.

For patients suffering from non-traumatic injuries, particularly hypoxic-ischemic brain injuries, the likelihood of progressing from a coma or vegetative state is much lower than those suffering from a TBI, and the prognosis becomes worse the longer that an individual remains in a vegetative or unresponsive state (Multi-Society Task Force on PVS, 1994). However, for those patients who do progress to a minimally conscious state, improvement in functioning and return to a higher level of consciousness is most likely to occur in the 12-months post-injury. This is especially so for those suffering from traumatic brain injuries (Giacino & Kalmar, 1997). Patients who progress to a higher level of consciousness and are able to consistently demonstrate the functional use of an object and functional communication skills are said to have "emerged" from the minimally conscious state (Giacino et al., 2002). Additional details on the criteria for emergence from a MCS, and the tools used to assess the progress of patients who have potential to emerge are explored in the second part of the literature review.

Literature Review Part II: The Emerging Consciousness Program & Predictors of Outcomes for Patients with Traumatic & Non-traumatic Brain Injuries

The VA's Polytrauma System of Care (PSC) includes five designated Polytrauma Rehabilitation Centers (PRCs), that are equipped to manage the rehabilitation and acute medical needs of patients suffering from a severe brain injury (Sigford, 2008). These include the EC program for veterans or service members in need of rehabilitative care for severe braing injuries and a disorder of consciousness. Other programs include a brain injury recovery program, an amputee "boot camp," general rehabilitation, and post-deployment 360 degree evaluation. The VA brain injury recovery program at the PRC includes an outcome-based rehabilitation treatment regime for patients suffering from traumatic and non-traumatic brain injuries. In order to be enrolled in the PRCs brain injury recovery program, patients must demonstrate an ability to participate in at least three hours of physical, occupational, and/or speech therapy daily, as needed. Recreation therapy, vision, and psychology services are also offered, along with specialized medical and nursing care (Cifu et al., 2009; McNamee et al., 2012). Patients who have been treated in the EC program who emerge and are able to engage in this level of care may do so in the brain injury recovery program within the polytrauma rehab centers.

Due to the diverse nature of polytrauma injuries, an interdisciplinary team (IDT) approach is used to manage patient care and rehabilitation. Professionals from the fields of physical therapy, occupational therapy, speech and language pathology, vision, recreation therapy, social work, skilled nursing, rehabilitation medicine, and neuropsychology work together to provide treatment to patients receiving rehabilitative treatment at one of the five polytrauma rehabilitation centers (PRCs). These IDTs meet on a weekly basis to conceptualize, consult, and plan the best course of treatment for veterans and service members on the unit. Interdisciplinary goals are created regularly to ensure that patients are making progress in their rehabilitation. Family goals are also created with the input of those closest to the veteran. Family meetings occur on a regular basis so that the team and the family members have the opportunity to engage and explore the best course of care for the veteran or service member being treated (Collins & Kennedy, 2008; Sigford, 2008).

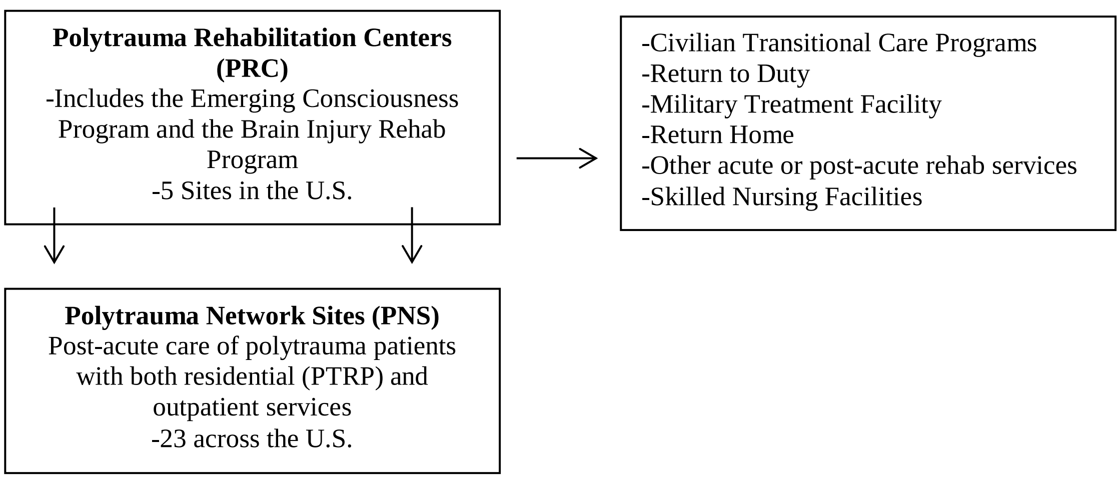
For those veterans or active duty service members who have sustained a severe brain injury within the past two years, are medically stable, but remain in an unresponsive or minimally conscious state, there is the emerging consciousness treatment program, located within the PRCs (McNamee et al., 2012). For the purpose of admission to the VA's EC programs, determinations on the level of impairment in both physical and cognitive functioning, as well as level of consciousness are based on medical observations and ratings from two commonly used measures in the treatment of brain injury patients: the Rancho Los Amigos Scale, more commonly referred to as the Levels of Cognitive Functioning Scale (LCFS) and the Disability Rating Scale (DRS), which will be described in detail below.

Similar to the brain injury recovery program, patients in EC programs are provided with an all-encompassing rehabilitative care treatment model, with the focus of returning the veteran to full consciousness (referred to as emergence), and beginning them on a journey towards functional and cognitive recovery. Patients are provided with a number of therapies (physical, recreational, occupational, and psychological, etc.) to help maximize positive long-term outcomes, with the intent of moving the patient to the next level of rehabilitative care, or transfer to outpatient treatment. All of this occurs in tandem with complete medical care, and continual monitoring of conditions that may hinder a veteran or service member's path to recovery (Department of Veterans Affairs, 2015). The criteria used for determining whether the patient has emerged or not will be explored in full detail below, as it relates to assessment measures used to track progress of veterans and services members recovery and rehabilitation within the program.

Typically, patients are provided a 90-day window to emerge. For those patients who are not demonstrating a strong likelihood of emergence after several days in treatment, family meetings are held to begin discussing alternative options for care. If patients have not emerged in 90 days, they are transferred out of the program to a facility or treatment type that best fits their needs. The patient's disposition or next step in treatment is determined based on several factors, including medical stability, potential to continue to engage in rehabilitative services, ability to care for one's self (activities of daily living and independent living skills), cognitive state, etc.

Patients who recover to a point where they are able to perform most activities of daily living (ADLs) and are medically stable, have the option of transitioning to a Polytrauma Transitional Rehabilitation Programs (PTRPs), which are housed onsite at certain VA medical centers. These programs are designed to provide veterans recovering from polytrauma injuries with the opportunity to continue in their rehabilitation process in a less structured and medically assistive environment, in order to help prepare the patient for re-entry into the community or return to duty (Sigford, 2008). Figure 1 demonstrates some of the program options for patients managing a disorder of consciousness who are eligible for treatment within the VHA system of care. As can be seen, there is some variety in the options available to patients once they complete the emerging consciousness program, some of which are housed within the VA’s polytrauma system, and others in the civilian sector.

Figure 1 Treatments Program Options for Emerging Consciousness Patients



Medical and Neurological Conditions Associated with TBI and non-TBI DOCs

In order to fully understand the type of rehabilitative care needed for patients suffering from a disorder of consciousness (DOC), and the rehabilitative outcomes that are sought in the VA’ s EC programs, common conditions or medical complications of both TBI and non-TBIs will be explored. These conditions are certainly not an exhaustive list of the medical comorbidities that can arise for someone managing a severe brain injury and a DOC, but are those that are commonly seen in the VHAs Polytrauma Rehabilitation Centers (PRCs) that might impact an individual’s ability to recover and meet the goals set out by one’s family or the interdisciplinary care team. It should be noted that patients who demonstrate significant medical instability are not typically admitted to these programs, but due to the extent of the severity of the polytrauma injuries treated in the PRC system of care, it is not uncommon for certain conditions to develop during a patient's stay. For those patients who require intensive levels of care that are beyond the scope of the treatment provided by PRC medical teams, transfers to medically appropriate care units are made until the patients are again medically stable and able to participate in rehabilitative treatment.

The use of electronic medical records by the VHA helps to streamline the care process both upon admission, and in the case that medical complications should arise during treatment. Providers can access historical medical records from any VA or DoD care facility, which is a unique aspect of the VHA's system of care (Cifu et al., 2009; McNamee et al., 2012). Because medical complications can significantly impact both the recovery of consciousness and the physical and functional recovery of a patient, a great deal of time and care is spent by the PRC medical and nursing staff in management and prevention of medical barriers to recovery. In order to assist in this process, patients typically undergo both head CT's and EEG's upon admission to the program, in order to screen for hydrocephalus, infections, and seizure activity (McNamee et al., 2012). Patients suffering from a severe head trauma face a heightened risk for infection when needing to undergo procedures such as a craniotomy, which is a medical procedure that involved removing a portion of the skull to allow room for the brain to swell. This is also the case in situations where a shunt must be placed within the skull cavity, in order to allow for drainage of fluid (NINDS, 2015). Neuroendocrine screenings are also recommended upon intake to emerging consciousness programs through the VA, to detect the presence of pre-existing disorders that might impact the responsiveness of the individual to treatment. Hormone tests may also be performed because of the possibility of interruption to the hypothalamic-pituitary axis. Patients commonly have their sleep-wake cycle monitored, since as noted above, this can be a sign of level of consciousness in brain injury patients (McNamee et al., 2012).

During a patients stay, several aspects of health are monitored to ensure patients can thrive to the fullest extent while undergoing rehabilitation. For example, nutrition and digestive functioning are a top priority. A nutritionist will work with the medical team to ensure that patients are receiving the sustenance needed to enhance recovery. Patients who are in an unresponsive state, or who have lost the ability to swallow (referred to as dysphagia; NINDS, 2015) may require tube feedings. Often patients in this state of unresponsiveness need assistance in managing bowel and bladder functioning, and care must be taken to avoid infection and dysfunction (McNamee et al., 2012).

Pain is a common condition faced by many veterans who are recovering from polytrauma injuries. In the case of head injuries, headaches are common and can significantly impact a patient's pain level and ability to engage in rehab (Cifu et al., 2009; Cifu & Lew, 2013; NINDS, 2015). Fatigue is also a persistent issue for patients recovering from polytrauma injuries, both "traditional" physical fatigue, and cognitive fatigue. Dizziness and nausea are also common physiological sequelae seen in patients recovering from a brain injury, as well as sleep disturbance (NINDS, 2015). Further complicating rehabilitative treatment for this population is the common occurrence of difficulty understanding or expressing language, termed aphasia (Giacino et al., 2002; NINDS, 2015). Dysarthria is also seen in many brain injury patients, and can cause slurred or diminished voice quality due to paralysis of the muscles used to control speech (NINDS, 2015; Sayer et al., 2009).

Physical deconditioning is also a concern of patients being treated for brain injuries, and especially for those suffering from DOCs. Lack of physical activity can lead to a number of negative health conditions, including the breakdown of skin, ulcers, and blood clots. Additionally, patients may experience changes in muscle tone that leads to tenseness and a decrease in mobility (referred to as spasticity; Cifu & Lew, 2013; NINDS, 2015). In a recent study on characteristics of patients being treated in VA ran emerging consciousness programs, spasticity was the most commonly experienced medical comorbidity for patients (Nakase-Richardson et al., 2013). Due to the negative impact that inactivity and deconditioning can have on a patient's overall well-being and rehabilitation, special care is taken in the PRCs to ensure that physical activity is a regular component of the rehabilitation process, based on the patient's ability level and recovery goals (McNamee et al., 2012; Sigford, 2008).

Seizures may also occur as a result of the initial head injury. In cases of traumatic brain injuries, posttraumatic seizures include those that are local to one area of the brain, or are more diffuse in natures (NINDS, 2015). Often in the case of TBI, they are located in the temporal or frontal lobe and can result in complex symptom presentations that appear similar to the behavioral content of psychiatric disorders (Riggio & Harner, 1995). The National Institute of Neurological Disorders and Stroke (NINDS) estimates that approximately 25% of patients with brain contusions or bleeding in the brain (hematoma) following a TBI will develop immediate seizures (within 24 hours) post-injury. This chance increases to 50% for those with penetrating head injuries. These immediate seizures increase the probability that a patient will experience seizures within a week of injury, but does not increase the chance of long-term epilepsy (NINDS, 2015). Researchers have found that severity and type of TBI (closed vs. penetrating, blast vs. non-blast) seems to be one of the stronger predictors of whether or not post-traumatic epilepsy will develop (Chen, Ruff, Eavey, & Wasterlain, 2009; Mukand & Santos, 1999). Researchers have found a 30% prevalence rate for seizures in patients admitted to EC programs, with a significant number occurring for those suffering from blast injuries, and a high incidence of occurrence for patients with penetrating TBIs (Nakase-Richardson, et al., 2013).

In cases of hypoxic and anoxic brain injury, incidence of either myoclonus (severe and widespread involuntary muscle spasms; NINDS, 2012), and seizure can vary, with estimates anywhere from 15 to 44% when a hypoxic ischemic brain injury occurred in conjunction with cardiac arrest (Khot & Tirschwell, 2006). Seizures following stroke are estimated to occur in 5 to 20% of stroke patients (Bladin et al., 2000; Dávalos et al., 1992). Fitzgerald and colleagues (2010) found that 11% of the 93 anoxic brain injury patients they surveyed experienced late-onset seizures (at least one week or beyond the initial event), and suggested that the risk for late seizures or epilepsy may in fact be higher than in cases of severe TBI (Fitzegerald et al., 2010). In any case, seizures can have a detrimental impact on the recovery process of patient's suffering from a disorder of consciousness, warranting an exploration of the effects that this complication can have in an EC patient's progress in cognitive recovery, physical recovery, and other rehabilitation outcomes.

Assessing Recovery & Level of Impairment in Patients with Severe Brain Injuries and DOCs

From the time that patients are admitted to VA EC programs until the day they are discharged from the unit, assessment of physical and cognitive functioning occurs through the use of several rehabilitation measures (Cifu & Lew, 2013; McNamee et al., 2012). As mentioned previously, at intake and throughout treatment, patients' overall level of consciousness is measured through the use of the Rancho Los Amigos Scale, more commonly referred to as the

Levels of Cognitive Functioning Scale[1] (LCFS; Hagen, Malkmus, & Durham, 1979), which helps to guide treatment goals and rehabilitative needs of the patients. The LCFS is an 8-level rating system used by providers to categorize the level of consciousness, cognitive functioning, and behavioral functioning of patients with severe brain injuries[1]. The scale ranges from Level I, which is no response from the patient to external stimuli, to Level VIII, which is the highest level of functioning for brain injury patients, and includes orientation to the environment, along with purposeful and appropriate responses to outside stimuli (Hagen, Malkmus, & Durham, 1979). See Appendix A for a full description of the scale. Patients being admitted to the EC program are typically at an LCFS level of four or lower. The LCFS is then used throughout rehabilitative treatment to help providers classify where patients are in their recovery of consciousness, and beyond (McNamee et al., 2012).

A more recently adapted measure in these programs is the Disability Rating Scale (DRS), which is intended to capture the extent of impairment in different areas of functioning for patients suffering from severe head injuries (Rappaport, Hall, Hopkins, Belleza, & Cope, 1982). It includes assessment of arousal and awareness, cognitive ability to manage different types of self-care activities, the patient's physical dependence upon others, and one's psychosocial ability to manage and adapt to work, school, and household tasks. The domains used to assess these areas are as follows: eye opening, communication ability, motor response, feeding (cognitive ability only), toileting (cognitive ability only), grooming (cognitive ability only), level of functioning in physical, mental, emotional, and social areas, and employability as a full-time employee, homemaker, or student (Rappaport, Hall, Hopkins, Belleza, & Cope, 1982). Research

[1] Although there is currently a revised version of the Rancho Los Amigos Scale (Levels of Cognitive Functioning Scale) in use that utilizes 10 levels of cognitive functioning, for the purposes of the current study, the original version of the RLAS is being cited, in order to match the scale that was being utilized during the time of data collection.

has shown that the DRS has strong test-retest reliability for use with TBI patients (Gouvier et al., 1987), and excellent interrater reliability with the same population (Gouvier et al., 1987; Malec et al., 2012; Rappaport et al., 1982). High internal consistency has also been demonstrated for the DRS with patients suffering from TBI and non-TBI acquired brain injuries (Eliason & Topp, 1984). See Appendix B for a description of the DRS. The DRS is intended to be a more sensitive instrument compared to the Glasgow Coma Scale (GCS) in measuring overall functioning and rehabilitation progress in patients suffering from severe head trauma. The maximum score that patients can receive on this measure is 29, which would indicate complete lack of responsiveness, and is indicative of an individual in a vegetative or unwakeful state. A score of 0 would imply full functioning on both a physical and cognitive level (Rappaport, Hall, Hopkins, Belleza, & Cope, 1982). Patients being admitted to an EC program typically have a DRS score of 18 or less, although behavioral observations and clinical judgement can also be used in deciding whether to admit a patient to the program (McNamee et al., 2012). DRS scores have been found to be predictive of the amount of time that it takes for a patient with a DOC to regain the ability to follow commands (Whyte et al., 2005).

In addition to these two rating scales, patients are assessed for their ability to function autonomously in certain physical and cognitive domains using subsets of the Functional Independence Measure (FIM; Hamilton, Granger, Sherwin, Zielezny, & Tashman, 1987). The FIM includes 18 items, 13 of which are related to physical domains of activities of daily living (ADLs), termed the motor subscale. These include activities such as bathing, bowel and bladder continence, grooming, feeding, etc. It also rates the extent of patient’s mobility, to do things like use a wheelchair or walker for movement, and one’s ability to transfer from a bed to a wheelchair, or from a wheelchair into a shower. In addition to assessment of ADLs and mobility, the FIM includes 5-items related to a patient's cognitive abilities, including problem solving, social interactions, memory, expression, and cognitive comprehension. Scores on each of the items ranges from 0 to 7, with a 0 indicating that the activity does not occur, and a 7 indicating complete independence in the activity. Total scores range from 18, which indicates the lowest level of independent functioning, to 126, which would indicate the highest level of functioning (Hamilton et al., 1987). The FIM is intended to be used by the full rehabilitation team, and requires training before use. It has been extensively normed using various types of inpatient rehab populations, including those with spinal cord injuries (Hall, Cohen, Wright, Call, & Werner, 1999) and stroke (Inouye, M., Hashimoto, H., Mio, T., & Sumino, K. 2001). Additionally, FIM scores have been found to be predictive of discharge dispositions for patients undergoing inpatient rehabilitative treatment due to stroke (Bottemiller, Bieber, Basford, & Harris, 2006; Saji et al., 2015), and functional autonomy for TBI patients after discharge from a rehabilitation setting (Corrigan, Smith-Knapp, & Granger, 1997; Guise, Leblanc, Feyz, & Lamoureux, 2005). Although it varies by site, in VHA-EC programs, the motor subscale of the Functional Independence Measure (FIM) is administered on a weekly basis (McNamee, Howe, Nakase-Richardson, & Peterson, 2012) to provide continual information on patient's progress in motor function and activities of daily living (ADLs) to the inter-disciplinary rehabilitation team.

Patients in the VA's emerging consciousness programs are assessed for changes in awareness and level of responsiveness using the JFK Coma Recovery Scale-Revised (CRS-R), and at some sites, the Coma Near Coma Scale (CNC). Both of these scales have been recommended for use in DOC patients by the American Congress of Rehabilitation Medicine (ACRM). The CRS-R is comprised of 23 items that includes six subscales examining auditory, motor, oral-motor, visual, communication, and arousal functions. The scale is intended to assess brain stem, cortical, and sub-cortical functioning and processes, and is based on the diagnostic criteria for vegetative or unwakeful state, minimally conscious state (MCS), and emergence from MCS (Giacino, Kalmar, & Whyte, 2004; Kalmar & Giacino, 2005). Patients are scored based on their ability to respond to stimuli. For example, in the auditory function category, patients are presented with an auditory stimulus, such as the sound of someone's voice or a bell, and are scored based on whether or not they are able to respond to the sound, perhaps by moving their head towards the stimulus or shifting their eyes to the source. Total scores on the measure can range from 0 to 23, with lower scores indicating a reflexive response, and higher scores indicating more cognitively intact responses to stimuli (Giacino, Kalmar, & Whyte, 2004). The CRS-R demonstrated high interrater and test-retest reliability when used with a sample of 80 patients being treated in an inpatient coma recovery program, and demonstrated moderate concurrent validity when compared to the DRS (Giacino, Kalmar, & Whyte, 2004). In a separate study with brain injury rehabilitation patients suffering from a disorder of consciousness, La Porta and colleagues (2013) determined that the CRS-R was a reliable tool for diagnosis and assessment of the varying levels of consciousness. See Appendix C for a full description of the scale.

The Coma Near Coma Scale (CNC) is an additional assessment tool that can be utilized to assess the presence of, or lack of responses and low-level changes in patients with a disorder of consciousness. The CNC includes 11-items that assess for responsivity and awareness in the following areas: response to auditory stimuli (bell ringing), command responsivity (response to a request or command), response to visual stimuli, threat, olfactory response, tactile cue, response to pain, and the ability to vocalize or make sounds. Patients are given a score of 0, 2, or 4 for each of the items, with 0 indicating a strong response to the stimuli, and 4 no response. Total scores are calculated by summing the ratings for each of the items, and dividing this number by the total number of items administered. Total scores range from 0 to 4, with 0 indicating no coma, or consistent responsivity, and 4 indicating extreme coma, or no responsivity at all. The CNC requires two or more examiners: one individual performs the actual testing, and one or more individuals observe the patient and score them on their performance (Rappaport et al., 1982; Rappaport, Dougherty, & Kelting, 1992). See Appendix D for a full description of the scale.

The CNC and CRS-R scales are typically administered on a bi-weekly, to weekly basis, depending on the specific EC program. Speech and language pathologists, along with neuropsychologists typically administer the tests. It should be noted that certain conditions or experiences of the patient can have an influence on their performance on these measures. For example, certain medications, pain levels, motor deficits, fatigue, etc. can significantly impact the ability of a patient to respond to the stimuli introduced during the CRS-R and CNC, and thus should be considered and discussed with the rehabilitation team so that the patient's level of consciousness is not distorted due to mitigating medical or environmental factors. It is also important to note that these measures often serve a dual-purpose within the rehabilitation setting. While typically administered on a re-occurring basis to measure changes in cognition, the CRS-R and CNC can also reveal variations in a patient's medical status, such as the presence of an infection or the experience of a seizure. Thus, it is common practice for therapists and providers to rely on these measures to not only assess levels of consciousness, but also to help detect medical complications in EC patients.

Emergence from Disordered Consciousness

Criteria for emergence from a minimally conscious state or disorder of consciousness are based on a number of factors, including the preceding scales and behavioral and medical observations from the interdisciplinary team. In the EC program being explored in the current study at Richmond VA Medical Center, emergence is a team-based decision, in that the interdisciplinary care team that is providing treatment to the patient defines what criteria they believe demonstrates emergence from a disorder of consciousness, based on standards that have been developed by Giacino et al., 2002 and the Aspen Neurobehavioral Workgroup. These standards include two main components: (1) Evidence of emergence will include the functional use of an object, consistently, and in a purposeful manner for at least two consecutive weeks. This can include the lowest level of object use, such as being able to hold a spoon to one's mouth, use a switch to indicate "yes" or "no", etc., but does not necessarily require object use that is in direct relation to activities of daily living, and (2) Patients who have emerged from a minimally conscious state will demonstrate functional communication, through either verbal or non-verbal means, that demonstrate understanding through accuracy of "yes/no," and global questions such as, "Are you sitting down?" (Giacino, et al., 2002; McNamee et al., 2012; Nakase-Richardson, et al., 2013).

Emergence is typically a gradual process, and in the Richmond VA Medical Center's EC program, patients are required to repeatedly demonstrate each of these responses for at least two weeks before they are considered to be "emerged" by the team. This is due to the highly inconsistent responses to external stimuli that are typically present for individuals with disordered consciousness (McNamee et al., 2012). When assessing whether a patient has emerged, tests like the JFK Coma Recovery Scale- Revised (CRS-R), the Coma Near Coma

Scale (CNC), and ratings on the Levels of Cognitive Functioning Scale (LCFS) are helpful in assisting the team in determining whether the patient's consciousness is improving as they progress through rehabilitative care.

Neurological Changes in the Process of Emergence

The neurological process of emergence is still not well understood, as research is ongoing in the changes that take place at the neuronal level for an individual who regains awareness and arousal after a severe brain injury. There is some contention on the extent to which rehabilitative therapy for brain injury patients impacts the recovery of the brain. In particular, the occurrence of plasticity, or the regrowth of neural pathways to support emergence is thought to occur both spontaneously, and through "training-induced" recovery of neural networks (e.g. cognitive rehabilitation), but the actual process through which this occurs is not well understood (See Bagnato et al., 2013 for a full review). Thus, the focus of the current study will be on observable changes in behavior, mood, and functionality in EC patients, in order to provide a better understanding for clinical providers on ways to facilitate positive outcomes in this unique population.

Assessing & Predicting Rehabilitation Outcomes in Severe Acquired Brain Injuries & DOCs: Differences by Mechanism of Injury, Age, and Other Factors

Researchers have begun to examine both the short and long-term impact that rehabilitation for severe brain injuries and disorders of consciousness have on patients, especially in the case of brain injuries with traumatic etiologies. This research has been further enhanced due to the creation of a national database to track TBI patients by the National Institute on Disability and Rehabilitation Research, called the Traumatic Brain Injury Model Systems. This program of data collection allows for tracking of rehabilitative care for TBI patients across the country at different time points in the rehabilitation process. In a 2012 study utilizing the TBI Model Systems database, Nakase-Richardson and colleagues (2012) evaluated the acute and long-term outcomes of 396 patients suffering from severe traumatic brain injury and a prolonged DOC. The patients had been treated at one of 20 neurocognitive rehabilitation centers across the U.S. from 1988 to 2009. Outcome measures included the DRS and FIM scores, among others. A majority of the participants had sustained brain injury due to a motor vehicle accident (66%), and 68% returned to consciousness during their inpatient stay (demonstrated by an ability to follow commands for at least two days in a row). In all, 128 patients did not regain consciousness during the initial rehabilitation process, but 78 of these patients went on to do so at one year post-discharge. Significant improvements in scores on both the motor and cognitive domains of the DRS and the FIM were seen from time of admission and at both one and two year follow-up for those patients who remained in the study (Nakase-Richardson et al., 2012). After two years, changes in DRS scores and the motor subset of the FIM were not as significant as cognitive improvements, demonstrating that physical gains may have plateaued for this cohort as the time from being discharged from rehabilitation increased (Nakase-Richardson et al., 2012). Thus, the study provides some evidence that although a majority of the gains in recovery of consciousness, cognition, and functional ability are seen within a year post-injury for patients with severe acquired brain injuries, changes do also occur at points thereafter. Findings such as these provide support for the use of continued rehabilitation efforts for this population. These finding were replicated in a study using the same population, focusing on the differences in FIM outcomes and functional independence in patients who demonstrated an ability to follow commands during their rehabilitation stay, and those who did not (Whyte et al., 2013). Patients who had regained the ability to engage in following commands had shorter durations of rehabilitation care, and 7%

to 21% were considered independent in at least one functional domain (according to the FIM) by the time of their discharge, and then continued to make significant gains one year post injury (Whyte et al., 2013). In contrast, those in the late recovery group did not demonstrate independence in functional autonomy by the time of discharge, but did see substantial rehabilitative gains at one year post-injury. However, compared to those who demonstrated early command following, those in the late recovery group had overall lower levels of functional independence at one, two, and five years post-injury (Whyte et al., 2013), demonstrating that in terms of functional autonomy, early progress in the recovery of consciousness and ability to follow commands likely predicts the prognosis of recovery, at least in those patients suffering from a TBI.

In 2013, Nakase-Richardson and colleagues conducted one of the first studies on the characteristics and treatment outcomes of veterans with both combat and non-combat related brain injuries who were admitted to a VHA-EC program between 2004 and 2009. In all, 122 participants were included in the study, and had experienced brain injuries as a result of blast exposure, penetrating TBI, other types of TBI (motor-vehicle accidents, falls), as well as non-trauma related injuries such as stroke, anoxia, or encephalopathy. Several measures were used to assess rehabilitation effectiveness including FIM scores, Levels of Cognitive Functioning Scale (LCSF) levels, and JFK Coma Recovery Scale- Revised (CRS-R) scores. The authors also looked at scores on the Galveston Orientation and Amnesia Test (GOAT), which is an assessment for posttraumatic amnesia (Levin, O'Donnell, & Grossman, 1979), and the Orientation-Log (O-Log), which is a brief assessment of orientation to place, time, and situation (Novack, Dowler, Bush, Glen, & Schneider, 2000). Emergence from a disorder of consciousness was included in the study, and was measured according to standards set by the Aspen

Neurobehavioral Workgroup. In addition, the authors included information on some of the common medical comorbidities that patients experienced during their stay in these programs (Nakase-Richardson et al., 2013).

The authors founds that 64% of the patients studied emerged from their DOC. Those with a trauma-related brain injury were more likely to emerge than those with other causes of brain damage. Improvements on cognitive and motor functioning, as evidenced by the FIM, were seen for all mechanisms of injuries, with individuals in the trauma category seeing the most distinct changes over time in motor functioning (Nakase-Richardson et al., 2013). Those who sustained their injuries due to blast exposure or through non-traumatic experiences had lower rates than TBI survivors on both motor and cognitive ability over the duration of rehabilitative treatment, based on FIM scores. Spasticity (muscle stiffness) was by far the most common medical comorbidity occurring in these non-trauma patients, with dysautonomia (dysfunction of the autonomic nervous system) occurring in just under a third of all emerging consciousness patients (Nakase-Richardson et al., 2013).

Other studies have demonstrated similar findings in terms of the discrepancy between outcomes for patients with trauma and non-trauma related brain injuries. In one case-controlled study, Cullen & Weisz (2011) matched 10 patients with anoxic brain injury and 10 patients with TBI on factors such as age, length of stay, and FIM admission scores to determine whether one group saw better outcomes in level of functioning after treatment in the same neuro-rehab program. Functional outcomes were based on discharge FIM and DRS (Disability Rating Scale) scores. The authors also explored whether there were differences in basic cognitive functioning based on results from neuropsychological tests that were administered upon admission to the program. Cullen & Weisz (2011) found that patients who were admitted with a severe brain injury due to anoxia had significantly lower functional abilities according to the FIM and DRS upon discharge, when compared to patients with a TBI. In terms of cognitive functioning, patients with anoxic brain injuries tended to perform worse on tasks assessing language, processing, and attention, compared to TBI patients (Cullen & Weisz, 2011). These findings were similar to an earlier study assessing the same population (TBI vs. non-TBI brain injuries) with similar outcomes measures (FIM and DRS), yet with a larger, matched sample (86 TBI and 86 non-TBI participants). In this larger study, the authors found that at discharge, patients with a brain injury other than TBI performed significantly worse on measures of functional and cognitive ability, but at 1-year post-injury, FIM scores were largely similar for both groups (Cullen, Park, & Bayley, 2008).

Aside from mechanism of injury, studies have shown that age is related to functional outcomes and recovery of consciousness for patients suffering from both a TBI (De Guise, LeBlanc, Feyz, & Lamoureux, 2005) and hypoxic-ischemic brain injuries (Howell, Grill, Klein, Straube, & Bender, 2015), with younger patients seeing better gains in recovery after rehabilitative care. Age has also been cited extensively in literature on adult traumatic brain injuries, including the significant impact that age has on mortality following a TBI (Harrison-Felix, et al., 2012; Mosenthal et al., 2002), on physical functioning during acute rehabilitation (Hart et al., 2014) re-hospitalization rates following TBI (Saverino et al., 2015), and long-term functional recovery (Marquez de la Plata et al., 2008).

As the literature review has shown, severe brain injuries and disorders of consciousness can be quite complex in their etiology, onset of symptoms, and prognosis. Some of this is likely due to the limited amount of research that has been carried out with this specialized population; particularly those who are treated through formal programs such as the VA's emerging consciousness program. The aim of this study is to clarify some of the outcomes that might be expected of patients managing a DOC who are receiving acute rehabilitative care, and to add to the literature noted above on what tools of measurement might be useful for providers in predicting successful emergence from a coma, vegetative, or minimally conscious state.

Statement of the Problem

The exploration of factors related to the successful recovery of patients who are suffering from a disorder of consciousness as a result of a severe brain injury has primarily been limited to descriptive data and prediction of outcomes through the use of scales such as the Disability Rating Scale (DRS) or the FIM. In addition, few researchers have examined the elements related to changes in levels of consciousness, and specifically the progression towards recovery for patients in emerging consciousness states. The VHAs introduction of a formal Emerging Consciousness program as a part of the Polytrauma System of Care, along with the use of computerized health records within the VHA system, provides an opportunity for clinicians and researchers alike to gather and analyze data related to both the positive and negative rehabilitation outcomes for this unique population. Thus, the purpose of the current study is to explore some of the factors related to positive and negative outcomes in patients recovering from a disorder of consciousness who have taken part in an EC program at one of the five VHA Polytrauma Rehabilitation Centers (PRCs). A second aim of the current study is to explore the utility of commonly used assessment measures in determining the likelihood that a patient in an intensive rehabilitation care setting will emerge from a disorder of consciousness.

Research Questions

- What factors predict emergence from a disorder of consciousness?

- Is age a significant variable in the prognosis of patients with a disorder of consciousness?
- Do certain types of patients have a higher likelihood of recovering from a disorder of consciousness?
- Does a “cut point” exist for measures of consciousness that would help to predict the likelihood of emergence for patients with disorders of consciousness?

Primary Hypotheses (Part I)

Age as a Predictor of Emergence and Functional Autonomy

Hypothesis 1: Age of the emerging consciousness patient will significantly predict whether a patient emerges, with younger patients being more likely to emerge than older patents.

Hypothesis 2: Age of the emerging consciousness patient will significantly predict time to emergence (based on date of the initial brain injury), where younger patients will have a shorter time to emergence than older patients.

Hypothesis 3: Age of the participant will significantly predict scores on the Functional Independence Measure (FIM) self-care subscale at discharge, with younger patients having higher average scores than older patients.

Hypothesis 4: Age of the participant will significantly predict scores on the Functional Independence Measure (FIM) cognitive subscale at discharge, with younger patients having higher average scores than older patients

Primary Hypotheses (Part II)

Predictive Values of the Functional Independence Measure (FIM), JFK Coma Recovery Scale-Revised (CRS-R), and the Coma Near Coma Scale (CNC)

Hypothesis 1: Lower scores on the initial measurement of the Coma Near Coma Scale (CNC) will significantly predict a higher rate of emergence from a disorder of consciousness, while higher scores on the same measure at intake will be predictive of a lower rate of emergence in emerging consciousness patients.

Hypothesis 2: Higher scores on the initial measurement of the Coma Recovery Scale-Revised (CRS-R) will significantly predict a higher rate of emergence from a disorder of consciousness, while lower scores on the same measure at intake will be predictive of a lower rate of emergence in emerging consciousness patients.

Hypothesis 3: Emerging consciousness patients who have emerged will have a significantly higher score on the Functional Independence Measure (FIM) of self-care activities and cognitive subscale at discharge, when compared to their intake scores on the same measure.

Exploratory Hypotheses:

Hypothesis 1: The Coma Near Coma Scale (CNC) can be used to predict whether patients with disorders of consciousness will or will not emerge, based on a given score on the measure at either intake, week 1, or week 3 of treatment.

Hypothesis 2: The Coma Recovery Scale – Revised (CRS-R) can be used to predict whether patients with disorders of consciousness will or will not emerge, based on a given score on the measure at either intake, week 1, or week 3 of treatment.

Method

Study Design

The current study uses a post-hoc, non-randomized design that included collection of archival, retrospective clinical data to describe the demographic and clinical characteristics of inpatients who received treatment in the EC program at the Hunter Holmes McGuire VA Medical Center in Richmond, Virginia. Data were collected by medical chart reviews through the use of the facility's computerized record system (CPRS). All data were de-identified prior to analyses. This study was approved by both the Hunter Holmes McGuire VA Medical Center's Institutional Review Board, as well as the Institutional Review Board at Virginia Commonwealth University in Richmond, Virginia.

Participants

Participants (*N* = 72) included patients who underwent treatment in the Hunter-Holmes McGuire Richmond VA Medical Center's EC program between 2003 and August of 2015**.** A total of 72 patients were deemed eligible for the study based on admission to the program during the pre-defined time period listed above. Participants who were missing information on 80% of the data related to the main variables in the study (excluding demographics) were not included in the final sample. A total of two cases were removed based on these criteria.

Demographic information is presented in Table 4. In terms of the makeup of the sample, the average age of participants was 29.03 years old (*SD* = 10.80), ranging from 18 to 62 years of age. A majority of the participants were single at the time of their admission (52.9%), while 40% were married, and 7.1% were divorced. In all, 96% of the patients were male, while 4% were female. In terms of ethnic background, a majority of participants were white (72.9%), with

African Americans representing 15.8% of the sample, Hispanic 5.7 %, Asian, 4.3%, and Pacific Islander 1.4%. In all, 75.5% had a high school education or equivalent, 13% had some college, and 11.5% had a Bachelor's degree or higher. Most participants were considered Active Duty at the time of their intake into the EC program (71.4%), while 27.1% were considered veterans (one participants was classified as "other" due to their status as a cadet at a military institution, making it unclear as to whether or not they were considered an active member of the Armed Forces at the time of treatment). In terms of branch of service, 47.8% serve in the Army, 21.7% Navy, 17.4% Marines, 10.1% Air Force, 1.4% served in the Coast Guard, and 1.4% served in the National Guard.

Table 4

Demographic Information (N = 70)

Demographic Variables	N	%
Gender		
Male	67	95.7
Female	3	4.3
Age		
19-29	47	67
30-39	11	15.8
40-49	8	11.5
50-59	2	2.9
60-69	2	2.9
Race/Ethnicity		
African American	11	15.7
Asian/Asian American	3	4.3
Hispanic, Latino	4	5.7
Am. Indian/Pac. Islander	1	1.4
White/Non-Hispanic	51	72.9
Marital Status		
Single	37	52.9
Married	28	40
Divorced	5	7.1
Education		
High School	53	75.5
Some College	9	13
Bachelor's Degree or Higher	8	11.5
Military Branch		
Army	33	47.1
Navy	15	21.4
Marines	12	17.1
Air Force	7	10.0
Other	2	2.8
Military Status		
Active	50	71.4
Veteran	19	27.1
Other	1	1.4

Measures

Demographic and General Medical Information. Demographic information collected from patient's medical files included age, gender, rank, branch of service, military status (veteran, active, reserve, guard), ethnicity/race, marital status, combat status, and education level. In addition, the intake and discharge dates from both the EC program and the PRC were recorded, to produce a total length of stay (in days). Date of injury, type of injury (TBI vs. anoxic), and mechanism of injury were also collected from patient charts. In addition, the planned discharge location for the patient once they completed their treatment was recorded.

Coma Near Coma Scale. The Coma Near Coma Scale (CNC) includes 11-items that assess for responsivity and awareness in the following areas: response to auditory stimuli (bell ringing), command responsivity (response to a request or command), response to visual stimuli, threat, olfactory response, tactile cue, response to pain, and the ability to vocalize or make sounds. Patients are given a score of 0, 2, or 4 for each of the items, with 0 indicating a strong response to the stimuli, and 4 no response. Total scores are calculated by summing the ratings for each of the items, and dividing this number by the total number of items administered. Total scores range from 0 to 4, with 0 indicating no coma, or consistent responsivity, and 4 indicating extreme coma, or no responsivity at all (Rappaport et al., 1982; Rappaport, Dougherty, & Kelting, 1992). The CNC has demonstrated high interrater reliability in previous assessments, with a correlation of $r = .95$, but lower ratings have been found with regard to the ability of the scale to efficiently assess and diagnose coma levels, with one study estimating the Cronbach's Alpha at .65, when patients were tested for their responsiveness at weeks one, eight, and sixteen post injury (Rappaport, Dougherty, & Kelting, 1992). See **Appendix D** for a full description of the scale.

It should be noted that patients in the polytrauma rehabilitation center being assessed in the current study are not administered the olfactory item on the CNC, which involves exposing the patient to the smell of ammonia to elicit a response. This practice has been discontinued due to the risk of damage to the olfactory system. There is however, a body of research that has not only linked olfactory dysfunction with traumatic brain injury, but also demonstrated that symptom can be especially impactful on a patient's quality of life (QOL; see Proskynitopoulos, Stippler, & Kasper, 2016 for a review).

Coma Recovery Scale- Revised. The JFK Coma Recovery Scale- Revised (CRS-R) is comprised of 23 items that includes six subscales examining auditory, motor, oral-motor, visual, communication, and arousal functions. The scale is intended to assess brain stem, cortical, and sub-cortical functioning and processes, and is based on the diagnostic criteria for vegetative or unwakeful state, minimally conscious state (MCS), and emergence from MCS (Giacino, Kalmar, & Whyte, 2004; Kalmar & Giacino, 2005). Patients are scored in various sensory domains based on their ability to respond to certain stimuli. For example, in the auditory function category, patients are presented with an auditory stimulus such as the sound of someone's voice or a bell, and are given a score based on whether they respond to that sound (e.g. moving their head towards the stimulus or shifting their eyes to the source). Total scores can range from 0 to 23, with lower scores indicating a reflexive response, and higher scores indicating more cognitively intact responses to stimuli (Giacino, Kalmar, & Whyte, 2004). The CRS-R demonstrated high interrater and test-retest reliability when used with a sample of 80 patients being treated in an inpatient coma recovery program, and demonstrated moderate concurrent validity when compared to the Coma Recovery Scale, and the Disability Rating Scale. The internal consistency has been deemed excellent, with a Cronbach's Alpha of .83 (Giacino, Kalmar, & Whyte, 2004).

In a separate study with brain injury rehabilitation patients suffering from a disorder of consciousness, La Porta and colleagues (2013) determined that the CRS-R was a reliable tool to use for diagnosis and assessment of the varying levels of consciousness. See **Appendix C** for a full description of the scale.

Functional Independence Measure "Self-Care" Subscale. The Functional Independence Measure (FIM) self-care subscale is a subcomponent of the larger FIM rating scale, and falls under the FIM Motor scale. The self-care subscale assesses six domains of a patient's ability to perform several types of activities related to self-care and hygiene. The domains include eating/feeding, grooming, bathing, dressing upper and lower body, and toileting. Patients are given a score between 1 and 7 depending on the level of care they require to complete the activities described above. A "1" indicates that a patient requires total assistance to complete the task (referred to as dependent), while a 7 indicates the patient is able to perform the activity on their own, without supervision (referred to as complete independence). If a patient cannot perform an activity in the domain in question, they are given a score of 0 for that particular area (Hamilton et al., 1987). Based on the medical charts reviewed, all patients being seen in the Richmond VAMCs EC program received a rating for each of the domains mentioned (no patient was left unscored or with a zero in any of the self-care domains assessed), resulting in total scores that ranged from 6 to 42. Patients' FIM self-care sub scores were recorded at both intake and discharge. Research has demonstrated that amongst TBI patients, there is an excellent interrater reliability for the FIM Motor subscale, with an intra-class correlation coefficient of r = .92, and excellent internal consistency for patients managing a neurological disorder, with a Cronbach's Alpha of .93 (Hobart, et al., 2001). For stroke patients in an inpatient rehabilitation setting, the Cronbach's Alpha was .88 (Hseuh, Lin, Jeng, & Hsieh, 2002). In a sample of elderly adults, with a mean age of 89.7 years, Pollak and colleagues (1996) found that the FIM Motor subscale has excellent tests-retest reliability, with an intra-class correlation of .95.

Functional Independence Measure for Cognitive Functioning. The FIM cognitive subscale is also a subcomponent of the larger FIM rating scale. It includes 5-items that assess a patient's cognition and speech through the following domains: problem solving abilities, social interactions, memory, expression, and cognitive comprehension. A "1" indicates that a patient requires total assistance to complete the task (referred to as dependent), while a 7 indicates the patient is able to perform the ADL one their own, without supervision (referred to as complete independence). If a patient cannot perform in the domain in question, then they are given a score of 0 for that particular area (Hamilton et al., 1987). For the current study, all patients received a rating for each of the domains mentioned, resulting in total scores that ranged from 5 to 35. In terms of the psychometric properties of the FIM cognitive subscale, researchers have found that the interrater reliability for patients with TBIs was somewhat less than that of the overall FIM measure and FIM motor subscale, with an intra-class correlation coefficient of .69 (Donaghy & Wass, 1998). For use with elderly adults, the intra-class correlation was somewhat higher, at .89 (Hobart et al., 2001).

Data Analyses

All analyses were conducted utilizing SPSS Statistical Software. Data were collected by the researcher through the use of the Hunter Holmes McGuire VA Medical Center's Computerized Record System. The researcher conducted two reviews of the data for accuracy and missing information before de-identifying the data set. The first step in the analytic process involved data cleaning and checking of assumptions for the planned analyses. Next, descriptive statistics, including the means and standard deviations were calculated to explore the demographic information that was collected. Third, one-way analysis of variance (ANOVA) models were used to explore differences in scores on the CNC and the CRS-R based on various demographic characteristics and medical experiences.

Fourth, changes in scores on pre- and post-treatment measures of functional independence in both the self-care and cognitive domains were analyzed using paired sample t-tests, and Cohen's *D* effect sizes. Fifth, linear regression and logistic regression models were used to explore whether age predicts the amount of time it takes to emerge from a minimally conscious state, and emergence itself. In addition, regression models were developed to explore whether intake scores on the CNC and the CRS-R could predict emergence and time to emerge.

The final set of analyses involved the use of logistic regression models and receiver operating characteristic (ROC) analyses to determine whether specific "cut" scores on the CNC or the CRS-R could be devised to better predict whether a patient will emerge (yes/no).

Results

Data Cleaning. Once the data were collected and transferred to a de-identified dataset, it was examined for missing data, multicollinearity, univariate and multivariate outliers, and normal distribution amongst the variables in questions. Data cleaning and assumption checking was based on of recommendations from Tabachnick and Fidell (2013). Assessment of the existence of outliers and normality of the data were carried out through the inspection of histograms, and by examining the skewness and kurtosis statistics. Only one transformation was conducted, and this was for the variable "length of stay," where an outlying data point was deleted and replaced with the mean of the group score on this variable. Data were also checked for multicollinearity, homoscedasticity, and linearity. No additional transformations were needed. Before conducting logistic regression analyses, additional assumptions of linearity were checked and met, using the Box-Tidwell procedure, while the independence of cases was assessed through the use of the Hosmer-Lemeshow test.

Missing Data. Data for two of the primary measures of interest, the CNC and the CRS-R were missing a number of data points at the selected time intervals that were being explored for this study. Table 5 depicts the total amount of data missing for each measure, at each time point. Based on suggestions from Tabachnick and Fidell (2013) regarding procedures for handling missing data, the researcher chose to refrain from implementing data replacement techniques for these measures for the entire sample for several reasons. First, when deciding whether to replace missing data, it is suggested to assess whether or not the data is missing at random. In the case of the CNC and the CRS-R, patients receiving treatment in the EC program did not begin regularly receiving these assessments until approximately 2008, five years into the data collection time period allotted for the current study. Additionally, due to the nature of the scales and their intent to measure levels of consciousness and progression towards emergence, it was often the case that a patient might have an initial score on one of these measures, but no subsequent scores on certain weeks because they emerged from their disorder of consciousness, and no longer warranted an assessment with the particular measure. Thus, it appears that in most cases, the data are missing either because the assessment measure in questions was not being used during the time the patient was being treated or for medical reasons, and not due to recorder error. In order to present an accurate portrayal of the progression of care for patients who were treated on this unit, the researcher created "subsets" of the data, where only individuals with at least one of the three times points measured for the CNC or CRS-R were available. Thus, any analyses where either the CNC or the CRS-R were the primary outcome variables of interest, these data subsets of the total population were used.

Table 5

Missing Data Totals for the Coma Near Coma Scale (CNC) and the JFK Coma Recovery Scale-Revised (CRS-R)

Data Collection Time Points	Coma Near Coma Scale *Included*	Coma Near Coma Scale *Missing*	Coma Recovery Scale Revised *Included*	Coma Recovery Scale Revised *Missing*
Intake	49	21	46	24
Week 1	36	34	36	34
Week 3	38	32	28	42

Descriptive Statistics

Table 6 provides a summary of the medical profile of the patients included in the study. A total of ten patients were deceased at the time of data collection. In all, 14.3% of the sample had injuries related to combat exposure, and 85.7% did not. The most frequent type of injury was TBI (82.9%), while anoxic brain injury accounted for the remaining 17.1% of patients. In terms of mechanism of injury, motor vehicle accident was by far the most frequently occurring incident at 55.7%, followed by "other" types of injuries, such as physical assault, drug overdose, or a medical condition. Blast associated injuries occurred in 8.6% of the sample, while falls accounted for 7.1%, gunshot wounds 7.1%, cardiovascular events 5.7%, and stroke 4.3% of the sample. 70% of patients emerged from their disorder of consciousness, while 30% did not.

The average length of stay for participants was 135 days (*SD* = 76), and the average time to emerge from a disorder of consciousness was 91.4 days (*SD* = 71.5). Discharge location varied amongst participants, with a majority being discharged to another rehabilitation program, be it acute care or long-term rehabilitation services (47.1%). Other locations included home (17.1%) a skilled nursing facility (17.1%), transitional living services (8.6%), a Military Treatment Facility (5.7%), or to hospice care (5.7%).

Table 6

Medical Demographics of Patient Sample (N=70)

Medical Profile Variables		*N*	%
Emerged			
	Yes	49	70
	No	21	30
Deceased			
	Yes	10	14.3
	No	60	85.7
Type of Brain Injury			
	TBI	58	82.9
	Anoxic	12	17.1
Mechanism of Injury			
	Motor Vehicle Accident	39	55.7
	CVA/Cardiovascular	7	9
	Combat/Blast Injury	6	8.6
	Fall	5	7.1
	Gunshot Wound	5	7.1
	Other	8	11.4
Discharge Disposition			
	Rehabilitation	33	47.1
	Home	12	17.1
	Skilled Nursing Facility	12	17.1
	Military Treatment Facility	4	5.7
	Hospice	3	4.3
		Overall Mean	Standard Deviation
Length of Stay		135.33	76.02
Time to Emerge		91.38	71.50

Descriptive statistics were also explored using data from the three main measures used in the study: The CNC, the CRS-R, the FIM "self-care" subscale, and the FIM cognitive subscale. Table 7 presents the frequency scores, means, and standard deviations for these measures.

Table 7

Frequency, Mean, and Standard Deviation for Primary Study Measures and Variables

Measure	*N*	Overall Mean	*SD*
Coma Near Coma Scale (CNC)			
Initial Assessment	49	2.04	.96
Week 1	36	1.94	.83
Week 3	38	1.73	.92
Coma Recovery Scale- Revised			
Initial Assessment	46	8.43	5.18
Week 1	36	10.81	4.92
Week 3	28	11.82	5.46
Functional Independence Measure (FIM) "Self- Care" Sub score			
Intake	70	6.73	3.47
Discharge	70	14.83	11.77
Functional Independence Measure (FIM) Cognitive Sub score			
Intake	56	5.26	.60
Discharge	46	14.39	8.36

Exploratory Analyses: Medical and Demographic Factors. Independent sample t-tests were used in order to explore differences between patients who did and did not emerge based on age, initial scores on CNC, and on the CRS-R. There was not a significant difference in the average age of those who emerged versus those who did not. Those who did emerge were slightly younger on average (*M* = 28.06, *SD* = 9.92), compared to those who did not emerge (*M* = 31.29, *SD* = 12.57). Independent sample t-tests did not demonstrate a significant difference in patients' initial scores on the CNC, based on whether or not they emerged (*N* = 50). Those who did not emerge had a slightly higher average initial score on the CNC (*M* = 2.43, *SD* = .86), while those who did emerge had a lower (better) average score (*M* = 1.88, *SD* = .97). In addition, there were no significant differences between average initial scores on the CRS-R based on emergence (N = 46). The average score for participants who did emerge and had CRS-R initial scores (*n*=34) was 9.21 (*SD* = 5.67), while those who did not emerge (*n* =12) had an average CRS-R score of 6.25 (*SD* = 2.45).

In addition, several one-way analyses of variance (ANOVA) models were used to explore whether significant differences existed between participants in terms of demographic variables such as race, education level, branch of service, military status, injury type, discharge disposition, and mechanism of injury in relation to the major outcome variables of the study, including initial scores on the CNC scale and the CRS-R, time to emergence, age, and length of stay. A majority of these models were not significant, likely due to low levels of participants in the various categories assessed. However, one model demonstrated a significant difference in the average age of participants based on their final discharge disposition, $F(5, 64) = 6.30$, $p < .001$. Specifically, patients who were sent to a Skilled Nursing Facility (SNF) were more likely to be older, compared to other discharge locations. See Table 8 for a summary of these results.

Table 8

One-Way Anova Model Exploring Differences in Discharge Location Based on Age (N=70)

Discharge Location	*n*	*M (SD)*
Rehabilitation	33	27.70 (8.42)
Home	12	23.92 (8.34)
Transitional Living	6	22.17 (2.23)
Skilled Nursing Facility	12	40.67 (12.26)
Hospice	3	38.33 (15.95)
Military Treatment Facility	4	23.75 (7.63)

Dependent Variable: Age

Additionally, after collapsing ethnic groups into three categories: White (*n*= 34), African American (*n* = 10), and other (*n* = 5), significant differences in group mean scores on the CNC initial were detected when reporting Welch's *F* statistic, *F*(2, 46) 26.71 = *p* <.001, after the assumption of Homogeneity of Variance was met using Leven's *F* test (*p* = .02). Specifically, a significant difference on initial CNC scores between white participants and those classified as "other" was detected, with white participants having a lower (better) score on the CNC at intake, compared to those from other ethnic backgrounds. See Table 9 for means and standard deviations.

Table 9

One-Way Anova Model Exploring Differences in CNC Initial Scores Based on Ethnicity (N=50)

Ethnicity	*n*	*M (SD)*
White	33	1.78 (.89)
African American	10	2.34 (1.0)
Other	5	3.15 (.23)

Dependent Variable: Coma Near Coma (CNC) Scale Initial Score

Data Analyses: Primary Hypotheses (Part I)

Age as a Predictor of Emergence and Functional Autonomy

Hypothesis 1: *Age of the emerging consciousness patient will significantly predict whether a patient emerges, with younger patients being more likely to emerge than older patients.*

A binomial logistic regression model was used to explore if age of the emerging consciousness patient was significantly related to whether or not an individual would emerge. The overall model was not significant, $\chi^2 = 1.28$, *df* = 1, *N* = 70, *p* = .26, and thus age was not a significant predictor of whether or not someone will emerge, *Wald* = 1.29, *df* = 1, *p* = .26, with 95% CIs of [.93 – 1.02]. The model effect size was small, with Nagelkerke $R^2 = .03$. A total of 70% of the cases were correctly predicted, with a majority of these being cases where the participant emerged (98%), versus did not emerge (4.8%).

Hypothesis 2: *Age of the emerging consciousness patient will significantly predict time to emergence (based on date of the initial brain injury), where younger patients will have a shorter time to emergence than older patients.*

To explore whether age was significantly related to the time it took a patient to emerge, a linear regression model was conducted where age was entered as the predictor variable, and time to emergence (days) was entered as the dependent variable. This model was significant, F (1, 47) = 4.07, p = .04, indicating that as the age of the participant increased, so too did their time to emerge. See Table 10 for a full summary of the results.

Table 10

Linear Regression Model: Hypothesis 2: Age as a Predictor of Time to Emergence

Variable	*B*	*SE(B)*	β	*t*	*p*	95% Confidence Intervals Lower Bound	Upper Bound
Step 1 (Constant)	34.90	29.66		1.18	.24	-24.76	94.56
Age	2.01	.99	.55	2.02	.04	.01	.21

Dependent Variable: Time to Emerge (Days)

Hypothesis 3: *Age of the participant will significantly predict scores on the Functional Independence Measure (FIM) self-care subscale at discharge, with younger patients having higher average scores than older patients.*

A linear regression model was used to explore whether age was a significant factor in patients' discharge scores on the FIM "self-care" subscale. Age was entered as the independent variable, while FIM "self-care" subscale scores at discharge were entered as the outcome variable. This model was significant, *F* (1, 68) = 4.91, *p* = .03, indicating that as the age of the participant increased, their scores on the FIM "self-care" subscale would decrease. See Table 11 for full results.

Table 11

Linear Regression Model: Hypothesis 3: Age as a Predictor of FIM "Self-Care" Subscale Scores at Discharge

Variable	*B*	*SE(B)*	β	*t*	*p*	95% Confidence Intervals Lower Bound	95% Confidence Intervals Upper Bound
Step 1 (Constant)	23.04	3.95		5.83	<.001	15.15	30.92
Age	-.28	.13	-.26	-2.22	.03	-.54	-.03

Dependent Variable: FIM "Self-Care" Subscale Scores at Discharge

Hypothesis 4: *Age of the participant will significantly predict scores on the Functional Independence Measure (FIM) cognitive subscale, with younger patients having higher average scores than older patients.*

A linear regression model was used to examine whether age was a significant factor in patients' discharge scores on the FIM cognitive subscale. Age was entered as the independent variable, while FIM cognitive subscale scores at discharge were entered as the dependent variable. Only a portion of the participants sampled in the study had discharge scores available on this measure (*N* = 47), and the model was not significant, *F* (1, 46) = 1.82, *p* = .18. See Table 12 for a summary of the results.

Table 12

Linear Regression Model: Hypothesis 4: Age as a Predictor of FIM Cognitive Subscale Scores at Discharge

	Variable	*B*	*SE(B)*	β	*t*	*p*	95% Confidence Intervals Lower Bound	Upper Bound
Step 1	(Constant)	18.48	3.39		5.46	<.001	11.66	25.30
	Age	-.15	.11	-.19	-1.35	.18	-.38	.07

Dependent Variable: FIM Self-Care Subscale Scores at Discharge

Primary Hypotheses (Part II)

Predictive Values of the Functional Independence Measure (FIM), JFK Coma Recovery Scale-Revised (CRS-R), and the Coma Near Coma Scale (CNC)

Hypothesis 1: *Lower scores on the initial measurement of the Coma Near Coma Scale (CNC) will significantly predict a higher rate of emergence from disordered consciousness, while higher scores on the same measure at intake will be predictive of a lower rate of emergence in emerging consciousness patients.*

A binomial logistic regression model was used in order to explore if initial scores on the CNC could significantly predict whether or not a patient will emerge from a disorder of consciousness. To accurately assess CNC as a predictor variable, only patients who had intake scores on the measure were included in the analysis. In one case, the mean of the group's initial CNC score was used to replace a missing value for this particular patient, as it was clear that the participant was missing the information due to recorder error at the time of their hospitalization. In all, 50 participants were included in the analysis.

When the CNC initial score was entered as the predictor variable, and emergence (yes/no) as the outcome, the overall model was marginally significant, $\chi^2 = 3.42$, $df = 1$, $N = 50$, $p =.06$. The model effect size was moderate, with Nagelkerke $R^2 = .1$. A total of 72% of the cases were correctly predicted. However, 100% of these were cases where patients emerged, and 0% were cases where they did not, demonstrating that the model was not efficient in accurately classifying all cases, using the default probability of .500. Table 13 displays the regression coefficient, Wald statistic, odds ratio and their associated confidence intervals.

Hypothesis 2: *Higher scores on the initial measurement of the Coma Recovery Scale-Revised (CRS-R) will significantly predict a higher rate of emergence from disordered consciousness, while lower scores on the same measure at intake will be predictive of a lower rate of emergence in emerging consciousness patients.*

A binomial logistic regression model was used to explore if initial scores on the CRS-R could significantly predict whether or not a patient would emerge. A total of 48 patients were included in this analysis, with the remaining 22 patients having missing data on any CRS scores during their stay.

The CRS initial score was entered as a predictor variable in the logistic regression model, and emergence (yes/no) was entered as the outcome. The overall model was marginally significant, $\chi^2 = 3.45$, $df = 1$, $N = 38$, $p = .06$, but CRS initial score as a predictor of emergence was not. The model effect size was moderate, with Nagelkerke $R^2 = .10$. A total of 72.9% of the cases were correctly predicted, however 100% of these were cases where the patient had emerged, and 0% of cases those who did not. This demonstrated that the model was not efficient in accurately classifying the cases, using the default probability of .500. See Table 13 for a full summary of findings.

Table 13

Logistic Regression: Hypothesis 2, Initial CNC and Initial CRS Scores as Predictors of Emergence

Variable	*B*	Standard Error	Wald	*Exp (B)*	95% Confidence Intervals Lower	Upper	*p*	Nagelkerke R^2
CNC Initial	-.65	.37	3.10	.52	.25	1.08	.08	.10
CRS Initial	.18	.09	2.67	1.16	.97	1.38	.10	.10

Dependent Variable: Emergence (Yes/No)

Hypothesis 3: *Emerging consciousness patients who have emerged will have a significantly higher score on the Functional Independence Measure of self-care activities and cognitive subscale at discharge, when compared to their intake scores on the same measure.*

To explore whether or not there were significant changes in patients' FIM scores from intake to discharge, paired sample t-tests were used to assess differences over time for patients who did emerge from a disorder of consciousness. Those who did not emerge were not included in this analysis due to a lack of expected variance in scores on physical and cognitive functioning at intake and discharge. Results indicated a significant difference between intake and discharge FIM self-care scores, t (69) = -7.06, p <.001, and intake and discharge FIM cognitive scores, t (45) = -9.49, p <.001 for participants who emerged from a disorder of consciousness. Cohen's *D* effect sizes were -.89 and -2.23, respectively. See Table 14 for a full summary of the findings.

Table 14

Paired Samples t tests: Hypothesis 3, Examining Differences Between FIM "Self-Care" Scores & FIM Cognitive Scores at Intake and Discharge for Patients who Emerged

Stigma Barriers		***M***	***SD***	***SE***	**t**	**Sig (2-tailed)**	**Cohen's *d***
Pair 1: FIM "Self-Care" Intake vs. Discharge	Intake	6.73	4.00		-6.06	<.001	-.89
	Discharge	14.83	12.30	1.34			
Pair 2: FIM Cognitive Intake vs. Discharge	Intake	5.26	.67		-7.48	<.001	-2.23
	Discharge	17.44	7.69	1.22			

Note: FIM Initial scores were entered first into the model, followed by discharge scores.

Exploratory Hypotheses:

Hypothesis 1: *The Coma Near Coma Scale (CNC) can be used to accurately predict whether patients with disorders of consciousness will or will not emerge, based on a given score on the measure at either intake, week one, or week three of treatment.*

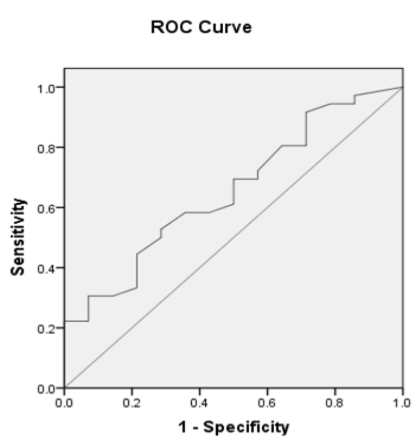
A total of three binary logistic regression models and receiver operating characteristic (ROC) analyses were used to determine whether an individual's CNC at either intake, week one, or week three of treatment could accurately predict whether someone emerges from a disorder of consciousness (emerged: yes or no).

Coma Near Coma Scale: Intake Score. In the first model, a logistic regression analysis was first conducted with initial scores on the CNC as the independent variable, and emergence (yes or no) as the dependent variable. A total of 50 participants in the sample had intake scores on the CNC, and so were included in this model. Using a base classification threshold predicted probability of target group membership of .5, the model was marginally significant, $\chi^2 = 3.42$, $df = 1$, $N = 50$, $p = .06$. The Nagelkerke pseudo R^2 suggested that the model accounted for a moderate proportion of the variance in emergence, at .1. An average of 72% of the cases were correctly predicted using the classification cutoff value of .500 for predicting emergence. In all, 100% of the cases were patients who emerged, and 0% were those who did not emerge, demonstrating that the model was not efficient in accurately classifying emergence.

To explore whether model performance could be improved with an alternative decision threshold, the predicted probabilities of emergence were subjected to a receiver operating characteristic (ROC) analysis. The ROC curve can be seen in Figure 2. The area under the curve was .655 (SE = .084), placing the fit of the model in the poor range (Meyers et al., 2013). See Table 15 for a full summary of the results. By changing the classification threshold from .50 to .71 based on the ROC analysis findings, the classification rate dropped from 72% down to 58%. However, 61% of patients who emerged were accurately classified, and 50% of patients who did not emerge were correctly predicted using the new classification threshold. Although the overall classification rate dropped, patients who did not emerge were now accounted for in the model, whereas with a decision threshold of .500, they were not. According to this model, patients with a probability value of .71542, or a CNC initial score of 2.2 or higher are less likely to emerge from a disorder of consciousness, although this model should be considered a marginally accurate predictor of emergence.

Figure 2

ROC Curve for Coma Near Coma (CNC) Scale, Initial Assessment

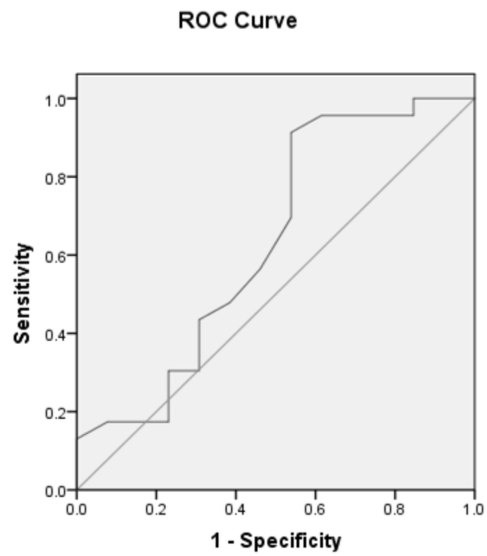


CNC Week One. In the second model, the independent variable in the binary logistic regression model was week one scores on the CNC, with emergence (yes or no) as the dependent variable. A total of 36 participants had CNC week one scores, and so were included in the model. Using a base classification threshold predicted probability of target group membership of .5, the model was not statistically significant, $\chi^2 = 2.06$, $df = 1$, $N = 36$, p =.16. The Nagelkerke pseudo R^2 suggested that the model accounted for a moderate proportion of the variance in emergence, at .08. An overall average of 66.7% of the cases were correctly predicted based on a classification cutoff value of .500, where 95.7% of patients who did emerge were accurately predicted, and 15.4% of patients who did not emerge were.

To explore whether model performance could be improved with an alternative decision threshold, the predicted probabilities of emergence were subjected to a ROC analysis. The ROC curve can be seen in Figure 3. The area under the curve was .632 (SE = .11), placing the fit of the model in the poor range (Meyers et al., 2013). Changing the classification threshold from .500 to .62 based on the findings of the ROC analysis resulted in the overall case classification average to decrease to 55.6%. However, 56.5% of patients who emerged were now accurately classified, as were 53.8% of patients who did not emerge In terms of a "cut score" for predicting emergence, patients with a probability value of .63828, or a week one CNC score of 2.0 or higher are less likely to emerge. These findings should be interpreted with caution due to the wide range of the confidence intervals for the area under the curve, which indicates a significant amount of error in the model. See Table 15 for a summary of the findings.

Figure 3

ROC Curve for Coma Near Coma (CNC) Scale, Week 1 Scores

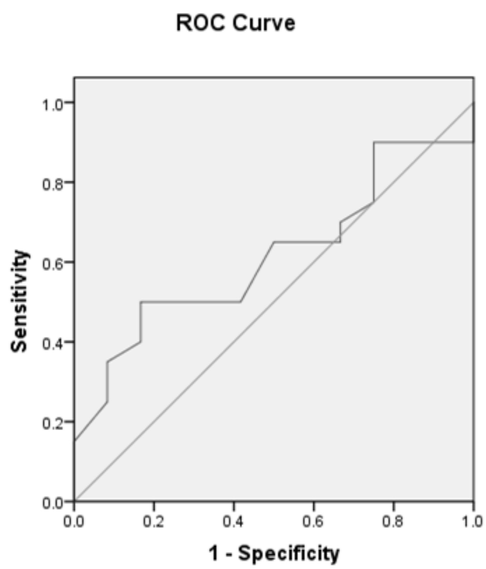


CNC Week 3. In the third model, the independent variable in the binary logistic regression model was week three scores on the CNC, with emergence (yes or no) as the dependent variable. A total of 32 participants had scores for the CNC at week three of treatment, and were thus included in the analysis. Using a classification threshold predicted probability of target group membership of .5, the model was not statistically significant, χ^2 = .69, *df* = 1, *N* = 32, *p* =.41. The Nagelkerke pseudo R^2 suggested that the model accounted for a low proportion of the variance in emergence, at .03. An average of 56.3% of the cases were correctly predicted based on a classification cutoff value of .500 for predicting emergence. For those who did emerge, 90% were accurately classified, while 0% of patients who did not emerge were included in this model.

To explore whether model performance could be improved with an alternative decision threshold, the predicted probabilities of emergence were subjected to a ROC analysis. The ROC curve can be seen in Figure 4. The area under the curve was .62 (SE = .10), placing the fit of the model in the poor range (Meyers et al., 2013). Changing the classification threshold from .500 to .63 resulted in a new overall case classification average of 59.4%, allowing for 65% of patients who did emerge to be accurately classified, and 50% of those who did not emerge to be accurately predicted. In terms of a "cut score" for predicting emergence based on week three measurements on the CNC, patients with a probability value of .64894, or a CNC week three score of 1.5 or above are less likely to emerge, although these findings should again be interpreted with caution due to wide ranging confidence intervals for the area under the curve of the ROC model. See Table 15 for a summary of the findings.

Figure 4

ROC Curve for Coma Near Coma (CNC) Scale, Week 3 Scores



Hypothesis 2: *The Coma Recovery Scale – Revised (CRS-R) can be used to accurately predict whether patients with disorders of consciousness will or will not emerge, based on a given score on the measure at either intake, week one, or week three of treatment.*

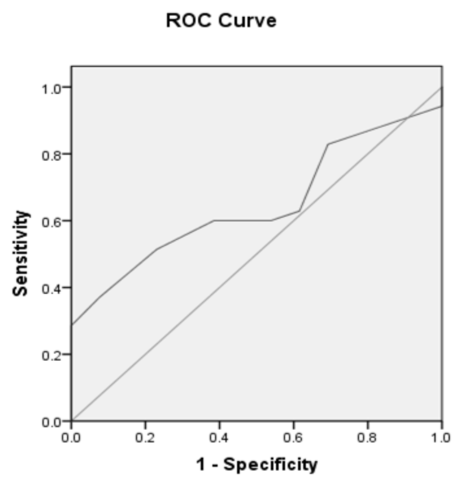
Binary logistic regression models and receiver operating characteristic (ROC) analyses were next used to determine whether an individual's CRS-R score at either intake, week one, or week three of treatment can accurately predict whether someone emerges from a disorder of consciousness (emerged: yes or no). Table 15 depicts a summary of the findings for each model.

Coma Recovery Scale, Intake. In the first model, the independent variable was initial scores on the CRS-R with emergence (yes or no) as the dependent variable. A total of 48 participants had initial scores on the CRS-R, and so were included in the analysis. Using a classification threshold predicted probability of target group membership of .5, the model was marginally significant, $\chi^2 = 3.45$, $df = 1$, $N = 48$, $p = .06$, The Nagelkerke pseudo R^2 suggested that the model accounted for a moderate proportion of the variance in emergence, at .10. CRS-R initial scores were not a significant predictor of emergence. An overall average of 72.9% of the cases were correctly predicted based on a classification cutoff value of .500 for predicting emergence. In all, 100% of patients who did emerge were accurately classified, while 0% of those did not emerge were.

To explore whether model performance could be improved with an alternative decision threshold, the predicted probabilities of emergence were subjected to a ROC analysis. The ROC curve can be seen in Figure 5. The area under the curve was .647 (SE = .080), placing the fit of the model in the poor range (Meyers et al., 2013). Changing the classification threshold from .500 to .69 resulted in a drop in the overall average classification rate from 72.9% down to 56.3%. Although the overall classification rate dropped, 60% of patients who did emerge were accurately classified in the new model, and 46.2% of patients who did not emerge were. According to the model, patients with a probability value of .71162 or above would be classified as having emerged. This corresponds to a CRS-R initial score of 7. Thus, patients with an initial score of 7 on the CRS-R or above had a higher probability of emerging, although this should be considered a marginally accurate model of prediction. See Table 15 for a summary of the findings.

Figure 5

ROC Curve for Coma Recovery Scale-Revised (CRS-R), Initial Scores



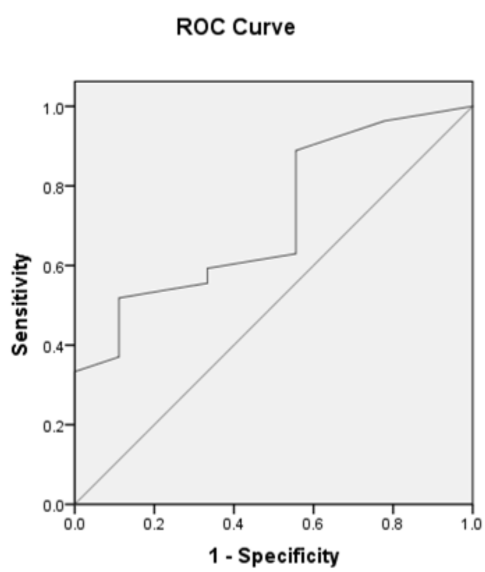
Coma Recovery Scale, Week 1. In the second model, the independent variable in the binary logistic regression model was scores on the CRS-R at week one of treatment, with emergence (yes or no) as the dependent variable. A total of 36 participants who had scores on the CRS-R at week one of treatment were included in this analysis. Using a classification threshold predicted probability of target group membership of .5, the overall model was significant, χ^2 = 4.81, *df* = 1, *N* = 36, *p* =.03. The Nagelkerke pseudo R^2 suggested that the model accounted for a moderate proportion of the variance in emergence, at .19. An overall average of 75% of the cases were correctly predicted based on a classification cutoff value of .500. 96.3% of patients who emerged were accurately classified, while 22.2 of patients who did not emerge were. CRS-R week one scores were a significant predictor of emergence, *Wald* = 3.78, *p* =.05, *b* = .20; 95% CI

[.998, 1.50], with a one-point increase in CRS-R scores associated with 1.22 times greater likelihood of emerging.

To explore whether model performance could be improved with an alternative decision threshold, the predicted probabilities of emergence were subjected to a ROC analysis. The ROC curve can be seen in Figure 6. The area under the curve was .72 (SE = .094), placing the fit of the model in the poor range (Meyers et al., 2013). By changing the probability classification threshold from .500 to .74, the average overall classification rate dropped from 75% down to 61.1%. However, 59.3% of patients who emerged were accounted for in the adjusted model, and 66.7% of patients did not emerge were. According to the model, patients with a probability value of .76122 or above would be classified as having emerged. This corresponds to a CRS-R week one score of 10. Thus, at week one, patients with a score of 10 or above had a higher probability of emerging, although this should be considered a marginally accurate model of prediction. See Table 15 for a summary of the findings.

Figure 6

ROC Curve for Coma Recovery Scale-Revised (CRS-R), Week 1



Coma Recovery Scale, Week 3. In the final model, the independent variable entered into the binary logistic regression model was scores on the CRS-R at week three of treatment, with emergence (yes or no) as the dependent variable. A total of 28 participants has week three scores on the CRS-R, and so were included in the analysis. Using a classification threshold predicted probability of target group membership of .5, the overall model was significant, $\chi^2 = 10.06$, *df* = 1, *N* = 28, *p* = .002. The Nagelkerke pseudo R^2 suggested that the model accounted for a large proportion of the variance in emergence, at .42 An overall average of 78.6% of the cases were correctly predicted based on a classification cutoff value of .500 for predicting emergence. 84.2% of patients who did emerge were accurately classified, while 66.7% of patients who did not emerge were. CRS-R week three scores were a significant predictor of emergence, *Wald* = 6.12, p =.05, b = .32; 95% CI [1.07, 1.77], with a one-point increase in CRS-R scores associated with a 1.37 times greater likelihood of emerging.

To explore whether model performance could be improved with an alternative decision threshold, the predicted probabilities of emergence were subjected to a ROC analysis. The ROC curve can be seen in Figure 7. The area under the curve was .83 (SE = .077), placing the fit of the model in the very good range (Meyers et al., 2013). Unfortunately, changing the classification threshold predicted probability to a value above .500 did not help to increase the overall accuracy of the model, so the threshold of .500 was retained. This is likely due to the low number of participants who had week three CRS-R scores.

According to the adjusted model, patients with a probability value of .56624 or above would be classified as having emerged. This corresponds to a CRS-R score of 10. Thus, at week three, patients with a score of 10 or above had a higher probability of emerging. This cut score finding should be interpreted with caution due to the use of a .5 cutoff for the probability score, and the large confidence intervals for the area under the curve of the model. See Table 15 for a summary of the findings.

Figure 7

ROC Curve for Coma Recovery Scale-Revised (CRS-R), Week 3

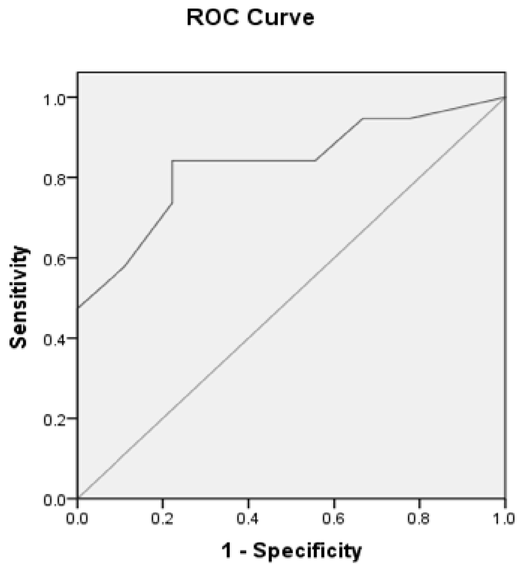


Table 15

Predictive Value of CNC and CRS at Selected Time Points for Emergence (Yes/No) & Results of ROC Analyses

Variable	*p*	*b*	AUC	AUC 95% Confidence Intervals		Cut Score	Nagelkerke R^2
				Lower Bound	Upper Bound		
Coma Near Coma Scale (CNC)							
Admission	.08	-.65	.66	.49	.82	2.2	.09
Week 1	.17	-.64	.63	.43	.84	2.0	.08
Week 3	.41	-.34	.62	.42	.81	1.5	.03
Coma Recovery-Scale (CRS-R)							
Admission	.10	.15	.65	.49	.80	7	.10
Week 1	**.05**	.20	.72	.54	.90	10	.19
Week 3	**.01**	.32	.83	.68	.99	9	.42

Dependent Variable: Emerged (Yes/No)
*Area Under the Curve

Discussion

The purpose of the current study was to explore some of the clinical characteristics of patients being treated in the Hunter Holmes McGuire Richmond VA Medical Center's Emerging Consciousness program, and specifically, to determine whether certain factors might better predict a patient's likelihood to emerge from a disorder of consciousness. Amongst those factors are a patient's level of functioning at the onset of admittance into the rehabilitation program, which is often measured using Rappaport's (1982) Coma Near Coma Scale (CNC), the JFK Coma Recovery Scale- Revised (CRS-R; Giacino, Kalmar, & Whyte, 2004) and the Functional Independence Measure (FIM) rating scales (Hamilton et al. 1987). As several researchers have demonstrated in previous work on the outcomes of severe brain injury, patients who exhibit a level of cognitive alertness that would place them in the minimally conscious state (MCS) versus a vegetative state (VS), are more likely to emerge and see stronger improvements in their physical and cognitive functioning through the course of rehabilitative treatment (Giacino et al., 2002; Godbolt et al., 2013; Katz et al., 2009). Thus, the current study sought to explore whether initial scores on the CNC and the CRS-R could accurately predict whether a patient will emerge. Age was also explored as a main factor throughout the study, based on previous research that has noted a significant relationship between younger age and faster recovery for both traumatic (De Guise, LeBlanc, Feyz, & Lamoureux, 2005) and non-traumatic (Howell et al., 2015) injuries.

Another major aim of the current study was to provide practical and meaningful information to clinicians working in rehabilitative care with patients managing a disorder of consciousness by exploring whether the CNC and CRS-R can be used as tools to predict emergence. Finally, the study sought to determine whether certain demographic or medical factors might help to predict discharge disposition, emergence from a disorder of consciousness, and length of stay, based on previous work in this area by Nakase-Richardson and colleagues (2013). The following sections will explore that major findings of the study, and compare them to existing research on emerging consciousness and acute rehabilitative care for severe brain injuries. Implications of the findings will be examined, along with limitations of the current study, and recommendations for future research and clinical practice.

Summary of Major Findings

Age as a Predictor of Emergence and Functional Autonomy

For the first hypothesis, a standard logistic regression model was used to examine whether age would predict emergence (yes/no) from a disorder of consciousness, with the belief that younger patients would be more likely to emerge when compared to older patients. This model was not significant, and there was not a significant relationship between age and likelihood of emergence, which is inconsistent with past research findings in this area. For example, De Guise and colleagues (2015) recently found that younger patients were more likely to recover from a severe brain injury during rehabilitative care. One of the reasons for the difference in findings may be related to the fact that patients entering the emerging consciousness program at the Richmond VAMC are “pre-screened” by providers for signs that that they have a high likelihood of emerging. Patients who are not good candidates for the level of rehabilitation that the program involves, and not likely to emerge, are not typically admitted for treatment. Thus, it is likely that the current sample being utilized for this study may differ medically from those patients who are included in studies sampling the general brain injury population.

A second hypothesis was that age of the emerging consciousness patient would significantly predict time to emerge from a disorder of consciousness. A standard linear regression model was used to explore this hypothesis, and analyses indicated that age is a significant predictor of time to emergence, where as one's age increased, so too did their time to emerge. As noted above, this finding is more in line with what researchers have demonstrated in previous research with brain injury patients. Age was also used as a factor in predicting patients' scores on both the "self-care" and cognitive subscales of the FIM at discharge. Separate standard linear regression models were used to explore these hypotheses, and only one model, whether age could predict scores on the FIM self-care measure at discharge, was significant. This model showed that as would be expected, when the age of the participant increased, their scores on the FIM self-care measure at discharge decreased. The lack of similar findings for the FIM cognitive model may have been influenced by the limited number of participants (N = 47) who received this measure at discharge from rehabilitative treatment in the Richmond VA's EC program.

Predictive Value of the Coma Near Coma (CNC) Scale and the Coma Recovery Scale (CRS-R)

In the next set of primary hypotheses, the predictive utility of both the CNC and the CRS-R measures were explored to determine whether intake scores on these scales could predict emergence from a disorder of consciousness. In the first set of analyses, a binomial logistic regression model was utilized to examine whether lower scores on the initial measurement of the CNC at the onset of treatment would translate to a higher rate of emergence for patients being seen in the EC program. The CNC is a reverse scored measure of coma severity, where lower scores indicate a higher level of cognitive arousal and awareness, and higher scores indicate less functioning. Findings demonstrated that the CNC initial score is not a significant predictor of whether or not a patient will emerge. Although the model as a whole was marginally significant, CNC initial scores were not independently a strong predictor of whether someone would emerge from a disorder of consciousness. The same findings were discovered for CRS-R initial scores.

Although it is likely that the limited sample size had an impact on the conclusiveness of the statistical findings for these measures and their relationship to emergence, researchers have called into question the validity and usefulness of the CNC in its ability to accurately assess and quantify the cognitive and behavioral attributes of patients managing a disorder of consciousness (Liu, Mallinson, Paper, & Guernon, 2015; Seel et al., 2010). However, the CRS-R has not endured the same level of criticism, and in one review was consistently rated as a worthwhile measure for exploring levels of disorders of consciousness (Seel, et al., 2010), so it is somewhat surprising that it was not found to be a significant predictor in the current study.

Changes in Functional Autonomy Over Time

Independent sample t-test models were used to assess changes in FIM scores over time for patients who emerged from a disorder of consciousness. Analyses showed that there were significant differences in the levels of physical and cognitive functioning for patients at intake and discharge, with a Cohen's *D* value of .89 for FIM "self-care" scores, and Cohen's *D* of 2.23 for cognitive functioning. These findings are consistent with recent literature that has explored the impact of acute rehabilitation on severe brain injured patients. Specifically, Nakase-Richardson and colleagues (2012) noted significant improvements in FIM motor and cognitive scores for patients recovering from a severe brain injury of both traumatic and non-trauma related etiologies at 1-year and 2-years post-injury. In a separate study using the same sample, Whyte et al. (2013) noted that 7% to 21% of patients who had regained the ability to follow commands during their time in acute rehabilitation were considered independent in at least one functional domain, as measured by the FIM. The current study's findings are also consistent with research conducted with patients treated exclusively in a VHA-EC program, where improvements in both motor and cognitive functioning were noted regardless of the mechanism of their injury (Nakase-Richardson et al., 2013). Unfortunately, due to the low number of non-TBI patients in the current study, the findings were limited to looking at differences in FIM scores across types of brain injures (both anoxic and TBI), but previous research has demonstrated that individuals managing a TBI tend to fare better overall in their functional abilities when compared to those with anoxic brain injuries (Cullen & Weisz, 2011; Nakase-Richardson et al., 2013).

Exploratory Hypotheses: Determining "Cut Scores" in the Coma Near Coma (CNC) Scale & Coma Recovery Scale- Revised (CRS-R) for Predicting Emergence

Another aim of the current study was to explore whether certain scores on two of the more commonly used measures for patients managing a disorder of consciousness (CNC and CRS-R) might be useful in predicting emergence. In order to do this, patients' scores from three separate time points for each measure were examined using binary logistic regression models to determine how well participants could be accurately classified as having emerged or not, using certain probability thresholds. For the purpose of this study, the researcher's aim was to find an equal balance between patients being accurately classified as emerged or as not emerged, as both classifications are significant in their clinical implications and in their utility to providers and family members. Next, ROC analyses were used to determine whether a predictive "cut point" in patients' scores could be determined to help predict emergence using the CNC or CRS-R. For each measure, a cut score was calculated for patients at intake, week one of treatment, and at week three. After conducting the binary logistic regression models and ROC analyses for each time point for the two measures, a few notable findings emerged. For the CNC, only intake scores on the measure demonstrated a marginally significant relationship with emergence. Using a classification threshold that translated to a 2.2 on the CNC scale, initial scores were able to provide a better fitting model for predicting whether a patient would emerge, when compared to week one and week three scores on the measure. This analysis essentially demonstrated that patients who have a score of 2.2 or higher at the initial onset of treatment are *less* likely to emerge. Unfortunately, and likely due to the low number of participants sampled in the study who had initial scores on the CNC (N= 48), there was a significant amount of error variance in the model, and the accuracy of the predictive score must be interpreted with caution.

In terms of the CRS-R, binary logistic regression analyses demonstrated different results from the CNC in terms of which time points during treatment were better predictors of emergence. The initial CRS-R scores were not significant predictors of emergence, while both the week one and week three scores were. In addition, the model fit for determining a "cut score" that would accurately classify patients as having emerged or not improved from intake, to week one, and again from week one to week three. After adjusting the classification probability threshold to more accurately classify those who did and did not emerge, and then using a ROC analysis, week three scores produced the most accurate model for predicting emergence. Taken together, these analyses indicated that the best guess for predicting whether a patient will emerge may come from looking at a patient's CRS-R week three score. For those with a score of 9 or above, the probability of emerging was enhanced. However, as mentioned with the models exploring the predictive value of the CNC, the high level of error variance noted in both the binary regression models and the ROC analyses indicates that these results should be interpreted with caution, and that the use of a more robust sample would help to bolster the validity of these findings.

Exploratory Analyses: Differences Based on Medical and Demographic Factors

One-way ANOVA models were utilized to explore whether emergence (yes or no), initial CNC scores, initial CRS-R scores, discharge dispositions, and length of stay varied based on several demographic factors. Of the numerous models that were explored, few were significant, likely to due to low representation of the various categories assessed, and unequal group sizes. Discharge disposition did tend to vary significantly depending on the patient's age, with the largest variance seen in the average age of patients who were sent to skilled nursing facilities (SNF) versus all other discharge sites (with older patients being more likely to be discharged to a SNF). SNFs tend to function as sites where patients go to receive additional assistance in their daily living, versus continued rehabilitation, making this finding somewhat unsurprising based on the results from the current study that linked age with functional recovery levels at discharge.

Another finding from exploring differences in certain clinical outcomes and patient characteristics was related to the ethnic background of the patients and initial scores on the CNC scale. A one-way ANOVA model demonstrated that patients who identified as white were more likely to see better scores on the CNC at intake when compared to patients from "other" ethnic background categories. This included individuals who identified as Asian, Hispanic, or American Indian, that had been combined as one group for the purpose of the analysis. White patients also had lower mean initial CNC scores compared to African American patients, although this difference was not statistically significant. In terms of the current literature in this area, one study has shown that for veterans in particular, the likelihood of sustaining a moderate to severe TBI is higher for African Americans and Hispanics (Dismuke, Gebregziabher, Yeager, & Egede, 2015). In civilian samples, the recovery of patients from different ethnic groups may also vary, with one large scale study indicating that Caucasians were at an increased risk of death compared to other minority groups after sustaining a brain injury (Berry, Ley, Mirocha, & Salim, 2010). However, little to no research has been conducted exclusively with emerging consciousness patients in terms of the impact that ethnic background has on functional recovery or emergence, so future research in this area is warranted.

Implications

The purpose of this study was to explore an area of clinical practice and research that is relatively unique, particularly where predicting emergence from a disorder of consciousness is concerned. Although limited by a relatively small sample size, the findings of the current study may help to benefit current providers in their assessment and treatment of the emerging consciousness population, and can also serve as a catalyst for future research.

In terms of specific clinical implications, one of the major findings of the current study has to do with the impact of age on the overall recovery and progression through treatment during acute rehabilitation for patients with a DOC. As noted, several studies on brain injury have linked those with a younger age to better physical and cognitive recovery following severe brain injury (De Guise, LeBlanc, Feyz, & Lamoureux, 2005; Howell et al., 2015). Therefore, providers should consider a patient's age when designing rehab treatment plans. It may be that elderly patients require a different level, or different type of care than their younger counterparts, due to the differences in how the brain "heals" after a traumatic or anoxic brain injury. As was seen in this study, the number of trauma-related brain injury patients far exceeded the number of anoxic brain injuries, so the conclusions that can be drawn on differences between TBI and non-TBI cases are limited. However, future research might clarify this issue by looking to multi-site studies involving VA and non-VA facilities in the years to come.

Another major finding of the current study is the utility of two of the more commonly used measures in assessing disorders of consciousness: the CNC and the CRS-R. Although this study was unable to provide the level of statistical acuity that is required to apply the findings beyond the sample that was explored, the trends of the data for these two measures are still worth noting. In particular, for the CNC earlier assessments of EC patients provided a better prediction on the likelihood of emergence; whereas for the CRS-R, the accuracy of predicting emergence was highest during the third week of treatment. Although these findings are somewhat inconclusive based on the small sample size, future research might be more conclusive by focusing on these specific time periods in treatment, and using a larger sample size.

It is also worth noting that 70% of the patients who were treated in the Richmond VAMC's EC program from 2003 until 2015 did eventually emerge. In addition, significant improvements in average FIM scores from intake to discharge were seen for patients in both the FIM self-care and FIM cognitive domains. A majority of patients went on to receive additional rehabilitation, some 47% of the sample, while only a small segment were placed in hospice care (4.3%) or a skilled nursing facility (17.1%). Taken together, these findings demonstrate that acute rehabilitation is effective, even for patients with the most severe of brain injuries.

Limitations

There were several notable limitations to the current study that can be viewed as areas of growth for future research endeavors of this kind. For one, the most pressing concern is the low number of participants available, and namely the large amounts of missing data that made this small sample size problematic. Future studies would certainly benefit from collecting data from multiple sites to increase the sample size, and therefore bolster the conclusiveness and external validity of the findings. A related limitation is the lack of data that was available for certain key variables, such as scores on the CNC and CRS-R, and on the FIM cognitive subscale. Although future studies might benefit from exploring ways to incorporate other information from patient's medical files to highlight the trajectory of recovery for EC patients, it may also be beneficial to explore the feasibility of implementing VA-wide changes for the EC programs to reduce the problem of missing or incomplete clinical data, especially as these programs continue to develop and change over time. This idea will be explored further in the "Recommendations" section of this paper.

Another limitation of the current study is the lack of diversity in the sample. Although some differences were found between patients based on their ethnic background, the low representation of people of color and of women made it difficult to draw any firm conclusions about how the experience of recovering from a severe brain injury may differ based on ethnic identity or gender identification. An additional issue that arose from this study is again related to a limited sample size, and specifically the low representation of patients who suffered from non-TBI related brain injuries. In all, 58 of the patients in the study had been diagnosed with a TBI, while only 12 experienced anoxic brain injuries. This uneven distribution made it difficult to draw comparisons between emerging consciousness patients based on type of brain injury. Future studies should include a much larger representation of anoxic brain injury patients suffering from disorders of consciousness to determine whether significant differences in rehabilitative outcomes and clinical characteristics exist between these groups.

A final limitation of the current study is the lack of information on the medical experiences of patient's post-treatment, or post-acute rehabilitative care. This type of study captures a relatively small glimpse into the lives and medical profiles of a unique subset of the rehabilitation population, especially considering that most of the patients were being treated within the first year of their injury. Thus, it is difficult to make presumptions about the progress or setbacks that the patients endured once they left the rehab environment. In fact, the only information that was gathered related to prognosis upon separation from the program is mortality rates. At the time of data collection, a total of 10 patients (out of the full 72 medical files that were reviewed) were listed in the VA's medical data base as being deceased. For some of these patients, it was clear that their death was related to their initial polytraumatic injuries. However, for others, the cause of death was not immediately clear. Thus, future studies would benefit from taking on a longitudinal approach to examine the medical course of emerging consciousness in both TBI and non-TBI patients.

Finally, due to the cross-sectional nature of the current study, it may be difficult to generalize findings beyond the current sample. The patients included were all active duty military personnel or veterans, which raises the question of whether they possessed unique physical or psychological attributes based on this designation alone. In addition, this study is investigating one of many brain injury rehabilitation programs in the U.S., making it likely that the type of care being received at this specific treatment center may be unique; even within the VA health care system. Some of this variability may be mitigated by the standards of practice that are set forth by international rehabilitation commissions such as the Commission on Accreditation of Rehabilitation Facilities (CARF) and the American Congress of Rehabilitation Medicine (ACRM), but nonetheless, having a sample of patients from several different types of acute rehabilitation treatment centers would substantially improve the external validity of the study, and allow for the opportunity to root out commonly occurring experiences among EC patient that go beyond the commonalities shared by this sample.

Recommendations for Future Directions

Several suggestions have been noted thus far in terms of how a study of this nature might be improved in future endeavors, with one of the most prominent recommendations being to expand data collection to multiple sites, starting with a multi-site collaboration between the five VA Polytrauma Rehabilitation Centers (PRCs). Through the use of a computerized record system, the VHA provides a unique opportunity for researchers to gather extensive information on veterans and service members who have gone through this type of program that involves minimal risk. One barrier, however to completing a study like this is the lack of uniform guidelines on treatment protocol and measurement tools across VHA-EC programs. For example, as mentioned earlier, providers in the EC program at the Richmond VAMC have certain criteria for what constitutes emergence. These criteria include patients being able to repeatedly demonstrate functional use of an object, and functional communication for at least two weeks before being considered as having emerged (McNamee et al., 2012). Although these standards are based on recommendations by prominent research in the field and the ACRM, the length of time and means by which these behaviors are measured is largely a decision made by the onsite medical team and therapists. Thus, without a common standard across VA polytrauma sites on what constitutes as emergence, it may be difficult to accurately collect information from multiple treatment centers, and from patients across several years of treatment. Having a more standardized procedure for defining emergence from a disorder of consciousness across PRC sites may help to bolster the consistency of this type of information, and will also help to enhance the accuracy of predicting emergence. As the ACRM continues to develop the standards of practice for working with patients in the emerging consciousness realm, it may become more feasible to achieve this level of consistency across sites in the near future.

Another area of improvement is the use of a uniform set of measures across VA polytrauma sites to assess levels of consciousness. A recent meta-analysis on the validity and reliability of scales that measure coma levels for patients with a disorder of consciousness demonstrated that the CRS-R consistently performed better than other measures assessing similar constructs (Seel et al., 2010). The CRS-R appears to be a common tool used within the VHA, based on previous research in this area (McNamee et al., 2012; Nakase-Richardson et al., 2013), while the CNC appears to be a tool that was more commonly utilized in the earlier years of the Richmond VAMC emerging consciousness program. Instituting a standard set of procedures across VA treatment centers that includes the type of measures used to assess level of consciousness for EC patients, and the frequency that assessment should occur would improve information sharing about the clinical outcomes for this population between providers and clinical researchers. More recently, this has been task has been addressed through the multi-site adoption of the CRS-R as a common tool for assessing cognitive changes for VHA-EC program participants. Continued efforts to communicate and work with each of the five polytrauma sites to enhance collaboration and promote uniformity in practice are encouraged.

In addition, it may also be beneficial to institute formal training on the administration, scoring, and interpretation of measures such as the CRS-R, the CNC, and the FIM for EC providers across disciplines. This will help to enhance the integrity of the information being collected through the use of these measures, and also improve sharing of information within the interdisciplinary teams on the polytrauma units. Currently, an effort is underway to implement this standard of practice within the polytrauma system of care, based on findings from VA led EC work groups.

Some final suggestions are related to the way that information is stored and categorized in patient medical files, specifically for those who are treated in the VA system of care. One of the main challenges of the current study during the chart review process was inconsistent record keeping by providers and medical staff, which certainly improved over time as the Richmond VAMC's emerging consciousness program evolved and became more organized. However, it was often the case that certain measures were not consistently used or recorded by providers for each of the patients seen in the program, or certain details about the patient's recovery were omitted or not made clear, such as the exact date or week the patient was considered to have emerged. In more recent years, the use of standardized weekly interdisciplinary team notes, and the implementation of the "TBI Toolbox" data system, which allows for uniform digital data entry of the more commonly used measures in the program (CNC, CRS-R, and FIM, for example) has helped to improve this process. Thus, setting and maintaining these types of standards of practice across polytrauma rehabilitation sites may help to ensure that patient information is readily available for providers and researchers in the future.

Final Thoughts

As a result of the wars in Afghanistan and Iraq, the VA has once again found itself in a unique position to be on the leading edge of clinical practice and research, particularly for patients managing severe brain injuries and disorders of consciousness. Although these individuals make up a relatively small proportion of the patient demographic in the VHA system, theirs is a unique experience that is further complicated by the complexities of the human brain, and the wide variability that is often seen in brain injury recovery. Thus, studies that attempt to isolate and bring to light some of the varying factors that might predispose or influence successful recovery from a severe brain injury are sorely needed. Continued efforts to better understand the long-term impact that these conditions have on medical outcomes and cognitive functioning will also help bring to light the care needs for this population as they age, while serving to enhance the lives of both the victims and the family members of brain injury survivors.

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Appendix A

Ranchos Los Amigos Scale – Levels of Cognitive Functioning (RLAS)

Level I	*No response.* Patient does not respond to external stimuli and appears asleep.
Level II	*Generalized Response.* Patient reacts to external stimuli in nonspecific, inconsistent, and non-purposeful manner with stereotypic and limited responses.
Level III	*Localized Response*. Patient responds specifically and inconsistently with delays to stimuli, but may follow simple commands for motor action.
Level IV	*Confused, Agitated Response.* Patient exhibits bizarre, non-purposeful, incoherent or inappropriate behaviors, has no short-term recall, attention is short and nonselective.
Level V	*Confused, Inappropriate, Non-agitated Response.* Patient gives random, fragmented, and non-purposeful responses to complex or unstructured stimuli- Simple commands are followed consistently, memory and selective attention are impaired, and new information is not retained.
Level VI	*Confused, Appropriate Response.* Patient gives context appropriate, goal-directed responses, dependent upon external input for direction. There is carry-over for relearned, but not for new tasks, and recent memory problems persist.
Level VII	*Automatic, Appropriate Response.* Patient behaves appropriately in familiar setting, performs daily routines automatically, and shows carry-over for new learning at lower than normal rates. Patient initiates social interactions, but judgement remains impaired.
Level VIII	*Purposeful, Appropriate Response.* Patient oriented and responds to the environment but abstract reasoning abilities are decreased relative to premorbid level.

Adapted from Hagen et al., 1979

Appendix B

Disability Rating Scale (DRS)

A. Eye Opening 0 – Spontaneous 1 – To Speech 2 – To Pain 3 – None	**Score**
Communication Ability 0 – Oriented 1 – Confused 2 – Inappropriate 3 – Incomprehensible 4 – None	
Motor Response 0 – Obeying 1 – Localizing 2 – Withdrawing 3 – Flexing 4 – Extending 5 – None	
Feeding (Cognitive Ability Only) 0.0 – Complete 1.0 – Partial 2.0 – Minimal 3.0 – None	
Toileting 0.0 Complete 1.0 Partial 2.0 Minimal 3.0 None	
Grooming (Cognitive Ability Only) 0.0 – Complete 1.0 – Partial 2.0 – Minimal 3.0 – None	
Level of Functioning (Physical, mental, Emotional, or Social) 0.0 – Completely Independent 1.0 – Independent In Special Environment 2.0 – Mildly Dependent-Limited Assistance 3.0 – Moderately Dependent-Moderate Assistance 4.0 – Markedly Dependent-Assist Major Activities 5.0 – Totally Dependent-24 Hour Nursing Care	
Employability 0.0 – Not Restricted 1.0 – Selected Jobs, Competitive 2.0 – Sheltered Workshop, Non-Competitive 3.0 – Not Employable	

Adapted from Rappaport, Hall, Hopkins, Belleza, & Cope, 1982

Appendix C

JFK Coma Recovery Scale – Revised (CRS-R)

Auditory Function Scale 4 – Consistent Movement to Command** 3 – Reproducible Movement to Command** 2 – Localization to Sound 1 – Auditory Startle 0 – None	**Score**
Visual Function Scale 5 – Object Recognition** 4 – Object Localization: Reaching** 3 – Visual Pursuit** 2 – Fixation** 1 – Visual Startle 0 – None	
Motor Function Scale 6 – Functional Object Use* 5 – Automatic Motor Response** 4 – Object Manipulation** 3 – Localization to Noxious Stimulation** 2 – Flexion Withdrawal 1 – Abnormal Posturing 0 – None/Flaccid	
Oromotor/Verbal Function Scale 3 – Intelligible Vocalization** 2 – Vocalization/Oral Movement 1 – Oral Reflexive Movement 0 – None	
Communication Scale 2 – Intelligible Verbalization* 1 – Non-Functional: Intentional** 0 – None	
Arousal Scale 3 – Attention 2 – Eye Opening w/o Stimulation 1 – Eye Opening with Stimulation	
TOTAL **Denotes emergence from MCS* ***Denotes MCS*	

Adapted from Cifu & Lew, 2013

Appendix D

Coma Near Coma Scale (CNC)

Domain	**Score Criteria**
Auditory	
a. Bell Ringing (orientation to sound)	3 or more responses = 0 1 or 2 responses = 2 No response = 4
b. Command responsivity	2 or 3 responses = 0 Inconsistent response = 2 No response = 4
Visual	
a. Light flashes	Sustained fixation or avoidance x 3 = 0 Partial fixation 1 or 2 times = 2 No tracking = 4
b. Follow face and look at me	Sustained tracking 3 or more times = 0 Partial tracking 1 or 2 times = 2 No tracking = 4
Threat	
a. Move hand within 1-3 inches of eyes	3 blinks = 0 1 or 2 blinks = 2 No blinks = 4
Olfactory	
Ammonia under nose for 2 seconds*	**N/A**
Tactile	
a. Shoulder tap	Orientation towards tap 2 or 3 times = 0 Partially orients 1 time = 2 No response = 4
b. Nasal swab	Clear, quick response 2 or 3 times = 0 Delayed or partial response 1 time = 2 No response = 4
Pain	
a. Pressure on finger nail	Withdrawal 2 or 3 times = 0 Gen. agitation/non-specific movement = 2 No response = 4
b. Ear pinch	Responds 2 or 3 times = 0 Gen agitation/non-specific movement = 2 No response = 4
Vocalization (spontaneous)	Spontaneous words = 0 Non-verbal vocalize = 2 No sounds = 4

Adapted from Cifu & Lew, 2013