EVALUATING THE RELATIONSHIP BETWEEN DEPRESSION, COGNITIVE PERFORMANCE AND QUALITY OF LIFE FOLLOWING TRAUMATIC BRAIN INJURY WITHIN THE CONTEXT OF THE CHRONIC CARE MODEL

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Depression is the most common mood disorder after traumatic brain injury (TBI). This study evaluated how the presence and/or severity of depression post-TBI affect a person's cognitive status and quality of life (QOL). Demographic variables, injury severity, and pre-morbid psychiatric histories were documented from patient interview and medical records. Persons with TBI were assessed at 6 and 12 months post-injury for posttraumatic depression using the Patient Health Questionnaire (PHQ-9). They were also evaluated for cognitive status and QOL at the same time points. Results indicate that persons with moderate/severe TBI exhibit worse cognitive status and report lower QOL post-injury than persons with no depression. Persons with mild depression report lower QOL than persons with no depression, but do not display worse cognitive functioning. The severity of posttraumatic depression, not just the presence of depression, affects a person's cognitive status and QOL after injury. TBI and posttraumatic depression are chronic conditions. The Chronic Care Model is a framework for identifying and improving care at multiple levels within the health care system including delivery system design, decision support, clinical information systems, self-management support, and within the community. The current health care delivery for persons with TBI suffering from posttraumatic depression and treated in southwestern Pennsylvania is discussed and areas for improvement within the system are identified.

The public health significance of this research is important for understanding the relationship of depression, cognition and QOL after TBI and effectively targeting persons with posttraumatic depression to formulate interventions which allow for better outcome and QOL post-injury.

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1.0 INTRODUCTION

Depression is the most common emotional disorder people experience after traumatic brain injuries (TBI). There is limited research addressing the effects of depression on cognitive status and quality of life (QOL) post-TBI. TBI and posttraumatic depression are chronic conditions that require continual interaction between patients and the health care system. The Chronic Care Model addresses areas and responsibilities of the health care system to identify current deficiencies in the delivery of health care. This model will be used as a framework to assess the current health care delivery for persons with TBI suffering from posttraumatic depression in southwestern Pennsylvania. Problems within the current system will be identified and potential improvements will be suggested.

The purpose of this research is to examine the following questions:

1. Does the presence and/or severity of depression post-TBI affect a person's QOL at 6 and 12 months post-injury?

   Hypothesis: People who exhibit depressive symptoms post-TBI, especially people with moderate/severe depression, will report lower QOL 6 and 12 months post-TBI

2. Does the presence and/or severity of depression post-TBI affect a person's cognitive status at 6 and 12 months post-injury?

Hypothesis: People who exhibit depressive symptoms post-TBI, especially people with moderate/severe depression, will have worse cognitive outcome 6 and 12 months post-TBI

3. How can the Chronic Care Model be utilized as a framework for identifying current deficiencies in the health care of persons with posttraumatic depression and what areas for improvements can be recommended?

2.0 REVIEW OF THE RELEVANT LITERATURE

The CDC reports that approximately 1.4 million people sustain a TBI each year in the United States resulting in 50,000 deaths, 235, 000 hospitalizations and 1.1 million people treated and released from the emergency department.[1] At least 5.3 million Americans, approximately 2% of the population, are currently living with deficits resulting from a TBI which require help to perform activities of daily living.[2] A person who survives the initial insult of a TBI is left with a variety of functional deficits after the injury which can affect cognition, sensation, language, and emotion.[3] The cost to society resulting from TBI was estimated to be $50 billion in the US in 2000. This cost includes both direct medical costs as well as the indirect costs associated with lost of productivity associated from sustaining a TBI.[4]

Disabilities resulting from TBI are not only physical in nature. Cognitive and emotional changes post-TBI can affect a person's return to normal productivity within the workplace, as well as within roles in their family, community and society. Cognitive dysfunction post-TBI includes a variety of processes such as memory, learning, reasoning, attention, language, and executive functioning. Emotional alterations post-TBI can contribute to depression, anxiety, personality changes, aggression and social inappropriateness.[3] Additionally, a person's QOL is often altered as a result of their injury.

Cognitive and emotional changes can affect a person after a TBI for the remainder of their life. A TBI survivor is seen as having a chronic condition after an injury as they must face the consequences of a brain injury for a lifetime. If a person with TBI also experiences posttraumatic depression, they then endure multiple chronic conditions that must be treated over an extended period of time. Chronic conditions require ongoing and extensive managed care and interaction with the health care system. The Chronic Care Model is a public health model which identifies the essential components necessary for improving care at multiple levels within the health system.[5] The Chronic Care Model will be discussed in the context of the chronic condition of traumatic brain injury.

2.1 ADULT TRAUMATIC BRAIN INJURY

The etiology and outcome of TBI is often related to epidemiologic factors. A review of the epidemiology of adult TBI reveals certain age groups, gender, and racial backgrounds serve as potential risk factors for sustaining a brain injury.

The leading causes of civilian TBI include falls (28%), motor vehicle or traffic related crashes (20%), struck by/against events (19%), assaults (11%), and other injuries (22%).[6] Fall related injuries are highest among older adults over the age of 75.[6] Motor vehicle accidents result in the greatest number of TBI related hospitalizations and are the highest cause of injury for people age 15-19.[6] Struck by/against events include mostly sports related injuries. Sports injuries account for 1.6-3.8 million TBIs a year although most of these are mild injuries which are not treated in the hospital or emergency department.[7] The Department of Defense reports that the leading causes of military TBIs include blast injury (72%), falls (11%), vehicular incidents (6%), injuries due to fragments (5%), and other injuries (6%).[8]

In the civilian population approximately 75% of TBIs each year are due to concussions or other forms of mild brain trauma [9], with the remaining 25% of injuries consisting of moderate to severe TBI. In the military population, approximately 88% of TBIs are classified as mild injuries while the remaining 12% consisting of moderate to severe injuries.[8]

Epidemiologic factors such as age, gender and race affect the risk and prevalence of TBI. The age group most at risk for sustaining a TBI as an adult is comprised of persons between the ages of 15-19.[6] Another group at risk for TBI is adults over the age of 75. People who sustain a TBI over the age of 75 have the highest rates of TBI related hospitalizations and deaths.[6] Emerging groups at risk for sustaining a TBI are members of the military. Walter Reed Army Medical Center reports that 30% of service members evacuated from the field had sustained a TBI between 2003 and 2005.[10] Army service members are relatively young with an average age of 28.[11] The prevalence of TBI also differs between males and females. Males are twice as likely as females to sustain a TBI in the civilian population. [6] Approximately 85% of military service members are male. [11] Therefore military members who sustain a TBI are also more likely to be male. Racial disparities exist within TBI outcome and management. African Americans experience the highest death rates from sustaining a TBI.[6] Additionally, African Americans and American Indians/Alaska Natives have the highest rates for TBI hospitalization[12] perhaps due to differing mechanisms of injury, insurance coverage, poverty rates or access to health care.

2.2 DEPRESSION

Depression is the most common psychological problem after TBI.[13-15] However, research concerning the prevalence of depression within the TBI population, risk factors associated with posttraumatic depression, the etiology of depression post-TBI, and the consequences of posttraumatic depression are mixed and inconsistent.

An accurate prevalence of depression within the TBI population is difficult to gauge as research findings report the prevalence of depression in persons with TBI to be between 6-77%.[14, 16-25] This variation in prevalence rates may be due to methodological issues including differences in depression assessment tools utilized in the research, the time course of depression assessment, and differences in injury severity of persons with TBI who are assessed (mild vs. severe injuries).

Depression has been assessed in the TBI population using a variety of measurement tools. Studies which have relied on single questionnaire items based on a dichotomous scale have identified the prevalence of depression to be between 6%[16] and 57%.[17] Researchers have used assessment instruments designed for psychiatric populations to describe depression after TBI injury including Zung Self Rating Depression Scale, Hamilton Rating Scale for Depression and Beck Depression Inventory. [24, 26-27] Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) criteria for identifying major depression have been utilized to assess depression in persons with TBI as well although still with varying prevalence rates. Jorge et al. [25] and Kreutzer[15] both reported prevalence of depression to be 42% in persons with TBI when assessed using DSM-IV criteria. However, Varney et al.[22] found depression rates as high as 77% utilizing DSM diagnostic criteria.

One unique challenge when assessing depression rates in TBI populations is the overlap between symptoms of depression and symptoms of the neurological disease. Overlapping symptoms can include insomnia, irritability, and lack of motivation. However, using standardized diagnostic criteria such as the DSM-IV is an effective way to assess depressive symptoms in the presence of TBI.[28] While depression rating scales are appropriate to rate the severity of depression and monitor the progression of antidepressant treatment, standardized assessment tools such as the DSM-IV are appropriate for diagnosing depression syndromes in persons with or without confounding neurological disease.[28]

Rogers 2007 [29] reviewed 13 studies reporting the prevalence of major depression after TBI. While depression was diagnosed in an aggregate of 24.5% of persons with TBI, the time period for the onset of depressive symptoms was variable. Several studies found that persons with TBI are at risk for depression for years after injury.[15, 30-36] However, other studies determined that, while depression rates decrease with time from injury, depression rates years after injury are still high within the TBI population. [13, 37] Jorge et al. [38] found that 80% of persons were diagnosed with depression within the first 3 months post injury. At 1 year post-injury only 33% of persons were troubled by depression which could either be due to decreased depression rates in the population or due to the natural recovery of symptoms over time. The prevalence of posttraumatic depression is highest within the first year post-TBI[37], although delayed depression is not uncommon. [39]

A number of potential risk factors affect post-injury depression rates although research findings are inconsistent. Seel et al. [31], found minority status, unemployment and low income to be associated with depression post-TBI. History of alcohol abuse and low education levels were also associated with post-TBI depression. [37] The impact of pre-injury psychiatric history on depression rates in persons with TBI is not fully determined. Fenton et al. found that persons with mild TBI who exhibited depressive symptoms were four times more likely to have had a psychiatric history prior to their TBI.[40] Jorge et al. found pre-injury psychiatric history to be associated with depression rates, although this relationship did not exist if substance abuse was excluded as a pre-injury psychiatric history variable.[41] The relationship of age and depression in TBI literature is also mixed. Age at the time of injury is reported to be associated with depression severity[36], associated with increased depression rates in older persons[40, 42], or not associated with depression rates at all.[14, 43] Gender differences in depression rates have been demonstrated in the general population with females experiencing depression rates two times that of males.[44, 45] However, female gender has not been consistently reported in the literature as a risk factor for posttraumatic depression. Some studies utilizing rating scales to assess depression have found women are more likely to be at risk for depression post-TBI[23, 40, 46] while other research has found no gender differences in depressive symptoms.[14, 41, 43] The relationship of injury severity to depression post-TBI is also debated in the literature. Some studies report depression to be associated primarily with more severe TBI injuries.[34] Some report depression to be associated primarily with people who are less severely injured[13, 47] and still others demonstrate that injury severity is not related to depression rates.[24, 48] Jorge et al. [14] found that injury severity was not related to depression rates except for in a select group of people who were described as "transiently depressed". These people exhibited more severe injuries, had greater frequency of diffuse injury and left anterior lesions, and expressed depression in the hospital setting but did not express depressive symptoms 3 months after injury.

Examining preliminary findings concerning the relationship of injury severity, lesion type and psychiatric history has led researchers to speculate as to whether the major contributing factor for the development of depression post-TBI is from the pathophysiological consequences of the injury itself, a pre-morbid proclivity, or a post-injury psychological response to the trauma.[29] Fann et al found a complex relationship between depression, injury severity and pre-morbid psychiatric histories. Their work lead them to conclude early depression is more likely to occur in severely injured persons with TBI due to the biological alterations after injury, whereas persons with mild TBI with comorbid psychiatric conditions are more socially vulnerable to prolonged depression after injury.[33] These preliminary finding have led researchers to suggest that there are both biological and psychological factors that play a role in the etiology of post-TBI depression.

Research is also mixed regarding the effects depression has on a person's outcome post-injury. Jorge et al. found that depression post-TBI was not related to either physical or cognitive impairment.[14] Levin found that depression post-injury was associated with disability, functional outcome, and community integration as measured by the Glasgow Outcome Scale (GOS) and Community Integration Questionnaire (CIQ).[46] Depression post-injury is also associated with poor performance on the general outcome measure of the GOS.[46, 49-50] Severity of depression has also been linked to functional outcome with greater depression severity being associated with poorer functional outcome.[51]

Associations between depression and neuropsychological functioning have been reported in a variety of other disease states including stroke, cancer and renal disease. [50] Depression in non-TBI populations result in reduced concentration, slowed thinking, memory difficulties, and less efficient recall of autobiographical memory.[52] However, the association between depression and cognitive status for persons with TBI has been less studied than some other diseases. Some studies report that depression is associated with impaired cognitive function, specifically psychomotor slowing[29], decreased information processing speed[29, 46], decreased memory[46], and diminished flexibility in problem solving.[46] Wood and Rutterford found an indirect relationship between working memory and depression after TBI with self-efficacy acting as a mediator between impairment of working memory, depression and satisfaction with life. [43] In contrast, Chaytor found that depressive symptoms were predictors of functional status independently of neuropsychological scores.[53] Depression was only weakly related to neuropsychological and cognitive outcome.[53] This contradicts previous research linking depression with poor neuropsychological outcome. [54]

Posttraumatic depression, however, consistently appears to negatively affect memory in persons with TBI. Depression was linked with diminished delayed recall and recognition on the California Verbal Learning Test-II (CVLT-II), a neuropsychological measure of verbal memory, in persons who had sustained mild to severe TBIs. Depressed subjects also failed to utilize semantic organization, the process of organizing words into related categories, to enhance their learning in this task.[55] Depressive rumination, or the tendency to dwell upon negative events, thoughts and symptoms, reduces access to autobiographical memories post-TBI and higher baseline levels of depression and rumination are associated with less specificity in recall.[56] In depressed persons with TBI, rumination is detrimental to memory and executive functioning.[57-59] One case report of a person with TBI suffering from depression demonstrated a direct relationship between depression and memory impairment. While the person was suffering from depressive symptoms, he exhibited difficulties in verbal memory. However, when his depression was in remission memory functioning improved.[60]

While it is appears that posttraumatic depression is detrimental, there is little conclusive evidence as to who is most at risk for developing depression after injury, what causes a person to develop posttraumatic depression, the timeline for depression symptoms to develop post-injury, and what the functional and neuropsychological consequences are.

Additionally, the need for improving mood, managing stress, and emotional upsets is found to be the second most cited need expressed by persons with TBI.[61] The first most important need being the ability to receive information about needed services. However, it was discovered that at least 17% of persons reporting the need for improving mood, stress and emotional issues were unable to receive adequate services because they did not know where to look.[61] Therefore, not only is posttraumatic depression an issue, but also the availability and accessibility of mental health services is a concern.

2.3 QUALITY OF LIFE

The concept of measuring Quality of Life (QOL) originated in the mid 1970's when social scientists began studying subjective well-being within the general population.[62, 63] Research topics then included studies assessing health related quality of life in persons who had experienced an injury or disease.[64-67] QOL was first developed in the health field with surgery patients to assess how they felt after their disease experience, in comparison to the dominant model of how the clinician felt about the recovery process.[68]

There is no universally agreed upon definition of QOL.[69] Multiple QOL measurements are used in research studies. The concept of QOL is not consistently defined and specific domains measured are not clearly identified.[70] QOL can be broadly defined as an indicator of the impact of injury/disease, treatment and level of recovery that a person subjectively expresses after experiencing an injury/disease.[70] It includes a person's perceived wellness, subjective well-being, and needs satisfaction.[69] These domains are most often collapsed into four general domains of physical, psychological, social, and cognitive well-being.[68]

QOL research in the TBI population provides unique challenges when assessing the cognitive component of quality of life after injury.[68] Since cognitive functioning is impaired after TBI the validity of subjective QOL reporting is often questioned. However, Kinsella et al. [23] report that QOL from persons with TBI is valid because their QOL information correlates well with measures from relatives. However, there are differences between persons with TBI and caregiver reports of QOL. Persons with TBI are found to report lower physiological impairment than caregivers whereas caregivers are more likely to report psychosocial issues than persons with TBI.[71]

Examining QOL in the TBI population has resulted in mixed findings. Seibert et al. 2002 find that women report lower QOL than men do after TBI[69], whereas gender is not related to QOL according to other reports. [43, 72] Older persons report higher QOL in comparison to younger persons in one study[69], while other studies find no relationship between age and QOL reporting.[43, 72] Marital status and education also do not appear to impact QOL.[43, 72] However, Kreuter et al. [72] report that time since injury, engagement in work, outcome (as measured by GOS), physical and social functioning, and mood are related to QOL post-TBI. Injury severity does not influence QOL after injury[48], but depressive symptoms are associated with reduced QOL after injury.[19, 50, 72-73] Aspects of cognitive function, such as motor function, memory, and construct ability are related to QOL for up to 4 years after injury. [74]

2.4 COGNITIVE STATUS

One of the most consistent consequences of TBI is cognitive deficit. Persons with TBI experience cognitive dysfunction including alterations in memory, reasoning skills, problem solving, concentration and executive function. Depending upon a variety of factors, these cognitive deficits can last for weeks, months, years or even a lifetime. Factors including age, injury severity, and gender have been examined for their affect on cognitive deficits post-injury.

Older age at time of injury is associated with worse cognitive function.[75-77] Specifically, older persons display worse executive functioning[75] and slower processing speed[76] after injury than younger persons with TBI.

Injury severity has also been associated with cognitive function after injury. More severe injuries correlate with poorer cognitive function.[78] There is limited research examining cognitive deficits which remain years after persons experience a TBI. However, injury related cognitive deficits can be present for up to ten years post-injury.[78]

Less research has been conducted examining the effects of gender on cognitive status post-injury. The lack of literature in this area could be due in part to the low number of females who sustain a TBI. Ratcliff et al. [79] found that females perform better than males on tests of attention, working memory and language. Males, however, perform better than females with visual analytic skills.[79] Examining sex differences in cognitive function following mild TBI show males perform better on visual memory tasks, while females perform better on verbal memory tasks.[80]

Regardless of the age, injury severity and age of persons with TBI, cognitive dysfunction after injury are commonplace. Lasting cognitive deficits impact a person’s return to productivity and interaction with their community.

2.5 OVERVIEW OF TBI HEALTH CARE IN SOUTHWESTERN PENNSYLVANIA

Subjects included in the research for this thesis are persons who sustained a moderate to severe TBI in southwestern Pennsylvania and were treated at UPMC Presbyterian Hospital. UPMC Presbyterian Hospital is a Level I trauma center which treats more adult patients than any other trauma center in the area.[81] Patients are flown via STAT MedEvac from their injury location to the hospital. TBI patients are flown to UPMC for treatment from western to central Pennsylvania, eastern Ohio, and northern West Virginia. UPMC is located an average of one hour from a patient's residence.

A person with a TBI is seen first in the emergency room by the trauma surgeon who manages their initial care and resuscitation procedures. Neurosurgeons are consulted for care specific to their head injury. Additional physicians such as orthopedic surgeons or general surgeons may be consulted dependent upon the nature of other injuries they have sustained. Trauma nurses provide care for the patient as well as coordinate communication between the hospital and the patient's family.

After a patient is stabilized, they are transferred to an intensive care unit where care is provided by the critical care nursing staff. In addition to caring for the patient, they report to the critical care physician and the neurosurgeon concerning the patient's condition. A trauma social worker provides support to the family, assists the family in making decisions during the acute care process, and assists in discharge planning.

During the acute inpatient stay, a physiatrist is consulted to aid in the rehabilitation process. The physiatrist assesses whether a patient is eligible for discharge to a rehabilitation facility versus a long term acute facility or nursing home depending upon the patient's condition and progress.

If a patient is eligible for inpatient rehabilitation, the physiatrist serves as the team leader responsible for the patient's care management. A neuropsychologist specifically evaluates changes in patient thinking and behavior. It is often during the inpatient rehabilitation stay when a patient begins to "wake-up" from the brain injury and may become disorientated, impulsive, and not aware of their injury or situation. The neuropsychologist, along with a psychologist and case manager, may assist the patient's family through this process providing education and counseling. During rehabilitation, a patient is also treated daily by physical therapy, occupational therapy and speech therapy. Lengths of stay are determined by the needs and progress of the patients. They can range from 4 to 16 weeks. A patient must require at least two therapy disciplines and daily nursing or physician care to remain in the program. Costs can range from $300 to $1500 per day.[82] Insurance coverage is often available for inpatient rehabilitation, although there are maximum lengths of stay provided for by insurance. Patients can not stay in inpatient rehabilitation indefinitely. Upon discharge from inpatient rehabilitation, educational resources are provided to family members as the patient often is still not capable of independent care. These educational resources can include information on support groups, vocational rehabilitation, outpatient rehabilitation, driving and return to work issues as well as information on common behavioral, cognitive and emotional issues the person will experience.

The majority of people who receive inpatient rehabilitation care also receive outpatient rehabilitation services upon discharge home. Outpatient services include further physical, occupational and speech therapy. The length of outpatient rehabilitation is variable and dependent upon the individual needs of the person. Patients also continue to follow-up with the physiatrist, neurosurgeon and any specialist (orthopedics, ophthalmologists, etc) as needed.

Rehabilitation after TBI is a specialized field. The majority of TBI specific inpatient rehabilitation facilities are located in urban areas. Rural areas have few resources available for long-term rehabilitation and community-integrated services for its residents with brain injuries.[83] Specifically within the southwestern Pennsylvania area, inpatient rehabilitation centers equipped to deal with persons with TBI are limited and located only in urban areas surrounding Pittsburgh. The Centers for Rehabilitation Services offers numerous outpatient therapy locations in the urban area of Pittsburgh but limited facilities in surrounding counties.[84] In more rural communities, facilities can accommodate general outpatient rehabilitation, but are often not equipped with personnel experienced in handling TBI specific rehabilitation.

Additionally most services provided in outpatient rehabilitation settings are geared toward physical, occupational, speech and occasionally cognitive rehabilitation. Emotional services, such as a referral to a psychiatrist, often are made during follow-up visits with either the person’s primary physiatrist or neurosurgeon. However if persons do not return for follow-up visits or concerns of emotional problems are not voiced by persons with TBI or caregivers, these issues are often overlooked. Locally, depression screening is not a typical part of follow-up visits with the physiatrist or neurosurgeon. Depression concerns are usually discussed only when concerns are voiced by persons with TBI or family members. Persons with TBI are often then placed on antidepressants medications or referred to a psychiatrist for follow-up

The UPMC health system offers comprehensive care for persons with TBI. The majority of people initially taken to UPMC for acute care receive inpatient rehabilitation at a UPMC facility. Neurosurgeons, physiatrists, and other specialty care physicians are able to provide a continuum of care when a patient’s rehabilitation process is performed within the same health system. Communication between providers is more consistent and information systems within the same health system allow more efficient patient care.

Physiatrist and neuropsychologist receive education and training in depression prevalence post-TBI. However, education is often limited to identification of symptoms of depression in persons with TBI and different screening tools available to recognize depressive symptoms in their patients. [82] Additionally, training in dealing with these symptoms is often limited to the inpatient rehabilitation setting. Providers are encouraged to provide a positive setting, encourage patients and family members about treatment, and seek group or individual therapy if needed. Antidepressant medications are often prescribed for persons with TBI during inpatient rehabilitation or at discharge from the facility.[82]

As depression, cognitive status and quality of life are difficult to assess in persons with TBI who are discharged to a nursing home, the cohort assessed in this study is limited to those persons who received either inpatient or outpatient rehabilitation services with the potential of reentry into the community. Eighty eight percent of the cohort was discharged to inpatient rehabilitation upon acute care discharge, 8% were initially discharged to a long term acute facility until they were capable of participating in inpatient rehabilitation, and 4% were discharged home with outpatient rehabilitation services. Of the people who received inpatient rehabilitation, 81% percent went to UPMC Institute of Rehabilitation and Research for inpatient rehabilitation services, 8% went to Health South Rehabilitation, 7% went to rehabilitation facilities in Ohio as their insurance did not cover Pennsylvania inpatient rehabilitation, and 4% went to the Children's Institute of Pittsburgh.

2.6 THE CHRONIC CARE MODEL

A person who survives a TBI is left with a chronic condition that they must learn how to cope with for the remainder of their life. A chronic condition can be defined as “any condition that requires ongoing adjustments by the affected person and interactions with the health care system”.[5] Persons with TBI who suffer from posttraumatic depression require care not only for the initial TBI insult but also for the secondary mental health condition of depression. Chronic conditions require ongoing and extensive managed care and interaction with the health care system. However, deficiencies exist within the health care system. These deficiencies include lack of care coordination, lack of active follow-up to ensure best outcomes, persons who are inadequately trained to manage their illness and rushed practitioners who do not follow established practice guidelines.[5]

In response to these deficiencies, the Chronic Care Model was developed to highlight the elements for improving care at multiple levels including the health system, delivery system design, decision support, clinical information systems, self-management support, and the community.[5] The goal of improving care at these multiple levels is to provide an environment for productive interactions between an informed, activate patient and a prepared, proactive practice team with the ultimate objective of obtaining improved outcomes.[5] The Chronic Care Model will be used as a framework for assessing deficiencies in the health care delivery to persons with TBI and specifically persons with TBI who experience posttraumatic depression.

2.6.1 Health System

At the level of the health system, the Chronic Care Model stresses the organization of the health care to create a culture, organization, and mechanism that promotes safe, quality care. Improvements at all levels of the organization must be supported starting with senior leadership and working down through all providers in the health system. The system must be motivated and prepared for change within the organization to promote improvement strategies. Senior leadership must be willing to identify areas for improvement of care, stress the importance for improvement, and translate this information into improvement goals and policies. Health systems must be willing to report and study current mistakes to make improvements to prevent future errors. Care coordination should be fostered through systems that facilitate communication and data-sharing as patients navigate through multiple health systems settings and providers.[5]

2.6.2 Delivery System Design

The Chronic Care Model emphasizes the importance of the delivery system design to ensure the delivery of effective, efficient clinical care and self-management support. Chronic conditions require transforming a system accustomed to reacting only when patients are sick into a proactive system whose efforts are to keep a patient healthy. A proactive system must be created by identifying the care which is needed, defining roles among providers to supply patient care, and ensuring follow-up is part of patient care. Additionally, health literacy and cultural sensitivity are vital to effective delivery systems for patients.[5]

2.6.3 Decision Support

Decision support is a vital part of the Chronic Care Model which emphasizes the promotion of care that is consistent with scientific evidence and patient preferences. The treatment and care patients receive should be based on proven guidelines which are supported by research. Guidelines should be discussed with patients so that they can understand the rationale behind their treatment. Providers should receive ongoing training of current treatment plans as well as incorporate new models of treatment which have clinical research support. [5]

2.6.4 Clinical Information Systems

The Chronic Care Model emphasizes effective clinical information systems necessary to organize patient and population data to facilitate efficient care. Effective clinical information systems can provide reminders for needed services to both patients and providers, identify specific groups of patients requiring additional care, and facilitate individual patient care planning. Additionally, clinical information systems can monitor performance of providers and health care systems for quality improvement.[5]

2.6.5 Self-Management Support

The Chronic Care Model stresses self-management support to empower patients (and/or families) to manage their health and care. Self-management includes emphasizing the patient's role in managing their own health in order to identify behaviors and decisions they make which affect their health. Collaborative efforts between patients and providers include defining problems, setting priorities and goals, creating treatment plans and problem-solving. Additionally, internal and community resources can be organized to provide self-management support for patients.[5]

2.6.6 Community

The final level the Chronic Care Model identifies is the community. Community resources must be mobilized to meet the needs of the patients. Patients should be encouraged to participate in community programs which provide additional services and resources. Additionally, health care systems should form partnerships with community organizations to develop interventions where needed and advocate for policies to improve patient care.[5]

2.7 SUMMARY

Research is inconsistent in reporting the effects of depression on cognitive status and QOL post-TBI. The goal of this thesis is aimed at addressing these inconsistencies and gaps in the current understanding of depression, cognition, and QOL after TBI within the framework of the Chronic Care Model. The following research examines if the presence and/or severity of depression after TBI affect a person's QOL after injury. Additionally, the research examines if the presence and/or severity of posttraumatic depression affect a person's cognitive status post-injury. The Chronic Care Model will be discussed as a framework for identifying deficiencies within the health care system in regard to persons with TBI who are experiencing posttraumatic depression.

3.0 METHODOLOGY

3.1 SUBJECTS

This study includes 50 subjects who sustained moderate to severe TBI, as defined by a Glasgow Coma Scale (GCS) of 3 to 12. All subjects were treated at UPMC hospital in Pittsburgh, PA and consented into IRB approved research studies through the Department of Physical Medicine and Rehabilitation. Subjects include a subset of participants from two studies examining TBI and recovery who met additional eligibility requirements for research conducted for the purpose of this thesis. Eligibility requirements for this study required that subjects completed measures of depression, QOL and specific cognitive assessments.

3.2 ASSESSMENTS

Subjects were assessed for depression status, quality of life and cognitive function at 6 and 12 months post injury.

3.2.1 Independent Variable: Depression

Depression after injury was measured as the primary independent variable. Depression was evaluated using the Patient Health Questionnaire-9 (PHQ-9). The PHQ-9 is a self-administered depression tool that uses items directly from the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) measures for diagnosing major depression. The items on the PHQ-9 correlate with the nine signs and symptoms of depression in the DSM-IV. The PHQ-9 also contains one item concerning functional impairment experienced as a result of the depression symptoms. The PHQ-9 has been tested for its validity and utility as a brief depression measure in primary care clinics.[85] This measure has been compared to previously used measures of depression in TBI research such as the Beck Depression Inventory and Zung's Self-rating Depression Scale and was found to best meet the criteria of an assessment sensitive to identifying depression status and severity. The PHQ-9 is selected on its brevity, response format, and ability to monitor response.[86] The PHQ-9 is considered a valid and reliable measure for assessing depression following TBI.[85-91]

Subject's PHQ-9 scores were collected at 6 and 12 months post-injury. Patient PHQ-9 scores were categorized for both the presence and severity of depression at each time point. A score of zero to four corresponded to being categorized as "no depression" whereas a PHQ-9 score greater than four categorized a subject as having "depression". Severity of depression was classified by PHQ-9 scores of 0-4, 5-9, and 10-27 categorized as "no depression", "mild depression" and "moderate/severe depression", respectively.

3.2.2 Dependent Variable: Quality of Life

Subjects completed two self-administered questionnaires, Percent Back to Normal and Perceived Quality of Life (PQOL), at 6 and 12 months to assess QOL after injury. The Percent Back to Normal quantitatively measures QOL by asking subjects to rate how much they feel "back to normal" on a continuous scale from 0-100% in the following domains; physical, emotional, cognitive, and total "back to normal" score. The PQOL quantitatively measures QOL by asking subjects to assess different domains in their life on a continuous scale of 0 to 100 both before and after injury. The 18 questions on the PQOL were categorized into domains relating to physical, mobility, cognitive, emotional, social, vocational, and economic categories. Total PQOL scores both before and after injury was calculated as a summation of the 7 domains illustrated in Figure 1.

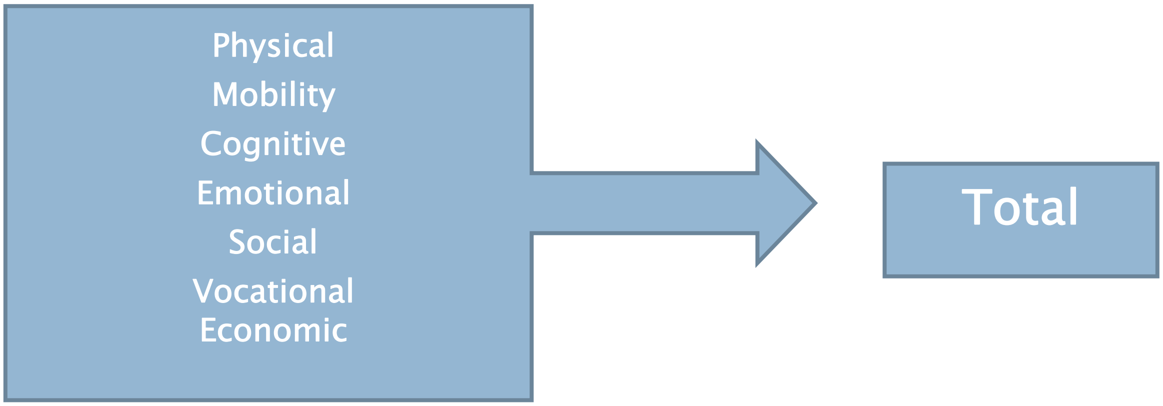

Figure 1. Category Development for Perceived Quality of Life

Descriptive analysis was conducted on all QOL measures. Total PQOL after injury was used as the primary dependent variable to measure QOL after injury in analysis.

3.2.3 Dependent Variable: Cognitive Function

Subjects completed neuropsychological evaluations at 6 and 12 months that were conducted by trained psychometrists to assess cognitive domains such as attention, working memory, problem solving, executive functioning, frontal systems behavioral syndromes, memory, and learning. Trail Making Test A and B at 6 months (alternate forms C and D at 12 months), Wisconsin Card Sorting Test, Symbol-Digit Modalities Test, and WAIS-III Symbol Search were administered to evaluate attention, working memory, problem solving and executive functioning. Frontal Systems Behavior Scale: Patient (FrsBE), was used to evaluate frontal systems behavioral syndromes. Memory and learning were assessed using the administration of the California Verbal Learning Test (CVLT-II). Subjects included in the analysis completed testing in all measures of cognitive function. All neuropsychological tools have been used to assess persons with TBI.

The Trail Making Test measures visuomotor and perceptual scanning skills, as well as flexibility to shift sets under time pressure. Part A (or alternate version C) requires a subject to consecutively connect circles numbered 1-25 as quickly as possible. Part B (or alternate version D) requires a subject to consecutively connect circles while alternating between numbers (1-13) and letters (A-L) as quickly as possible. Performance is based on time to complete each part. Both parts require visuomotor and perceptual scanning skills and part B (D) also requires flexibility to shift from number to letter sets.[92, 93]

The Wisconsin Card Sorting Test is a widely accepted measure of abstraction and complex problem-solving that is sensitive to frontal lobe dysfunction. A subject must sort response cards according to specific principles. Performance is based on number of sorts achieved, total number of correct card placements, and number of perseverative errors. This task requires the ability to generate, switch, and maintain response strategies.[94]

The Symbol Digit Modalities Test (SDMT) is a measure of complex attention and psychomotor speed. It involves a simple substitution task in which the examinee has 90 seconds to pair specific numbers with given geometric designs. Responses can be written or oral. Impaired performance is seen in a number of neurological disorders, including TBI.[95]

The Symbol Search from the WAIS-III measures visual working memory. The participant is presented with a series of paired groups, each pair consisting of a target group and a search group. The examinee indicates, by marking the appropriate box, whether either target symbol appears in the search group.[96]

The Frontal Systems Behavior Scale (FrSBe) provides a brief, reliable, and validated measure of three behavioral syndromes associated with prefrontal and orbitofrontal compromise: apathy, disinhibition, and executive dysfunction. It also quantifies behavioral changes over time by including both baseline (retrospective) and current assessments of behavior. The FrSBe includes a Total Score, as well as scores on three subscales related to the three frontal systems behavioral syndromes: apathy (14 items), disinhibition (15 items), and executive dysfunction (17 items), and consists of a 46-item, paper-and-pencil behavior rating scale.[97]

The California Verbal Learning Test-II (CVLT) is a brief, easily administered measure of immediate memory span, new learning, susceptibility to interference, and recognition memory using word lists of nouns. A parallel form is available to minimize practice effects from repeated administration.[98]

Composite scores were calculated for each subject at 6 and 12 months to evaluate their overall cognitive performance at each time point. Subject’s raw scores on each cognitive test variable were converted into rank scores with lower ranks being equivalent to a worse score on the test. Ranked scores were summed to create an overall cognitive composite score. Higher composite scores equate to better cognitive outcome while lower composite scores equate to worse cognitive outcome. Raw scores, as opposed to scaled scores, were used for the creation of a cognitive composite score. Scaled scores can be calculated for neuropsychological assessments to create standardized scores based on age and gender. However, not all neuropsychological assessments used in the calculation of the composite scores have standardized norm values for age or gender. Therefore, raw scores were used so that the composite score was calculated consistently with raw scores as opposed to a combination of raw and scaled scores. Cognitive composite scores were evaluated as the primary dependent variable to measure cognition after injury in analysis.

3.2.4 Potential Confounders: Demographic Factors, Injury Severity and Pre-morbid Psychiatric Conditions

Demographic variables, injury severity, and pre-morbid psychiatric conditions were documented from subject interview and/or medical record review. Demographic variables included subject's age, gender, and education. Injury severity was defined using the Glasgow Coma Scale (GCS). The GCS is the primary instrument used to measure severity of neurological injury after trauma and is used as a predictor of mortality and gross outcome in conjunction with other variables.[99] Subjects with a GCS of 3-5 are defined as having a very severe level of head injury, subjects with GCS of 6-8 are regarded as having a severe level of injury and subjects with a GCS of 9-12 are considered to have a moderate head injury. Pre-morbid psychiatric conditions were documented from medical record review as well as subject and family interview at time of consent, 6 months and 12 months post injury. For the purposes of this research, pre-morbid psychiatric conditions were defined to include the following conditions: depression, bipolar disorder, and anxiety disorders. A subject was defined as having a pre-morbid psychiatric condition regardless of whether or not subjects were experiencing the condition/disorder at the time of injury or if they had experienced it in the past.

3.3 STATISTICAL METHODS

Statistical analysis was performed using SPSS Version 16.0 (Chicago, IL). Analysis included basic description of the population, descriptive analysis of independent and dependent variables, univariate analysis for outcome variables of quality of life and cognitive status, and multivariate analysis utilizing linear regression.

Descriptive analysis was conducted on all independent, dependent, and potential confounding variables. Mean, median, and ranges were calculated for continuous variables including age, quality of life scales and cognitive outcomes. Frequencies were calculated for categorical variables including gender, education, injury severity, pre-morbid psychiatric history, depression status and severity.

Univariate analysis was performed for outcome variables of interest for QOL and cognitive status. The primary measure of quality of life was Total PQOL after injury at both 6 and 12 months post injury. The primary measure of cognitive status was the Cognitive Composite Score at both 6 and 12 months post injury. To analyze specific aims of the study, univariate analysis was conducted to examine depression status and depression severity in relation to both cognitive and quality of life status at 6 and 12 months post injury. T-tests and

ANOVAs were utilized in analysis of categorical independent variables of depression status and depression severity.

Univariate analysis was conducted for demographic factors, injury severity, and pre-morbid psychiatric history to identify potential confounders of quality of life and cognitive status. T-tests and ANOVAs were utilized in analysis of categorical independent variables and correlations were used in analysis of continuous independent variables. Univariate analysis was also conducted for Cognitive Composite Scores in relation to QOL variables at both 6 and 12 months using correlations. This analysis was conducted to examine how cognitive function affects QOL.

Additionally, univariate analysis was conducted for demographic factors, injury severity, and pre-morbid psychiatric history with the dependent variable being depression severity in order to assess factors affecting depression reporting at 6 and 12 months after injury. Chi-square tests were conducted for these analyses.

Multivariate linear regression models were developed to determine the independent relationship of depression severity post-injury with quality of life and cognition. Dummy variables were created to analyze depression severity as there are three depression categories; no depression, mild depression and moderate/severe depression. After identifying potential confounders through univariate analysis, these independent variables were included in the initial linear regression model for each dependent variable at each time point. Potential confounders were included in the linear regression models if they were found to have $p<0.20$ in univariate analysis. Initial models were created for each dependent variable by including the independent variable for depression severity along with any confounding variables found to have $p<0.20$ in the univariate analysis. Cognitive Composite Scores were also included in multivariate regression models for QOL If a variable was found to have a $p>0.20$ in the regression model, it was removed and the model was re-rum with the remaining variables. Variables were removed from the regression model one at a time, starting with those variables with the largest p values. Final models were selected once all variables in the model were found to have $p<0.20$ in the regression.

4.0 RESULTS

4.1 DESCRIPTIVE ANALYSIS

The cohort analyzed in this study includes 50 subjects with moderate to severe TBI. All 50 subjects completed 6 month assessment at time of analysis whereas only 38 subjects completed 12 month assessment. Since not all subjects have completed both time points at time of analysis, a description of cohorts at each time point are included.

At 6 months post-injury, male TBI subjects account for 82% of the sample (n=41) while females account for 18% (n=9). This gender distribution is relatively consistent with reports of gender differences in the incidence of TBI in the general population with men having a higher incidence of TBI than women and reported incidence ratios ranging from 2.0:1-2.8:1.[2] The mean age was 34.34±1.97. Age was not normally distributed within the sample. Therefore, the square root of age was used in analysis as this variable was normally distributed (Table 1). In the cohort, 14% (n=7) of subjects were found to have less than a highschool graduate education, 40% (n=20) of subjects had graduated from highschool, and 46% (n=23) of subjects had at least some college education or had graduated from college. Ten percent (n=5) of subjects were found to have very severe head injuries as defined by a GCS score of 3-5. Eighty percent (n=40) of subjects had severe head injuries defined by a GCS score of 6-8. Ten percent (n=5) of subjects had moderate head injuries of GCS 9-12. The proportion of subjects who had pre-morbid psychiatric conditions was 26% (n=13), while 74% (n=37) of the subjects did not have a pre-morbid psychiatric history. At 6 months post-injury 52% (n=26) of subjects did not report depression symptoms on the PHQ-9, while 48% (n=24) of subjects indicated depressive symptoms. When examining depression severity at 6 months post-injury. Twenty four percent (n=12) of subjects exhibited mild depression and 24% (n=12) of subjects displayed moderate/severe depression. Descriptive statistics for independent variables at 6 months can be found in Tables 1 and 2.

Table 1. Descriptive Analysis of Independent Variable Age at 6 months

Continuous Variables	Mean (SE)	Median	Range
Age	34.34 (±1.97)	29.67	18.29-71.69
Square Root of Age	5.70 (± 0.16)	5.40	4.20-8.40

Table 2. Descriptive Analysis of Independent Variables Gender, Education, GCS, History of Pre-morbid Psychiatric History, Depression Status and Depression Severity at 6 months

Variable	Number (Percentage)
Gender	
Males	41 (82%)
Females	9 (18%)
Education	
Less than High school	7 (14%)
Graduate High school	20 (40%)
Some College or College Graduate	23 (46%)
GCS	
Very Severe (GCS 3-5)	5 (10%)
Severe (GCS 6-8)	40 (80%)
Moderate (GCS 9-12)	5 (10%)
History Pre-morbid Psychiatric	
Yes	13 (26%)
No	37 (74%)
Depression Status and Severity	
No Depression	26 (52%)
Mild Depression	12 (24%)
Moderate/Severe Depression	12 (24%)

At 12 months post-injury only 38 of the initial 50 subjects had completed depression, quality of life, and cognitive assessment. Male TBI subjects account for 82% of the sample (n=31) while female TBI subjects account for 18% (n=7). The mean age at 12 months was 36.17±2.31. Age was not normally distributed within the 12 month sample so the square root of age was used in analysis (Table 3). In the 12 month cohort, 10% (n=4) of subjects were found to have less than a highschool graduate education, 45% (n=17) of subjects had graduated from highschool, and 45% (n=17) of subjects had at least some college education or had graduated from college. Thirteen percent (n=5) of subjects were found to have very severe head injuries as defined by a GCS score of 3-5. Seventy four percent (n=28) of subjects had severe head injuries defined by a GCS score of 6-8. Thirteen percent (n=5) of subjects had moderate head injuries of GCS 9-12. The proportion of subjects who had pre-morbid psychiatric conditions was 26% (n=10), while 74% (n=28) of the subjects did not have a pre-morbid psychiatric history. At 12 months post-injury 45% (n=17) of subjects did not report depression symptoms on the PHQ-9, while 55% (n=21) of subjects indicated some depressive symptoms. Examining depression severity at 12 months post-injury showed that 31% (n=12) of subjects exhibited mild depression and 24% (n=9) displayed moderate/severe depression. Descriptive statistics independent variables at 12 months are found in Tables 3 and 4.

Table 3. Descriptive Analysis of Independent Variable at 12 months

Continuous Variables	Mean (SE)	Median	Range
Age	36.17 (±2.31)	35.93	18.29-71.69
Square Root of Age	5.90 (± 0.19)	5.99	4.20-8.40

Table 4. Descriptive Analysis of Independent Variables Gender, Education, GCS, History of Pre-morbid Psychiatric History, Depression Status and Depression Severity at 12 months

Variable	Number (Percentage)
Gender	
Males	31 (82%)
Females	7 (18%)
Education	
Less than High school	4 (10%)
Graduate High school	17 (45%)
Some College or College Graduate	17 (45%)
GCS	
Very Severe (GCS 3-5)	5 (13%)
Severe (GCS 6-8)	28 (74%)
Moderate (GCS 9-12)	5 (13%)
History Pre-morbid Psychiatric	
Yes	10 (26%)
No	28 (74%)
Depression Status and Severity	
No Depression	17 (45%)
Mild Depression	12 (31%)
Moderate/Severe Depression	9 (24%)

Descriptive analysis was conducted for all subscales and primary measures of quality of life and cognitive status at 6 and 12 months post-injury. The mean value for Total PQOL after injury was 1099.66(±62.69) at 6 months post-injury and 1275.21(±57.51) at 12 months post-injury. Total PQOL after injury was not normally distributed in the 6 and 12 month cohorts. The square root of Total PQOL after injury was used in secondary analysis as this variable was found to be normally distributed. The mean value at 6 months for square root of Total PQOL after injury was 32.97 (±1.28) and the mean value at 12 months was 35.28 (±0.91). Additional descriptive analysis of the primary measure of QOL as well as descriptive analysis of all QOL subscales is found in Table 5. Definitions of QOL categories are located in Appendix A.

Table 5. Descriptive Analysis of Quality of Life Variables

Quality of Life	Mean (SE)	Median	Range	Mean (SE)	Median	Range
	6 month			12 month		
Total %	62.96 (±3.64)	70.00	0-100	72.69 (±3.88)	80.00	10-100
Physical %	68.29 (±3.80)	75.00	5-100	78.14 (±3.64)	80.00	10-100
Cognitive %	68.49 (±4.00)	70.00	0-100	73.30 (±3.83)	80.00	5-100
Emotional %	72.88 (±4.38)	85.00	0-100	72.76 (±4.66)	80.00	0-100
Cognitive Before	86.46 (± 2.56)	90.00	10-100	91.82 (±1.65)	95.00	60-100
Cognitive Now	60.34 (± 4.14)	67.50	0-100	61.53 (±4.85)	72.50	0-100
Economic Before	75.18 (±4.27)	85.00	0-100	79.71 (±4.58)	90.00	0-100
Economic Now	41.06 (±5.02)	30.00	0-100	44.74 (±5.89)	50.00	0-100
Physical Before	271.08 (±4.91)	280.00	140-300	275.42 (±6.52)	290.00	110-300
Physical Now	204.24 (±10.15)	229.00	0-300	231.95 (±11.44)	250.00	40-300
Mobility Before	188.96 (±2.90)	200.00	100-200	192.34 (±2.68)	200.00	120-200
Mobility Now	130.98 (±9.28)	150.00	0-200	164.74 (±8.46)	185.00	9-200
Vocational Before	281.56 (±11.81)	300.00	90-400	323.97 (±10.99)	342.50	260-400
Vocational Now	179.74 (±16.64)	175.00	0-385	237.13 (±18.89)	255.00	15-400
Emotional Before	254.62 (±7.09)	272.50	100-300	268.26 (±7.28)	280.00	110-300
Emotional Now	207.06 (±13.38)	240.00	0-300	219.71 (±12.06)	240.00	25-300
Social Before	339.82 (±9.86)	360.00	150-400	359.87 (±8.15)	380.00	200-400
Social Now	272.24 (±14.63)	287.50	0-400	316.42 (±10.48)	334.00	176-400
Total Before	1497.68 (±30.05)	1575.00	935-1800	1591.39 (±30.13)	1636.00	940-1800
Total After	**1099.66 (±62.69)**	**1147.50**	**50-1730**	**1275.21 (±57.51)**	**1340.00**	**353-1800**
Total After (square root)	**32.97 (±1.28)**	**34.73**	**7-42**	**35.28 (±0.91)**	**36.61**	**19-42**

The mean value for Cognitive Composite Score at 6 months post-injury was 630.26 (±27.62) and 476.61 (±22.94) at 12 months post-injury. Additional descriptive analysis of the primary measure of cognitive function as well as descriptive analysis of all cognitive subscales is found in Table 6.

Table 6. Descriptive Analysis of Cognitive Function Variables

Cognitive Function	**Mean (SE)**	**Median**	**Range**	**Mean (SE)**	**Median**	**Range**
	6 month			**12 month**		
Trails A/C	57.32 (±9.22)	36.50	17-300	36.03 (±3.11)	29.50	17-105
Trails A/C Errors	6.20 (±3.35)	0.00	0-99	0.13 (±0.07)	0.00	0-2
Trails B/D	114.28 (±9.73)	95.00	41-300	81.26 (±7.67)	68.00	21-300
Trails B/D Errors	8.50 (±3.81)	0.00	0-99	3.34 (±2.59)	0.00	0-99
SDMT Oral	41.20 (±2.27)	43.50	0-68	45.45 (±2.32)	43.50	8-72
SDMT Written	36.46 (±2.03)	37.00	0-69	41.34 (±2.21)	40.50	10-70
WCST	4.30 (±0.30)	6.00	0-6	4.63 (±0.32)	6.00	0-6
WCT Errors	31.02 (±4.32)	19.50	0-99	17.11 (±3.13)	9.00	3-99
Symbol Search	22.84 (±1.32)	25.00	0-41	24.29 (±1.49)	24.00	4-45
CVLT Trials 1-5	38.28 (±1.93)	37.50	9-67	40.21 (±1.82)	39.50	18-64
CVLT Trial B	4.66 (±0.22)	5.00	1-8	5.16 (±0.43)	5.00	0-14
CVLT Short Delay Free Recall	6.64 (±0.61)	6.50	0-15	7.82 (±0.67)	8.00	0-15
CVLT Short Delay Cued	7.88 (±0.64)	9.00	0-16	9.39 (±0.55)	9.50	3-15
CVLT Long Delay Free Recall	7.00 (±0.61)	7.00	0-15	7.92 (±0.67)	9.00	0-14
CVLT Long Delay Cued	8.00 (±0.61)	8.50	0-16	9.37 (±0.62)	11.00	2-15
CVLT Recognition	13.12 (±4.28)	14.00	0-16	13.3 (±0.50)	14.00	4-16
CVLT Repetitions	4.56 (±0.50)	4.00	0-15	5.87 (±0.98)	4.00	0-25
CVLT Intrusions	7.22 (±1.11)	5.00	0-30	5.68 (±1.06)	3.50	0-25
CVLT False Positives	4.60 (±0.73)	2.50	0-17	4.58 (±0.79)	2.50	0-17
Patient Apathy Before	45.64 (±1.65)	44.00	23-77	47.37 (±1.98)	46.00	29-74
Patient Disinhibition Before	53.16 (±2.16)	51.00	29-85	53.24 (±2.67)	48.00	26-95

Table 6 continued

Patient Executive Dysfunction Before	54.44 (±2.09)	53.00	27-92	55.03 (±2.76)	52.00	25-96
Patient Total Before	51.52 (±2.02)	52.00	24-93	55.11 (±3.39)	49.50	26-124
Patient Apathy After	59.90 (±2.80)	59.50	23-98	57.95 (±3.30)	54.00	30-112
Patient Disinhibition After	56.30 (±2.35)	59.00	25-87	56.26 (±3.06)	56.50	26-115
Patient Executive Dysfunction After	61.50 (±2.74)	61.50	29-111	63.08 (±3.67)	68.50	25-148
Patient Total After	61.58 (±2.99)	61.00	25-108	64.08 (±4.19)	65.00	28-152
Cognitive Composite Score	**630.26 (±27.62)**	**65l.00**	**260-952**	**476.61 (±22.94)**	**516.50**	**193-750**

4.2 UNIVARIATE ANALYSIS

Univariate analysis was conducted to examine depression status and depression severity in relation to both QOL and cognitive status at 6 and 12 months post injury. Demographic factors, injury severity, and pre-morbid psychiatric history were evaluated as potential confounders of quality of life and cognitive status.

4.2.1 Quality of Life

Analysis of Variance (ANOVA) was performed to evaluate injury severity, education, and depression severity in relation to the QOL variable Total PQOL after injury at both 6 and 12 months post-injury. A correlation was used to examine age in relation to the QOL variable Total PQOL after injury at both 6 and 12 months post-injury. T-tests were performed to examine independent variables of gender, pre-morbid psychiatric history, and depression status in relation to the QOL variable Total PQOL after injury at both 6 and 12 months post-injury.

Depressed subjects were significantly more likely to report lower QOL on the Total PQOL after injury ($p<0.001$) at 6 months post-injury. At 12 months post-injury, depressed subjects were again more likely to report lower QOL on the Total PQOL after injury ($p=0.001$).

Analysis of depression severity showed significant between group differences in quality of life reporting with Total PQOL after injury at 6 months post-injury ($p=0.001$). At 12 months post-injury analysis of depression severity displayed significant between group differences in quality of life reporting with the Total PQOL after injury ($p=0.001$).

Univariate analysis of demographic factors reveal females were significantly more likely to report lower QOL on Total PQOL after injury ($p=0.019$) 6 months post-injury, though this gender difference did not reach significance at 12 months after injury ($p=0.25$). Older subjects were more likely to report lower QOL on Total PQOL after injury ($p=0.027$) at 6 months though this age difference did not reach significance at 12 months post-injury ($p=0.31$).

Univariate analysis of Cognitive Composite Scores reveals that there is a correlation with QOL at both 6 and 12 months post injury. Persons with higher Cognitive Composite Scores, indicating better cognitive status, report higher QOL (6 and 12 months $p<0.001$). Table 7 displays univariate analysis for QOL data.

Table 7. Univariate Analysis for Quality of Life

Independent Variable	Total PQOL After Injury (square root) 6 months	Total PQOL After Injury (square root) 12 months
Age (square root)	Pearsons=-0.312 p=0.027**	Pearsons= -0.159 p=0.341
Gender		
Males	33.44 (±1.15)	35.78 (±1.01)
Females	26.73 (±2.73)	33.06 (±2.07)
	p=0.019**	p=0.253
Education		
Less than High school	34.52 (±2.55)	35.99 (±2.44)
Graduate High school	32.59 (±1.57)	35.29 (±1.37)
Some College or College Graduate	31.22 (±1.87)	35.10 (±1.46)
	p=0.613	p=0.962
History Pre-morbid Psychiatric		
Yes	30.11 (±2.23)	36.55 (±0.68)
No	32.98 (±1.28)	34.82 (±1.21)
	p=0.262	p=0.220
GCS		
Very Severe (GCS 3-5)	33.44 (±1.86)	34.09 (±1.40)
Severe (GCS 6-8)	32.04 (±1.33)	35.66 (±1.18)
Moderate (GCS 9-12)	32.58 (±3.19)	35.36 (±1.73)
	p=0.930	p=0.793
Depression Status		
Not Depressed	35.84 (±1.02)	38.27 (±0.75)
Depressed	28.32 (±1.74)	32.85 (±1.32)
	p<0.001**	p=0.001**
Depression Severity		
Not Depressed	35.84 (±1.01)	38.27 (±0.75)
Mild Depression	29.52 (±2.98)	34.90 (±1.37)
Moderate/Severe Depression	27.13 (±1.87)	30.13 (±2.27)
	p=0.001**	p=0.001**
Cognitive Composite Score	Pearsons=0.541 p<0.001**	Pearons=0.475 p<0.001**

* p<0.10, **p≤0.05

4.2.2 Cognitive Performance

Analysis of Variance (ANOVA) was performed to evaluate injury severity, education, and depression severity in relation to the cognitive function Cognitive Composite Score after injury at both 6 and 12 months post-injury. A correlation was used to examine age in relation to the cognitive function variable Cognitive Composite Score at both 6 and 12 months post-injury. T-tests were performed to examine independent variables of gender, pre-morbid psychiatric history, and depression status in relation to the cognitive function variable Cognitive Composite Score at both 6 and 12 months post-injury.

At 6 and 12 months post-injury no association was not found between cognition and presence of depression (6 months p=0.146, 12 months p=0.210). Although a relationship between depression status and cognitive function was not found at 6 and 12 months post-injury, analysis of depression severity showed significant between group differences in cognitive function at 6 months post injury (p=0.041) and a trend at 12 months post injury (p=0.062).

Univariate analysis of demographic factors reveal females were significantly more likely to display worse cognitive function (p=0.047) at 6 months post-injury, though this gender difference did not reach significance at 12 months after injury (p=0.287). At 6 months post-injury there was a trend for older subjects to be more likely to display worse cognitive function (p=0.070). This relationship was found to be significant at 12 months post-injury (p=0.032). At 12 months post-injury, there was a trend for subjects with no history of pre-morbid psychiatric history to be more likely to display worse cognitive function (p=0.08). Table 8 summarizes univariate analysis results for cognitive function.

Table 8. Univariate Analysis for Cognitive Function

Independent Variable	**Cognitive Composite 6 months**	**Cognitive Composite 12 months**
Age (square root)	Pearsons=-0.257 **p=0.070***	Pearsons= -0..329 **p=0.032****
Gender		
Males	655.80 (±29.33)	488.35 (±24.38)
Females	513.89 (±65.53)	424.57 (±62.45)
	p=0.047**	p=0.287
Education		
Less than High school	590.14 (±47.44)	420.75 (±59.66)
Graduate High school	602.60 (±45.71)	463.82 (±37.55)
Some College or College Graduate	666.52 (±42.71)	502.52 (±32.49)
	p=0.484	p=0.526
History Pre-morbid Psychiatric		
Yes	584.46 (±49.83)	543.90 (±29.60)
No	646.35 (±32.93)	452.57 (±28.17)
	p=0.331	**p=0.079***
GCS		
Very Severe (GCS 3-5)	632.00 (±114.65)	471.20 (±53.96)
Severe (GCS 6-8)	611.35 (±29.15)	479.89 (±26.35)
Moderate (GCS 9-12)	779.80 (±87.75)	463.60 (±88.25)
	p=0.194	p=0.970
Depression Status		
Not Depressed	669.00 (±39.60)	508.88 (±31.67)
Depressed	588.29 (±37.30)	450.48 (±32.19)
	p=0.146	p=0.210
Depression Severity		
Not Depressed	669.00 (±39.60)	508.88 (±31.61)
Mild Depression	668.83 (±49.41)	502.75 (±42.70)
Moderate/Severe Depression	507.75 (±46.87)	380.77 (±40.47)
	p=0.041**	**p=0.062***

* p<0.10, **p≤0.05

4.2.3 Depression as a Dependent Variable

Univariate analysis was conducted for demographic factors, injury severity, and pre-morbid psychiatric history with depression severity at 6 and 12 months post-injury as the dependent variable to assess factors affecting depression reporting at those time points. Results of the univariate analysis are located in Appendix B. At 6 months post-injury, the only factor found to affect depression reporting was history of pre-morbid psychiatric disorders. Subjects with a history of a psychiatric disorder were more likely to report depression after injury (p<0.001). However, pre-morbid psychiatric disorder was not associated with depression reporting at 12 months post injury.. At 12 months post-injury there was a trend for older persons to be more likely to report mild depression (p=0.100). Gender, GCS, and education were not associated with depression reporting at either time point. However, results of this analysis cannot be interpreted for changes in depression reporting across time domains as the cohort of subjects for 6 and 12 months are not the same.

4.3 MULTIVARIATE ANALYSIS

Four multivariate linear regression models were developed for analysis. Models were developed for cognitive status at both 6 and 12 months post injury. Models were developed for QOL at both 6 and 12 months post-injury. In these linear regression models, the size of the standardized coefficient of each independent variable explains the size of the effect that variable is having on the dependent variable. Since there are multiple independent variables in this model, the coefficient describes the amount the dependent variable is expected to increase when the independent variable increases by one, holding all other independent variables constant.

Cognitive function at 6 months post injury is associated with depression severity. At 6 months (Table 9), cognitive status is significantly better for subjects who did not report any depression symptoms than for subjects who report moderate/severe depression (p=0.019). Injury severity plays a role in cognition at 6 months post injury with subjects who have less severe injuries exhibiting better cognitive status (p=0.028). Age, gender and mild depression were not found to be significant in the model for cognitive function at 6 months. The adjusted r square for the regression model was 0.206 (p=0.003).

Table 9. Linear regression analysis of factors influencing Cognitive Function 6 months

Independent Variable	Standardized Coeffiecients (β)	Significance (p-value)
GCS Injury Severity	0.293	0.028
Moderate/Sev. depression	0.312	0.019

Cognitive function at 12 months post injury is associated with depression severity. At 12 months (Table 10), cognitive function is significantly better for subjects who did not report depression symptoms than subjects with moderate/severe depression (p=0.009). Older subjects are more likely to have worse cognitive function (p=0.016). History of pre-morbid psychiatric conditions and mild depression were not found to be significant in the model for cognitive function at 12 months. The adjusted r square for the regression model was 0.238 (p=0.003)

Table 10. Linear regression analysis of factors influencing Cognitive Function 12 months

Independent Variable	Standardized Coeffiecients (β)	Significance (p-value)
Age (sqrt)	-0.364	0.016
Moderate/Sev. depression	0.397	0.009

Quality of life at 6 months post injury is associated with depression severity and cognitive status. At 6 months (Table 11), subjects with no depression report significantly higher QOL than subjects reporting moderate/severe levels of depression (p=0.016). Additionally, subjects with no depression report higher QOL than subjects with mild depression (p=0.005). Subjects with better cognitive status report higher QOL (p<0.001). Age and gender were not found to be significant in the final model. The adjusted r square for the regression model was 0.399 (p<0.001).

Table 11. Linear regression analysis of factors influencing QOL 6 months

Independent Variable	Standardized Coeffiecients (β)	Significance (p-value)
Mild depression	0.346	0.005
Moderate/Sev. depression	0.311	0.016
Cognitive Composite Score	0.469	<0.001

Quality of life at 12 months post injury is also found to be associated with depression severity and cognitive status. At 12 months (Table 12), subjects with no depression report significantly higher QOL than subjects with moderate/severe depression (p=0.002). There is a trend for subjects with no depression to report higher QOL than subjects with mild depression (p=0.057). Subjects with better cognitive status report higher QOL (p=0.031). These results were consistent with findings at 6 months post injury. The adjusted r square for the regression model was 0.373 (p<0.001).

Table 12. Linear regression analysis of factors influencing QOL 12 months

Independent Variable	Standardized Coeffiecients (β)	Significance (p-value)
Mild depression	0.277	0.057
Moderate/Sev. depression	0.501	0.002
Cognitive Composite Score	0.318	0.031

5.0 DISCUSSION

The purpose of this research is to examine how posttraumatic depression affects a person's QOL and cognitive status after injury. Another aim is to examine the Chronic Care Model as a framework for assessing the care of patients experiencing the chronic condition of posttraumatic depression and brain injury.

Depression rates are 48% at 6 months and 55% at 12 months post-injury. These figures are slightly elevated in comparison to the rate of 42% reported in previous studies which also evaluated depression using DSM-IV criteria.[14, 15]

QOL after injury is affected by both depression and cognitive status. Subjects with no posttraumatic depression report significantly higher QOL than subjects who have mild or moderate/severe depression at both 6 and 12 months post-injury. Cognitive status after injury also affects a subject's QOL reporting. Subjects with better cognitive status report higher levels of QOL at both 6 and 12 months post-injury. Depression severity and cognitive status independently affect QOL.

Depression severity affects cognitive status only in subjects with moderate/severe depression. These subjects exhibit worse cognitive function at both 6 and 12 months post-injury. Subjects with mild depression after injury do not display significant differences in cognitive status in comparison to subjects with no depression. Whereas QOL is affected by any level of posttraumatic depression, cognition is negatively affected only in the presence of moderate/severe posttraumatic depression.

At 6 months post-injury cognitive status is also associated with injury severity. Subjects with less severe injuries exhibit better cognitive status, whereas subjects with more severe injuries display worse cognitive status. Although this finding was not present at 12 months post-injury, this result is consistent with the general recovery process of TBI. Persons who are more severely injured exhibit worse cognitive status after injury than those who have sustained less severe injuries.[78] The injury effect on cognition may not have been apparent at 12 months post-injury as persons with more severe injuries are recovering to similar cognitive status levels exhibited by persons with less severe injuries.

At 12 months post-injury cognitive status is associated with age. Older subjects display worse cognitive status than younger subjects. Older subjects have worse cognitive status as found through univariate analysis at 6 months post injury, however this association was not found to be significant in the 6 month cognitive multivariate model. There are a few possible reasons for this age difference in cognitive status post-injury. Previous research has shown that older persons with TBI exhibit worse cognitive status after injury in comparison to younger persons.[75-77] One of the limitations of the study is that the cognitive composite score was calculated using raw values as compared to standardized scores. Some neuropsychological assessments are standardized against gender and age norms in the population. If multiple cognitive measures included in the cognitive composite score had standardized norms for age, it is possible that if standardized scores were used, the age association with cognitive status may not have been found to be significant.

An additional limitation of this study is with the collection of pre-morbid psychiatric history data through patient/family interview and medical record review. It is possible that persons with pre-morbid psychiatric histories were not categorized as such if the illness had not been diagnosed appropriately before their injury. Additionally, pre-morbid psychiatric histories were documented for people who had ever experienced a condition, though the disorder may not have been active at the time of injury. There could be depression susceptibility differences between people who were actively experiencing psychiatric conditions at the time of injury versus those who have been affected in the past. A history of pre-morbid psychiatric history was not found to be significant in either QOL or cognitive outcome in this study. However, if cases of pre-morbid psychiatric history were missed or not documented the affect of these conditions on posttraumatic depression, QOL and cognitive outcome may be important. If that is the case, knowing a person's pre-morbid history would be imperative for identifying persons potentially at risk for posttraumatic depression, lower QOL and cognitive dysfunction after injury.

As with assessing any subjective measure in a cognitively impaired population, there is the chance that the measure of QOL isn't fully capturing the person's quality of life. Some persons with TBI experience deficits in self-awareness post-injury which may affect their responses on subjective measures such as QOL. However, one could argue that persons with self-awareness deficits would over report their QOL rather than under report it because they are less aware of the how their deficits affect their QOL. QOL was reported to be lower after injury for all persons regardless of injury severity. Therefore it does not seem to be case that persons are over reporting QOL after injury as related to self awareness issues.

Depression negatively affects QOL and cognition after TBI. Additionally, posttraumatic depression afflicts people for up to a year post-injury. Both TBI and depression are chronic conditions which affect person’s health for years after injury if not for a lifetime. In order for patients to achieve an improved outcome in the face of these chronic conditions, they must interact with the health care system in a productive way. The Chronic Care Model is used to assess the care that persons with TBI suffering from posttraumatic depression are currently receiving and to identify possible areas for improvement.

5.1.1 Senior Leadership

The health system in which the patient is receiving care should be an organization that promotes safe, quality care. Persons with TBI who have posttraumatic depression and are receiving acute and rehabilitative care at UPMC hospital are in a health care system that is conducive to quality care. UPMC hospital is equipped to allow for effective communication for patients as they pass through the hospital system and multiple facilities. However, there are a few areas for improvement. While providers, such as neurosurgery and physiatry, are aware of major secondary health complications of TBI, mental health disorders, such as depression, often are lower priority than physical disability and cognitive deficits. Senior leadership within the administration of the health care system must recognize the importance of identifying persons with TBI who are experiencing posttraumatic depression so as to equip providers with the tools and time necessary to identify and treat this condition. Currently providers are given minimal time allotments to assess patients for their multiple concerns. Increasing time allotments for patient assessment would increase costs for providers as well as decrease the number of patients which could be seen. However, another option would be to allow other providers to assist in identifying depressive symptoms in persons with TBI. These other providers, including therapists, nurses, and research staff, often have more frequent interaction with patients and would be better equipped to identify depressive behavior tendencies in patients. While additional training on posttraumatic depression would be necessary for these providers, it may be more cost-effective for these providers to assist in the identification of depressive systems in persons with TBI. Additionally, utilizing other providers for identifying posttraumatic depression would allow for a more team based approach to patient care.

5.1.2 Definition of Provider Roles

Clinical care and self-management support should be delivered effectively within the health care system. The health care system must be transformed into a proactive environment where efforts are made to keep patients healthy, not just prevent patient's sickness. The delivery system design is an element which could use improvement within the area of posttraumatic depression care. Previous research has found that the most expressed need of persons with TBI is "receiving information about services.[61] While providers have defined roles in the specialty areas of therapy, neurosurgery, rehabilitation, etc., there is no defined process by which providers within the system are consulted if a patient (or their family) voices concerns of posttraumatic depression. Patients often consult either the next provider they come into contact with or multiple providers. When multiple providers are consulted it is possible that each think that the other service is supplying the needed care. A necessary improvement would be to designate one provider as the primary contact for patients expressing posttraumatic depression. All providers would be notified of the primary contact and their role so they can direct patients to the appropriate point of care. Additionally, patients and families would be introduced to this contact early in the hospital setting and be informed of their role so that ongoing communication could be maintained. This provider need not be responsible for treating posttraumatic depression, but for ensuring that patients are directed to the right resources for care. If only one provider was responsible for being the resource center for the management of posttraumatic depression, care could be delivered in a more effective manner. The coordinator could be a liaison not only for posttraumatic depression, but also as a point person able to direct persons with TBI and families to other resources they need such as vocational or legal issues. The rehabilitation department would be a good provider to offer this liaison service as they are often involved in a patient's care from acute time points through multiple years following the injury. Persons with TBI are followed by case management personnel through acute and rehabilitation care, however, case management personnel is not consistent across acute and rehabilitation facilities. It would be necessary for the coordinator liaison to be consistent across all levels of care for person with TBI so as to facilitate patient care.

5.1.3 Posttraumatic Depression Screening

Decision support ensures that is consistent with scientific evidence and patient preferences. The UPMC hospital system is affiliated with the University of Pittsburgh. Researchers at the University of Pittsburgh conduct cutting edge research in the area of TBI. However, little research is conducted in the University in the area of mental health disorders post-TBI. Additionally, there is little research conducted concerning the services which are provided to persons with TBI versus the need for services expressed by these persons. It is necessary for providers to receive ongoing training and education in the area of posttraumatic depression in order to follow proven guidelines for treating posttraumatic depression.

Currently posttraumatic depression screening is not part of follow-up care for persons with TBI within the UPMC system. It is imperative that such screening take place during follow-up visits so that posttraumatic depression can be identified and treated as soon as possible. It would be beneficial to set up an infrastructure which allows for routine posttraumatic depression screening protocol at follow-up visits. There is ample time during follow-up visits for patients to complete a brief depression screening instrument, such as the PHQ-9. Minimal training is required to administer and score this assessment, so that nurses and research staff could be trained to perform such tasks prior to the patient being seen by the physician. Alternatively, the PHQ-9 could be administered via computer so that patient results could be immediately uploaded into their health care record. Results indicating posttraumatic depression could be flagged so that physicians are aware of this issue and proper referrals can be made as quickly as possible. Additionally, this approach could allow for depression screening to occur across multiple follow-up visits to track depression changes over time. This information may not only benefit the patient, but provide information for depression rates, risk factors, and outcomes for future research and intervention initiatives.

There is a need for improvement for decision support that promotes patient preference. As persons with TBI are often affected by cognitive disruption and self-awareness issues, it may be necessary for providers to consult not only the patients for their care preferences, but also family and caregivers preferences when applicable. Due to the rushed nature of health care delivery, patient/family preferences for care are not often discussed by clinicians. More often than not, providers promote their care options without consulting patients and their families. Improvements for decision support would consist of improved communication between patients, caregivers and physicians.

5.1.4 Follow-up Completeness

UPMC hospital system supplies effective clinical information systems through electronic medical records to organize patient and population data to facilitate care. However, the TBI population may require additional assistance providing reminders for follow-up care. Persons with TBI are often faced with cognitive deficits and memory issues that impede their ability to remember appointments. Additionally, family members of persons with TBI often are overcome with caregiving responsibilities. The burden often is placed on them for scheduling multiple follow-up visits with providers. It would be helpful for the TBI population to have a contact person within the system who assists with follow-up care, including scheduling appointments with necessary providers, providing help in contacting specialty services when needed, and assisting in reminding patients/families of scheduled visits.

5.1.5 Empowering Patients and Families

Another important aspect of chronic disease management is empowering patients (and families) with the management of their own health. Providers and the patient can collaborate to identify problems and set goals with patients to be more responsible of their own behaviors to improve their health. Since persons with TBI may not be cognitively capable of setting goals for improving health care behaviors, it is important for family members to be involved in the person’s care. Although including family members in patient care may not be feasible in every situation, when possible, it could have positive affects on patient health. Signs and symptoms of posttraumatic depression are often difficult to separate from the symptoms of brain injury. However, patients/families should be provided with information concerning signs and symptoms, observing changes in behavior over time, and be made aware of providers to contact. Since persons with TBI may have self-awareness deficits, it is necessary for family members to be educated about behaviors which could indicate posttraumatic depression.

5.1.6 Targeting and Mobilizing Rural Communities and Online Community Resources

Finally, the community must be equipped to meet the needs of persons with TBI by assisting in identifying and treating posttraumatic depression. Persons with TBI need to be encouraged to participate in community programs such as support groups or counseling as a means of coping with depressive symptoms. The UPMC health care system also needs to form more partnerships with community organizations to develop interventions and advocate for policies for persons with TBI who are facing posttraumatic depression. The UPMC health care system partners with some community organizations, such as the Pittsburgh Area Brain Injury Alliance, within the Pittsburgh area. However, the majority of persons with TBI live in more rural locations. Sixty four percent of the persons with TBI involved in this research study resided in areas outside of Allegheny County. Patients are unable to drive initially after their injury and family members are often unable to provide transportation to the Pittsburgh area for community resources. Family members and caregivers are already taking the time to transport patients to and from physician follow-up visits. Long commutes for activities run by community organizations are lower priority. Additionally, if patients do not have family or caregivers able to provide transportation, they can rely on transportation services provided by ACCESS which is provided through Port Authority.[100] Persons with TBI living in more remote locations or in other states do not have access to these services. Therefore, it would be beneficial for UPMC hospital to partner with other hospitals or organizations in more rural areas, where the majority of persons with TBI are located, for better access to community services. Providing education to local hospitals, support groups, and community organizations on issues such TBI prevention, TBI outcome and mental health issues could be a first step in forming partnerships with rural communities.

It is not feasible for UPMC to partner with every community in the surrounding area they provide services to. It would be beneficial to track the areas persons with TBI are coming from to receive care at UPMC to identify “hot spots” for targeting community outreach. An area outside of the urban Pittsburgh location that has a high prevalence of persons with TBI is southeast of Pittsburgh in Fayette, Washington, and Westmoreland counties. Thirty percent of subjects in this research study originated from these areas. It would be a daunting task to provide community outreach to all areas where persons with TBI may be originating. However, targeting a few hot spots for persons with TBI may be an effective way to provide community outreach and partnerships. Geographical tracking would be beneficial not only to track areas people are coming from to receive services at UPMC hospital, but also to track communities in which people with posttraumatic depression are residing. Posttraumatic depression screening results could be linked with demographic information to track locations to identify “hot spots” for communities where persons with posttraumatic depression are more likely to be located.

Since UPMC health system services such a large area and community outreach will not be possible for all areas, the internet may be used to provide community resources to more rural persons with TBI. The internet offers online support groups, TBI education, and family/caregiver resources. The online community of Facebook offers numerous groups persons with TBI and families can join. These groups not only include information on TBI, but offer persons with TBI the opportunity to chat with other people who have experienced similar trials and obstacles in their TBI recovery. However, patients and families need to be made aware of these online resources for them to be utilized effectively.

There are also limitations with regards to recommendations for improvements for care of persons with posttraumatic depression. UPMC hospital is a large health system providing care for many specialties. It may be challenging to allot enough time and resources for improving TBI care, specifically care for persons with posttraumatic depression, when they are only a fraction of the patients treated at UPMC facilities. Additionally, these recommendations are primarily for people who receive the entirety of their care, acute and rehabilitative, at a UPMC facility. If a person is discharged to another rehabilitation facility or to a long term acute facility, it will be more challenging to improve their health care delivery across facilities located in different or less developed health care systems. Another limitation is in the mobilization of communities for assisting persons with TBI and families. Since persons with TBI are transported to UPMC for care from multiple communities in the surrounding areas it will be a challenge to mobilize resources in rural communities. Although persons with TBI are more likely to reside in rural locations, these locations may be scattered within a 100 mile radius of the city. Mobilizing multiple communities within that large of an area may be a challenge.

6.0 CONCLUSIONS

In conclusion, both QOL and cognitive function were affected by a person's posttraumatic depression status after moderate/severe TBI. People with no depression report higher QOL and have better cognitive function than people who report moderate/severe depression. People who exhibit only mild depression report lower QOL, but do not have worse cognitive functioning than people with no depression.

Posttraumatic depression is a common problem after TBI. If people who exhibit moderate/severe depression after injury can be identified through depression screening instruments, such as the PHQ-9, perhaps interventions can be aimed at alleviating their symptoms. This research has shown that experiencing a mild depression after injury is less detrimental than more severe depression in relation to cognitive function. However, depression, QOL and cognitive function all impact a person's recovery and return to functioning.

Posttraumatic depression can be viewed as a chronic condition which requires ongoing interaction between the patient and health care system for improved outcomes. The Chronic Care Model was used as a framework for identifying deficiencies within the current health care system in regards to the care for patients with posttraumatic depression.

To summarize, there are six areas which the current system should address. These areas include issues within senior leadership, clear definition of roles within providers, the inclusion of posttraumatic screening as part of follow-up, assistance with follow-up completeness, empowering patients/families, and mobilizing rural communities.

Senior leadership should be aware of the degree to which posttraumatic depression negatively affects a patient's QOL, cognition and outcome. Although posttraumatic depression is an issue for persons with TBI, more research needs to be conducted to support this problem as a substantial issue in the TBI community. Senior leadership needs to be in agreement that this is a significant issue to motivate them to initiate change in their care and to encourage additional providers within the system to be aware of this issue.

There needs to be a clearly defined role for one provider within the health care system to be responsible for disseminating information about posttraumatic depression to persons with TBI, families and other providers across acute and rehabilitative care. Fewer people will get lost in the system if all parties know whom to contact with posttraumatic depression issues.

Posttraumatic depression screening should be integrated into follow-up visits for persons with TBI so as to identify changes in behaviors over time which could indicate depression. Additionally, in order for people to be screened at follow-up visits, assistance needs to be available for persons with TBI to aid in follow-up visit scheduling, appointment reminders, and transportation issues.

Persons with TBI and family members need to be empowered as active members of their own health. They need to be clearly told of the signs and symptoms of posttraumatic depression. They also need to have information about their access to behavioral health services, including providers and medications.

Finally, rural communities in which persons with TBI are living need to be educated on practical methods to provide resources and support for persons with TBI and their families.

Practical methods may include providing education, online support, and transportation resources. Communities capable of providing resources closer to home will aid in the delivery of services to this hard to reach population. It may be beneficial to target communities with more people with TBI for outreach. Additionally, online support group alternatives may be utilized as resources for persons with TBI in more distant communities.

Although these recommendations may be challenging to the current health care system, addressing even one of these issues will lead to better health care delivery for persons with TBI who are experiencing posttraumatic depression. Confronting the public health problem of posttraumatic depression will lead to increased QOL and cognitive function which, in turn, will result in successful recovery for persons with TBI.

APPENDIX A

QOL QUESTIONNAIRE DESCRIPTIONS

Percent Back to Normal

Questionnaire Category	**Description**
Total %	On a scale of 0-100, I want you to tell me how close you are now to being back to normal. For example, are you 100% recovered, fully back to your old self? Are you 50% back to your old self? What percentage would best describe how close you are to being as good as you were before the injury?
Physical %	On a scale of 0-100 how close are you to being back to normal in regards to physical issues which could include walking, exercising, balance, headaches, fatigue, vision problems, etc?
Cognitive %	On a scale of 0-100 how close are you to being back to normal in regards to cognitive issues which could include concentration, memory, word finding, figuring things out, etc?
Emotional %	On a scale of 0-100 how close are you to being back to normal in regards to emotional issues which could include irritability, sadness, anxiety, mood swings, changes in self-esteem, etc?

Perceived Quality of Life

Questionnaire Category	**Description**
Cognitive Before	On a scale of 0-100 how satisfied are you with your ability to think and remember before your injury?
Cognitive Now	On a scale of 0-100 how satisfied are you with your ability to think and remember after your injury?
Economic Before	On a scale of 0-100 how satisfied are you that your income met your needs before your injury?
Economic After	On a scale of 0-100 how satisfied are you that your income meets your

	needs after your injury?
Physical Before	On a scale of 0-100 how satisfied are you with the health of your body before your injury? On a scale of 0-100 how satisfied are you with your ability to take care of your personal needs before your injury? On a scale of 0-100 how satisfied are you with your ability to take care of your homecare responsibilities before your injury?
Physical After	On a scale of 0-100 how satisfied are you with the health of your body after your injury? On a scale of 0-100 how satisfied are you with your ability to take care of your personal needs after your injury? On a scale of 0-100 how satisfied are you with your ability to take care of your homecare responsibilities after your injury?
Mobility Before	On a scale of 0-100 how satisfied are you with your ability to get from one place to another before your injury? On a scale of 0-100 how satisfied are you with your ability to travel from one place to another other than by foot before your injury?
Mobility After	On a scale of 0-100 how satisfied are you with your ability to get from one place to another after your injury? On a scale of 0-100 how satisfied are you with your ability to travel from one place to another other than by foot after your injury?
Vocational Before	On a scale of 0-100 how satisfied are you with work/not working/retirement before your injury? On a scale of 0-100 how satisfied are you with being in school / not being in school before your injury? On a scale of 0-100 how satisfied are you with your contribution to your community before your injury? On a scale of 0-100 how satisfied are you with your recreational or leisure time activities before your injury?
Vocational After	On a scale of 0-100 how satisfied are you with work/not working/retirement after your injury? On a scale of 0-100 how satisfied are you with being in school / not being in school after your injury? On a scale of 0-100 how satisfied are you with your contribution to your community after your injury? On a scale of 0-100 how satisfied are you with your recreational or leisure time activities after your injury?
Emotional Before	On a scale of 0-100 how satisfied are you with how respected you are before your injury? On a scale of 0-100 how satisfied are you with the meaning and purpose of your life before your injury? On a scale from 0-100, how happy are you before your injury?
Emotional After	On a scale of 0-100 how satisfied are you with how respected you are after your injury? On a scale of 0-100 how satisfied are you with the meaning and purpose of your life after your injury? On a scale from 0-100, how happy are you after your injury?
Social Before	On a scale of 0-100 how satisfied are you with your sexual activity (or romantic relationships) before your injury? On a scale of 0-100 how satisfied are you with how much you see your

	family or friends before your injury? On a scale of 0-100 how satisfied are you with the *help* you get from family or friends before your injury? On a scale of 0-100 how satisfied are you with your ability to relate to other people and your social interactions in general before your injury?
Social After	On a scale of 0-100 how satisfied are you with your sexual activity (or romantic relationships) after your injury? On a scale of 0-100 how satisfied are you with how much you see your family or friends after your injury? On a scale of 0-100 how satisfied are you with the *help* you get from family or friends after your injury? On a scale of 0-100 how satisfied are you with your ability to relate to other people and your social interactions in general after your injury?
Total Before	Summation of Cognitive, Economic, Physical, Mobility, Vocational, Emotional, and Social categories assessing a patient before their injury
Total After	Summation of Cognitive, Economic, Physical, Mobility, Vocation, Emotional and Social categories assessing a patient after their injury

APPENDIX B

UNIVARIATE ANALYSIS OF DEPRESSION

Depression Severity at 6 months

Independent Variable	Depression Severity 6 months			P value
	No Depression	Mild Depression	Moderate/Severe Depression	
Age^				
≤29	16 (64%)	5 (20%)	4 (16%)	p=0.254
>29	10 (40%)	7 (28%)	8 (32%)	
Gender				
Males	23 (56%)	9 (22%)	9 (22%)	p=0.428
Females	3 (33%)	3 (33%)	3 (33%)	
Education				
Less than High school	4 (56%)	1 (14%)	2 (29%)	p=0.902
Graduate High school	9 (45%)	6 (30%)	5 (25%)	
College	13(56%)	5 (22%)	5 (22%)	
History Pre-morbid Psychiatric				
Yes	1 (8%)	7 (54%)	5 (38%)	**p<0.001****
No	25(68%)	5 (13%)	7 (19%)	
GCS				
Very Severe (GCS 3-5)	3 (60%)	1 (20%)	1 (20%)	p=0.969
Severe (GCS 6-8)	21(52%)	9 (22%)	10(25%)	
Moderate (GCS 9-12)	2 (40%)	2 (40%)	1 (20%)	

* p<0.10, **p≤0.05

^age dichotomized by median

Depression Severity at 12 months

Independent Variable	Depression Severity 12 months			P value
	No Depression	Mild Depression	Moderate/Severe Depression	
Age^				
<36	11 (58%)	3 (16%)	5 (26%)	**p=0.100***
≥36	6 (32%)	9 (47%)	4 (21%)	
Gender				
Males	15 (48%)	8 (26%)	8 (26%)	p=0.319
Female	2 (29%)	4 (57%)	1 (14%)	
Education				
Less than High school	2 (50%)	0 (0%)	2 (50%)	p=0.484
Graduate High school	9 (53%)	5 (29%)	3 (18%)	
College	6 (35%)	7 (41%)	4 (24%)	
History Pre-morbid Psychiatric				
Yes	3 (30%)	4 (40%)	3 (30%)	p=0.579
No	14(50%)	8 (29%)	6 (21%)	
GCS				
Very Severe (GCS 3-5)	2 (40%)	3 (60%)	0 (0%)	p=0.593
Severe (GCS 6-8)	13(46%)	7 (25%)	8 (29%)	
Moderate (GCS 9-12)	2 (40%)	2 (40%)	1 (20%)	

* p<0.10, **p≤0.05

^age dichotomized by median

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