**An Examination of Racial Disparities in Healthcare Service Utilization and Outcomes Following Traumatic Brain Injury: A TRACK-TBI Pilot Study**

by

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BA, Kenyon College, 2013

Submitted to the Graduate Faculty of

the Department of Epidemiology at the

Graduate School of Public Health in partial fulfillment

of the requirements for the degree of

Master of Public Health

University of Pittsburgh

2018

UNIVERSITY OF PITTSBURGH

Graduate School of Public Health

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**Abstract**

**Background:** Traumatic brain injury (TBI) is a major public health issue in the United States and is growing in incidence. Racial and ethnic disparities in both health outcomes and healthcare utilization have been documented across a wide range of conditions; however, the data on these disparities in the TBI population remain sparse and equivocal. Disparities in the use of healthcare services may account for observed differences in TBI outcomes.

**Methods:** This study examined 586 TBI patients who presented to one of three level I US trauma centers between April 2010 and June 2011 and were prospectively enrolled into an observational database. Subjects were longitudinally assessed out to 1 year post-injury. In-hospital and post-hospital healthcare utilization, functional and clinical, and neuropsychological outcomes were collected and assessed for differences between minorities and whites. Univariate and step-wise multivariate analyses were used on each outcome. Multivariate analyses were adjusted for patients’ demographical, clinical, past medical history, and socioeconomic factors.

**Results:** Overall, there were no observed differences between minorities and whites in in-hospital or post-hospital healthcare utilization, or functional outcomes after controlling for known confounders. Clinically, minorities experienced a significantly higher symptom burden at both three months and six months post injury compared to whites. Minorities also demonstrated increased levels of psychological distress and depression and a decreased satisfaction with life scores compared to whites at the six months following injury.

**Conclusion:** Though healthcare utilization rates were similar, patients from minority groups had an increased TBI-related symptomatology and psychological distress following TBI compared with whites, even after controlling for known key confounders. Potential disparities in psychological distress and symptom burden in minorities following TBI represent an opportunity for public health interventions.

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**1.0 INTRODUCTION**

**1.1 WHAT IS TRAUMATIC BRAIN INJURY?**

Traumatic brain injury (TBI) is defined as an intracranial injury induced by a physical event that results in a physiological disruption to the brain’s normal functioning1. Patients are diagnosed with traumatic brain injury following presentation with: 1) loss of consciousness (LOC), 2) post traumatic amnesia (PTA), or 3) alteration in consciousness, and 4) a focal neurological deficit (most commonly, intracranial hemorrhage) after an identified traumatic event2. TBI is defined intro three categories of severity using the Glasgow Coma Scale (GCS). Mild traumatic brain injury (mTBI), also commonly referred to as concussion, is defined as a GCS score of 13 to 15, moderate TBI is defined as a GCS score of 9 to 12, and severe TBI is defined as a GCS Score of 8 or below3 (Figure 1). TBI has recently garnered national attention due to increased awareness of its immense impact in military combat and the emerging evidence of its long-term effects on professional athletes involved in contact sports4.

**1.2 Incidence Rates of Traumatic Brain Injury**

 It is estimated that up to 60 million people across the world may incur a traumatic brain injury each year5. A recent systematic review determined the pooled annual international incidence rate of traumatic brain injury across all age groups to be 618 per 1000 person-years6. Another review found that in developed countries, 12% of the adult population had incurred TBI at least once in their life6. While there have been no recent studies on the estimated incidence of TBIs, using the recent increases noted in the emergency department (ED) visits, it is estimated that up to 3.8 million Americans may incur a TBI annually7. In 2013, there were 2.5 million TBI-related ED visits, 282,000 TBI-related hospitalizations, and 56,000 TBI-related deaths in the United States. TBI accounted for 2.2% of all ED visits in the United States, and moreover, age-adjusted ED visit rates increased by 47% from 2007 to 20138. Approximately 80% of TBI patients are treated within the ED9. However, many individuals who incur milder injuries frequently do not seek care and thus, are not captured in many current surveillance systems. Accordingly, current estimates of TBI incidence likely underestimate the true incidence of TBI4. A population-based study in New Zealand that utilized an advanced, prospective and retrospective surveillance in attempt to ascertain an accurate incidence, found an annual incidence rate of 790 per 100,000, with 95% of those being mTBIs. The observed increased rate was attributed to the system’s increased ability to capture mTBIs that are typically unaccountedfor5.

**1.3 Risk Factors of Traumatic Brain Injury**

In the United States, falls were the most common cause of TBI, followed by being struck by or against an object and motor vehicle accidents accounting for approximately 47%, 15%, and 14% of TBIs annually, respectively8. Motor vehicle accidents were the most likely to cause mortality, representing 31.8% of TBI deaths. Elderly patients accounted for the greatest rate of TBI-associated hospitalizations and mortality10. Patients older than 75 years old had the highest rate of ED visits, hospitalizations, and deaths, followed by patients aged 0-4 and patients aged 5-148. Males are 1.4 to 1.67 times more likely to sustain a TBI than females5. Minorities are at an increased risk of incurring TBI, accounting for nearly half of all TBI hospitalizations, with African-Americans experiencing the highest incidence rates of TBI, followed by Hispanics11,12. Alcohol consumption plays a large role in the occurrence of TBI, with approximately 36 to 55 percent of TBI patients presenting with a blood alcohol concentration (BAC) above the legal level of intoxication13,14. A history of TBI is associated with an increased risk of incurring another TBI. A population-based study found the relative risk of incurring a secondary TBI is 2.8 to 3 times greater for patients who have sustained one TBI15. The risk of recurrent TBI has also been shown to be associated with alcohol consumption, with those incurring an alcohol-related injury after age 12 being four-times more likely to sustain a repeat head injury by 347.

**1.4 Economic Burden of Traumatic Brain Injury**

While many TBI cost studies have been limited by utilizing select patient populations and regional data, the economic burden of TBI on the economy is substantial, to both society at large and to survivors and their family members, friends, and employers. Using the Nationwide ED Samples database, Marin et al. estimated the total costs associated with TBI treatment in emergency departments to be $30 billion and the average cost of admission to be $60,000 thousand dollars. For moderate to severe TBI patients, these costs can be even more exorbitant, with costs averaging over $130,00016. After adjusting for injury severity, costs were relatively higher for adults over the age of 45, for males, for self-pay patients, and for those with the lowest income. Metropolitan locale, adult care provision, private investor ownership, and trauma center designation were significant hospital-level factors associated with higher costs. The price of treatment increased approximately 22% for admitted patients, and 94% for discharged/transferred patients from 2006 to 201017.

TBI costs rose 417% from 1993 to 2007 nationally and this increase was largely attributed to the advent of multiple new patient management strategies and the general rise in healthcare costs18. A national study of geriatric patients over the age of 55 estimated the 1-year cost of care to be approximately $75,000 in 2005 dollars, with the bulk of the costs related to post-hospitalization costs including re-hospitalization, rehabilitation, outpatient care and caretaker costs19. Many claim the excess usage of computed tomography imaging and neurosurgical consultations amongst mild TBI patients is largely responsible for the inflating costs of TBI care20–22. In response, Joseph et al., created the Brain Injury Guidelines to reduce neurosurgical consultations and CT scans, and demonstrated that accordingly, there was significant reduction in hospital length of stay (LOS) and costs per patient with no difference in in-hospital mortality rate, progression of intracranial hemorrhage (ICH), neurosurgical intervention, and 30-day readmission rate23. Many studies also fail to account for the indirect costs associated with TBI, with evidence demonstrating these costs far surpass those of care and treatment. Corso et al., estimated that 80% of losses resulting from all fatal and non-fatal injuries resulted from lost productivity, totaling to over 326 billion dollars lost in 200024.

**1.5 Morbidity and Mortality of Traumatic Brain Injury**

**1.5.1Symptomatology**

The Center for Disease Control (CDC) once dubbed TBI as the “silent epidemic” because the downstream symptoms resulting from TBI are often physically hidden. Given the global regulatory function of the brain in multiple biological systems, TBI patients present with a constellation of cognitive, physical, and affective disorders, which can manifest clinically or sub-clinically, even in those with the mildest injuries. Moreover, TBI survivors often experience drastic limitations in activities of daily living, social integration, and financial independence25. Commonly reported neurobehavioral symptoms following TBI include: behavioral abnormalities26, memory and executive dysfunction26,27, and emotional instability28. In the TRACK-TBI pilot study, 82% of patients with mTBI who presented to the ED experienced post-concussive symptoms at 6 and 12 months following injury. Furthermore, 34% of patients had a lingering disability at 6 months29. Recurrent TBI has been associated with greater symptomatology at 1-year compared to controls who had only sustained one TBI30. Individuals with a history of TBI are 66% more likely to receive welfare or disability payments compared to those without a history25.

**1.5.2Morbidity and Mortality**

TBI is a major public health issue globally and is rising in incidence. Approximately 43% of hospitalized TBI patients develop TBI-related long-term disability25, and it is estimated that more than 5.3 million Americans are current living with persistent disabilities resulting from TBI31. Using the Glasgow Outcome Scale (GOS), the current gold standard outcome measure of disability in TBI research32, a 14-state CDC funded surveillance study estimated that 17% of TBIs exhibit moderate to severe disability upon discharge33. In the United States, TBI is a leading cause of death in trauma patients, with approximately one third of injury-related deaths receiving a diagnosis of TBI 9. In 2013, TBI accounted for 2.2% of all deaths in the United States8. The estimated annual mortality following TBI is 18.4 per 100,000. From 1997 to 2007, despite an increase in TBI hospitalizations, there was an 8.2% decrease in the number of TBI-related death, from 19.3 to 17.8 per 100,000. These data are consistent with a long-standing trend of decreased TBI-related mortality9. Individuals with a history of TBI are also at an increased risk of incurring subsequent neurological disorders including: seizures, epilepsy, stroke, Alzheimer’s, Parkinson’s, chronic traumatic encephalopathy34. Given the aforementioned trends, it is highly probable that the number of patients who experience chronic impairment and disability following TBI will increase in the future. The advancement of research efforts analyzing TBI as a chronic condition, manifest by chronic symptoms and premature death is imperative in reducing disability induced by TBI and ultimately aiding the prevention of the TBI-related mortality.

**1.6 Disparities in Traumatic Brain Injury Outcomes**

While numerous studies suggest that ethnic minorities may be affected disproportionately by trauma and TBI compared to their white counterparts, the evidence for poor outcomes amongst minorities is unclear and warrants further investigation35–42. Using the National Trauma Data Bank, Haider et al. determined that after controlling for major risk factors for poor outcomes, African-Americans and Hispanics were 17% and 47% significantly more likely to experience mortality after sustaining a traumatic injury compared with white patients43. A longitudinal study examining functional outcomes amongst hospitalized moderate to severe TBI patients demonstrated that even after adjusting for demographic and clinical characteristics, minorities demonstrated impaired functional impairments on multiple scales compared to whites 1-year following injury4. A national study of US veterans demonstrated that after adjusting for sociodemographic characteristics and comorbidities, Hispanics were more likely to die compared to non-Hispanic whites5. Hospitalized ethnic minorities with a TBI demonstrated worse long-term functional outcomes on three functional measures used 6 months post injury6. A study of severe TBI patients demonstrated that minorities were 2.2 times more likely to have a moderate to severe disability 6 months following injury compared to whites7. A two-year longitudinal study demonstrated that mental health trajectories of TBI patients differed as a function of race and ethnicity, with Blacks experiencing higher levels of depression and satisfaction with life compared to whites8.

**1.7 Race, Healthcare Utilization, and Traumatic Brain Injury Outcomes**

Research suggests differences in healthcare utilization both by providers during hospitalization and by TBI survivors and families post-discharge may play a crucial role in determining outcomes following TBI. Moreover, studies suggest race and ethnicity may play a role in determining healthcare utilization. A recent systematic review demonstrated that six out of ten studies which examined healthcare utilization demonstrated racial and ethnic disparities in healthcare utilization during and after hospitalization39. Post-hospitalization, multiple studies observed that African Americans were less likely to be placed in rehabilitation compared to whites7, 13, 14. An additional study found they were less likely to receive physical, occupational, speech-language, and psychotherapy compared to whites15. A study of national ED visits found that nonwhites were three times more likely to have received care from a resident and 53% less likely to have be sent back to the referring physician after discharge44. While research has documented the impact of race and ethnicity’s effect on outcomes ensuing traumatic brain injury, just one paper has assessed the effect health care utilization may play in determining outcomes. Recently, a national cohort study found that disparities found in mortality between Hispanic veterans and non-Hispanic veterans was mediated by patients’ utilization of services following discharge5. This study provided the first objective evidence to suggest healthcare utilization may mediate the relationship between race/ethnicity and poor outcomes following TBI, but more research is needed to elucidate this relationship in the civilian population.

**1.8 Public Health Significance and Gaps in Knowledge**

The United States' minority population has grown significantly in recent years, and it is projected that by 2050, African Americans and Hispanics alone will constitute approximately 40% of the population36. Given the anticipated population growth, the heightened incidence of injury, and worse long-term outcomes of minorities, deconstructing the complex relationship between race and ethnicity and culture on health services utilization and TBI outcomes is an important public health concern and imperative to facilitate optimal treatment and long-term outcomes across all populations with TBI. The National Institute of Health has echoed this sentiment identifying minority group members with TBI as a priority for research. The research to date remains conflicted on the impact of race and ethnicity in determining functional and neuropsychological outcomes in individuals with TBI. Moreover, consistent with a recent review12, few studies to date have prospectively examined the role of race and ethnicity play in determining health care utilization in traumatic brain injury patients.

**2.0 OBJECTIVES**

The primary aim of this study is to examine the impact of race and ethnicity on long-term functional and neuropsychological outcomes following TBI. We hypothesize that minorities will experience worsened outcomes than non-minorities, and that this relationship will be attenuated by the inclusion of socio-economic risk factors. The secondary aim is to examine the impact of race and ethnicity on healthcare utilization and outcomes following TBI. We hypothesize that minorities will exhibit lower levels of utilization of both in-hospital care and post-hospital care following traumatic brain injury, however this relationship will be attenuated by the inclusion of socioeconomic status (SES) into the models.

**3.0 METHODS**

**3.1 Data Source**

Data were extracted from the Transforming Research and Clinical Knowledge in Traumatic Brain Injury (TRACK-TBI) pilot study database. The TRACK-TBI pilot study was a multicenter, prospective observational cohort study of TBI patients who presented at one of three Level 1 US Trauma Centers across the nation (University of Pittsburgh Medical Center, University of California San Francisco, or University Medical Center Brackenridge in Austin, Texas) between April 2010 and June 201129. All participants or their legal authorized representative provided written informed consent prior to participation. At follow-up outcome assessments, participants previously consented by legally authorized representatives, if neurologically improved and capable, were consented for continuation in the study. The Institutional Review Board of each institution approved the study protocol at each respective institution. In order to be included in the study, the patient had to be over the age of 16, have presented to the ED within 24 hours of TBI with trauma sufficient enough to warrant a CT head examination per American College of Emergency Physicians/Center for Disease Control evidence-based joint practice guidlines45, and have no contraindications to MRI. Patients were excluded if they were incarcerated, in custody, or on psychiatric hold. For these analyses, patients were also excluded if they were under the age of 18 or if they died during their hospital stay. A more detailed description of this study population and recruitment criteria can be found in prior publications29,46.

**3.2Exposure**

The primary exposure of interest in this study is minority status. Race was ascertained through a semi-structured interview conducted by the study coordinator when speaking with the patient or legal representative at enrollment. Patients were asked about what their ethnicity and their race was. To examine the impact of minority status, race was dichotomized into non-Hispanic whites (herein referred to as “whites”) and minorities. Due to the relatively small sample size, for this analysis, patients were considered minorities if they indicated Hispanic ethnicity, or identified their race as African-American, Asian, American-Indian, Alaskan, Hawaiian, Pacific-Islander, or multi-racial.

**3.3 Outcomes**

The TRACK-TBI outcomes battery was formulated to validate the feasibility of implementing the TBI common data elements (CDE). The TBI CDE were a national initiative established by the National Institute of Neurological Disorders and Stroke and the Department of Defense to conjoin data collection efforts to enhance comparability, and measures were identified according to their applicability for the acute, subacute, and chronic phases of TBI care and recovery. When feasible, demographic and clinical data were collected through the abstraction of medical records. Information that was not able to be captured via the medical record was collected by trained neuropsychological personnel in a semi-structured interview. At three months post injury, patients were contacted by telephone for administration of the GOS-Extended version (GOS-E), the Neurological Symptoms Inventory (NSI), and the Post Discharge Outpatient Care Assessment. The six-month and twelve-month evaluations were conducted in person by trained personnel and preceded by the Galveston Orientation and Amnesia Test (GOAT) to assess functional capacity. Patients under the age of 18 did not receive the GOS-E, and thus were excluded.

**3.3.1In-Hospital Care Utilization Outcomes**

Hospital discharge disposition, receipt of neurosurgical procedure, intracranial procedural volume, and extracranial procedural volume were used to assess in-hospital care utilization. These variables were collected prospectively and input by the research personnel. Discharge disposition was categorized into three categories: 1) home, 2) rehab, or 3) other hospital, skilled nursing facility, and respite (hospice). Receipt of neurosurgical outcomes was treated as dichotomous variable, and patients were identified as having a procedure or not. Intracranial procedural volume was measured by the number of documented neurosurgical procedures, and extracranial procedural volume was measured by the number of documented extracranial procedures.

**3.3.2Post-Hospital Care Utilization Outcomes**

Rehabilitation type, as captured by the Post Discharge Outpatient Care Assessment, were used to assess post-hospital care utilization. Rehabilitation type was categorized into three groups: none, outpatient, and inpatient rehabilitation, and was evaluated at the three-month and six-month time points.

**3.3.3Clinical and Functional Outcomes**

In-hospital mortality was used to assess differences in mortality between minorities and non-minorities. In-hospital morality was defined as a death occurring in the hospital after admission and prior to discharge from the hospital. Neuropsychological personnel acquired information regarded TBI-related neurological symptoms via a semi-structured interview, in which patients or their families were asked if the patients suffered from a list of 23 common symptoms that were compiled from the International Mission for Prognosis and Analysis of Clinical Trials and encompassed physical, emotional, cognitive, and sleep domains. Patients were assessed at three months, six months, and twelve months. The GOS-E, is the gold standard for measuring global disability following TBI and was used to assess functional outcome. GOS-E scores fall on an 8-point ordinal scale ranging from Death (1) to Upper Good Recovery (8). The Craig Handicap Assessment and Report Technique (CHART) was used to assess how well TBI patients function as active members of their respective communities in five domains: physical independence, cognitive independence, mobility, occupation, social integration, and economic self-sufficiency. For the purposes of assessing functional outcomes, the physical independence and mobility categories were used in this study. The GOS-E and CHART were both measured at the six-month and twelve-month time points.

**3.3.4Neuropsychological Outcomes**

To accurately and comprehensively assess the breadth of TBI-related sequelae and downstream effects, a host of neuropsychological batteries were utilized to assess the impact of race on long-term functional outcomes32. The Brief-Symptom Inventory-18 (BSI) was used to measure psychological distress following TBI. The BSI-18 is a self-report symptom checklist that measures severity in three sub-domains: Somatization, Depression, and Anxiety. The three sub-domain scores are summed to give the total distress score, the Global Severity Index. All four scores were assessed in this study. Satisfaction with Life Scale (SWLS) is a global measure of life satisfaction and consists of 5 questions that are completed by the individual. The responses correspond to level of agreement with a 1 being a strongly disagree and 7 being a strongly agree. The SWLS Total Score was used to assess differences in life satisfaction. The BSI-18 and SWLS were both measured at the six-month time point.

**3.4 Covariates**

There are several covariates that may confound the relationship between race and ethnicity and the aforementioned outcomes. Multivariate models will be used to adjust for these factors to facilitate accurate ascertainment of the causal effect of race and ethnic on utilization and outcomes. Potentially confounding variables were identified using an a priori causal model generated based on previous trauma literature, investigator knowledge, and hypothesized associations between variables. The major demographical covariates used were age and sex. The major socio-economical covariates used were years of education, employment type, and marital status. Employment type was categorized into four categories: unemployed, part-time, full-time, and student or retired or disabled preinjury. The major clinical variables adjusted for were: patient type, mechanism of injury, and ED presentation with a positive drug toxicology screening, ED GCS, Injury Severity Score (ISS), presence of intracranial hemorrhage on CT, and presence of skull fracture on CT. The patient’s past medical history was included in the analyses as well, and was captured by the four variables: 1) history of a cardiological, endocrine, gastro-intestinal, hematological, pulmonary, or renal disorder, 2) history of a psychological disorder, 3) history of a developmental learning disorder, and 4) history of a neurological disorder.

**3.5 Statistical Analyses**

Univariate analyses were used to examine the effect of each exposure of interest individually on the covariates and outcomes of interest. Chi-square test of independence assessed the relationship between categorical exposures and categorical outcomes, whereas a T-Test or Mann-Whitney was used to examine the relationship between dichotomous exposure variables and continuous outcomes where appropriate. Wilcoxon signed-rank test was conducted for ordinal variables.

Multivariate analyses were then conducted in a step-wise fashion to detect the relative impact of socioeconomic factors in determining outcomes. The first set of multivariate models examined the association between the race/ethnicity and the outcome of interest, while controlling for all major demographic and clinical variables. The second set of multivariate models examined the association between race/ethnicity and the outcome of interest after controlling for all major demographic and clinical variables, while also including major socioeconomic variables. Linear regression was used to assess differences in BSI-18 and SWLS Scores. Poisson regression was used to assess the differences in intracranial procedural volume, extracranial procedural volume, and TBI-neurological related symptoms. Logistic regression was used to assess differences in receipt of neurosurgical procedures. Ordinal Logistic Regression Model was used to examine GOS-E. Polytomous logistic regression was used to examine rehabilitation type, and hospital disposition. Parameter estimates of a variable were considered significant if their obtained p-value was less than .05. A complete case analyses were used to handle the missing data. Twelve month outcomes were not assessed due to the large amounts of attrition in the study (greater than 50%).

**4.0 RESULTS**

**4.1 Patient Characteristics**

A total of 586 TBI patients were evaluated in these analyses who met the inclusion and exclusion criterion. Six additional patients were excluded due to having significant missing data. 415 (71.5%) of patients completed their six month follow-up outcomes assessment. Table 1 shows the descriptive statistics for the total patient group's major demographic, socioeconomic, clinical, radiological, and mortality data. The average age of the patients at admission was 43 (±18.5) years old, with 72% male, and 33% were married at the time of ED admission. 32% of the patients were from minority groups, 68% of patients were white. Specifically, 7.8% of patients were African Americans, 3.8% were Asian, 14.6% were Hispanic, .35% were American Indian or Alaskan, 2.6% were Hawaiian or Pacific-Islander and 3.1% were multi-racial. The average patient had 14 years of education with 21% unemployed at the time of injury, 17% employed part-time, 40% employed full-time, while the rest of patients were either students, retired or disabled.

A total of 99% of the subjects sustained an isolated, closed head injury, while .9% and .2% of subjects sustained penetrating and blast injuries respectively. Subjects had a mean GCS score of 13, and an average ISS score of 12. 87.3% of participants sustained mild TBIs, 5% sustained moderate TBIs, and 7.6% sustained severe TBIs. A total of 49.3% of the participants sustained ICH, and 5% sustained skull fractures. Further, 9% of TRACK-TBI pilot study participants had a positive toxicology screen in the ED, with the average blood alcohol level of 90 mg/mL. Also, 27% and 29% of subjects had a prior history of at least one neurological condition and one psychological disorder, respectively. Additionally, 55% of participants had a prior history of at least one cardiological, endocrine, gastrointestinal, hematological, pulmonological, or renal disease. Lastly, 3% of the subjects died during their hospitalization, and 4.8% died by the 12 month follow-up.

Table 2 presents the univariate analysis of study participants demographic, socioeconomic, clinical and radiological data, and mortality data by minority status. On average, white patients were significantly older than the minority patients, with whites being an average of 45 years old and minorities being an average of 36 years old (p<.0001). White patients were also significantly more likely to be married than minorities participants, with 37% of whites being married compared to 18% of minorities (p=.0003). There was also a significant difference in employment status between whites and minorities (p=.004) with 35% of minorities unemployed compared to 18.5% of white patients. Whites had a significantly higher injury severity compared to minorities patients as measured by the ISS (p =.006). Whites were also more likely to have sustained ICH compared to minorities (53% vs 49%; p=<.0001). Whites were also more likely to have a past medical history of at least one cardiological, endocrine, gastrointestinal, hematological, pulmonological, or renal disease compared to minorities (55% vs 39%; p=.0003). Whites were also more likely to have died during hospitalization compared to minorities (3.8% vs 0%; p=.032). There were no statistically significant differences demonstrated between minorities and whites by sex, years of education, employee type, GCS, skull fracture, drug usage, ED blood alcohol level, past medical history of neurological and psychological conditions, and twelve-month mortality.

**4.2In-Hospital Utilization**

The univariate analyses comparing in-hospital utilization outcomes by minority status can be found in Table 3. There were no significant differences between whites and minorities for in hospital discharge disposition, receipt of neurosurgical procedure, intracranial procedural volume, or extracranial procedural volume. The multivariate analyses of in-hospital utilization outcomes by minority status can be found in Table 4. Like the univariate analyses, there were no significant differences found between whites and minorities by hospital discharge disposition, receipt of neurosurgical procedure, intracranial procedural volume, or extracranial procedural volume.

**4.3 Post-Hospital Utilization**

The univariate analyses comparing rehabilitation type by minority status is presented in Table 5. At both 6 months and 12 months, there were significant differences (p<0.05) in the rehabilitation type between whites and minorities, with whites being more likely to have received in-patient rehabilitation. Specifically, at 6 months, 54% of white patients had yet to receive rehabilitation, and 22% of white patients received inpatient or TBI-specific rehabilitation, compared to 65% and 8% of minority patients, respectively. At 12 months, 54% of white patients had not received rehabilitation while 22% of white patients received inpatient or TBI-specific rehabilitation, compared to 72% and 8% of minority patients, respectively. There were no significant differences in rehabilitation type at three months. The multivariate analyses of rehabilitation type by minority status is in Table 6. Multivariate analyses revealed that after controlling for demographic, clinical, radiological, and past medical history, there were no significant differences between minorities and whites in discharge to rehabilitation type at the three-month, six-month, or twelve-month time points. An additional model including socioeconomic status yielded the same results.

**4.4Clinical and Functional Outcomes**

The univariate analyses comparing clinical and functional outcomes by minority status can be found in Table 7. While there were no significant differences at three months, minorities participants in the TRACK-TBI pilot study exhibited significantly more neurological TBI-related symptoms than whites (2.8 vs 2.4; p=.049) at six months post injury. There were no significant differences found between minorities and whites in GOS-E, CHARTS physical total, CHARTS mobility total at six months.

The multivariate analyses of clinical and functional outcomes by minority status is presented in Table 8. The mean number of TBI-related neurological symptoms per patient was 17% and 19% (IRR=.83, 95% CI=.71-.96, and IRR=.81, 95% CI=.68-.94, respectively) higher for minorities compared to whites at three months and six months, respectively after controlling for age, sex, drug usage, GCS, ICH, skull fracture, and past medical history. This relationship remained significant and was further augmented when marital status, employee type, and years of education where included in the model, at both the three-month and six-month time points (Table 8). After controlling for demographic, clinical, radiological data, past medical history, and in a second model, for socioeconomic status, there were no significant differences between minorities and whites in GOS-E, CHARTS physical total, and CHARTS mobility total six months post-injury.

**4.5 Neuropsychological Outcomes**

The univariate analyses comparing neuropsychological outcomes by minority status can be found in Table 9. At six months, minorities exhibited higher levels of depression and general psychological distress compared to whites (µ=55.8±12.1 vs. µ=52.6±11.0, p=.036 and µ=57.2±12.7 vs. µ=54.0±11.0, p-value=.039, respectively), as measured by the depression subscale of the BSI-18 and the total BSI-18. Moreover, minorities also exhibited a lower satisfaction with life compared to whites at six months (µ=21.9±7.8 vs. µ=19.6±7.8, p=.027). At six months post TBI, there were no significant differences noted in somatization or anxiety.

The multivariate analyses of neuropsychological outcomes by minority status can be found in Table 10.Minorities exhibited significantly higher levels of depression, and general psychological distress at six months post-TBI compared to whites(β=-3.15 and β=-3.11; p=.038 and p=.040, respectively), after controlling for age, sex, drug usage, GCS, ICH, skull fracture, and past medical history. Minorities exhibited a lower satisfaction with life at six months post-TBI compared to whites after controlling for age, sex, drug usage, GCS, ICH, skull fracture, and past medical history (β=2.48; p =.021). Both these associations were attenuated to levels of statistical non-significance after the inclusion of socioeconomic status, marital status, and years of education. Minorities also exhibited higher PTSD symptomatology compared to whites (β=-5.44; p=.007). This relationship was attenuated by the inclusion of marital status, employee type, and years of education, but remained statistically significant (β=-4.28; p=.032). There were no significant differences between minorities and whites in BSI-18 somatization, anxiety at six months.

**5.0 DISCUSSION**

While racial disparities in healthcare utilization and outcomes following TBI have been documented, the literature remains inconclusive. In the current study, we examined healthcare utilization and outcomes in a prospective cohort of TBI patients across the spectrum of TBI. We identified no significant disparities in either in-hospital healthcare utilization or post-hospitalization health care for minorities compared to whites, or in terms of functional outcomes at six months. However, minorities did demonstrate higher levels of TBI-related neurological symptoms at three months and six months, even after controlling for demographical, clinical and radiological data and after controlling for past medical history. Interestingly, contrary to our hypotheses, this relationship was slightly augmented by the inclusion of socioeconomic variables. Minorities also demonstrated significantly higher levels of depression, general psychological distress, and a lower satisfaction with life at six months compared to whites, and both associations were affected significantly by the inclusion of socioeconomic factors. While satisfaction with life at six months was attenuated by the inclusion of socioeconomic variables, psychological distress was augmented.

**In-Hospital Utilization**

Four studies have recently examined in-hospital healthcare utilization, and all of them relied upon retrospective data47–50. Similar to our findings, Missios et al. found there were no significant differences in probability of African Americans receiving a high procedural volume compared to whites in a national dataset after controlling for age, sex, insurance status, systolic blood pressure, temperature, GCS, heart rate, hospital status and bed size, number of neurosurgeons and trauma surgeons, ISS, and mechanism of injury47. Using the same national dataset as Missios et al, another study determined (after controlling for demographic and injury severity, and hospital region) Asians, blacks, and Hispanics were more likely to have a TBI procedure performed during their hospitalization compared to whites, contrary to our data. Blacks and Hispanics were also significantly more likely to have longer hospital stays48. This study did not control for comorbidities, marital status, and years of education, and the authors mentioned a change in coding in the race variable during the study which may have contributed to the observed differences between the results in their study and ours.

The two other studies examining in-hospital utilization assessed outcomes that were not measured in this study. Using the National Trauma Databank, Pickham et al., found that blacks were 30% significantly more likely to have received a prophylactic inferior vena cava filters compared to whites after controlling for demographics, insurance status, hospital characteristics, and ISS49. While these data relied upon retrospective data of both TBI and spinal cord injury patients and used only one measure of in-hospital utilization, there are no firm guidelines for the usage of prophylactic inferior vena cava filters, which may be a situation in which disparities in utilization may emerge. Similar methodologies employing similar techniques in prospective studies should be used in future studies. Rubin et al., demonstrated after controlling for income and significant predictors, minorities were significantly less likely to withdraw mechanical ventilation compared to whites with no subsequent differences noted in mortality. The authors note this was largely driven by the patients’ families’ preferences, not providers. Thus, these studies shed light on potential cultural differences in making end-of-life decisions, and future studies on deconstructing these differences are warranted.

**Post-Hospital Utilization**

This study stands in contrast to many of the studies which have examined racial disparities in discharge disposition amongst TBI patients51,42,48,52–55 in that we found no differences in discharge to rehabilitation in our multivariate analysis. Three National Trauma Databank studies all found that black and Hispanics were significantly less likely to be discharged to a higher level of rehabilitation compared to whites even after adjusting for age, sex, injury severity, mechanism of injury, and insurance status48,51,56. Two other national studies revealed blacks and Hispanics were less likely to be discharged to inpatient rehabilitation, Hispanics were more likely to be discharged to home without support, and blacks were less likely to utilize outpatient rehabilitation52,54. These trends persisted with Hispanics even in areas in which Hispanics were the majority53.

All the aforementioned studies except one used national or regional population-based databases from all levels of hospitals and trauma centers, as opposed to our study that looked solely amongst Level I academic medical centers. These studies also included penetrating TBIs, which have been associated with worsened outcomes, and African-Americans are at increased risk of sustaining a penetrating TBI57. Thus, African Americans may be at an increased risk of lower utilization and worsened health outcomes following TBI due to their worsened clinical status in those studies. While we attempted to control for confounding, TBI is complex and we cannot rule out the possibility that residual confounding, particularly by other clinical variables, may have affected the observed relationship. In our study, the majority of patients were closed TBI, and this could have accounted for part of the observed differences in outcomes and utilization between our studies and others. Also, academic medical centers may be less prone to disparities in utilization and outcomes relative to their counterparts, but more research is necessary to determine the reason behind the observed discrepancies.

To date, just one study examined post-hospitalization healthcare utilization outcomes following TBI. Dismuke et al. found that Hispanic veterans were less likely to utilize the TBI, neurology, rehabilitation, and other services, while being more likely to utilize mental health services compared to whites in a national cohort of veterans within the Veterans Administration service, after controlling for age, marital status, gender, urban residence, hospital region, and ICD-9 coded comorbidities58. This study was limited in that it utilized retrospective data, and only included only veterans, but data on utilization following hospitalization within the VA system is more easily captured which may account for the observed differences. Our study was only able to examine discharge to rehabilitation and accordingly, a study amongst a larger prospective cohort of patients covering a wider range of post-hospitalization services is necessary to examine racial and ethnic disparities in post-hospital healthcare utilization.

**Clinical and Functional Outcomes**

 Interestingly, no minority patients in our population died during hospitalization. One limitation to our work was our subsequent inability to examine whether there were differences in mortality rates in minorities compared to whites. Numerous studies have demonstrated that minorities experience a significantly different risk of mortality compared to whites, with most studies suggesting minorities being at an increased risk of incurring in-hospital mortality35,43. In our study population, whites experienced higher levels of pre-existing conditions contrary to existing medical literature. These findings reinforce the need for the inclusion of past medical history in future studies of TBI outcomes. While we did account for comorbidities simplistically, future studies studying the relative impact of particular comorbidities are crucial in accurately identifying key risk factors in determining outcomes. Our study found no differences in functional outcomes between minorities and whites, contrary to existing literature36,59. At least three papers, which analyzed Functional Independence Measure and Disability Rating Scale, supported our findings and similarly did not find racial disparities in these outcomes after controlling for major demographical, socioeconomic, and injury severity variables60–62. Some studies’ difference in findings can be explained by a limited patient population57,63, pediatric population scope64, lack of control for known socioeconomic and injury severity confounding variables65,66, and examination of only Hispanic race67.

**Neuropsychological Outcomes**

Three studies to date have prospectively examined racial disparities in neuropsychological outcomes amongst TBI patients, all of which utilized the TBI Model Systems Project database68–70. Subsequently, the need for further research efforts in the evaluation of racial disparities in neuropsychological was articulated in two reviews59,71. Consistent with our study, the two most recent of the three studies demonstrated minorities exhibited lower satisfaction with life, as measured by the SWLS, compared to whites, one at 1-year post-injury70 and the other at 2-years post-injury68. The former study did not account for injury severity or socioeconomic variables which may have significantly confounded the observed relationship, as we observed in our data. The TBI Models Systems is a prospective cohort study that enrolls moderate to severe TBI patients who were admitted into rehabilitation units. One limitation to this cohort is that the majority of TBI patients are mild TBIs, and many TBI patients are not admitted to rehabilitation services. No studies to date had specifically examined the impact of racial disparities on amongst the general TBI population. Accordingly, our study is the first to demonstrate racial disparities in psychological distress amongst TBI patients of all severities, who both did and did not attend rehabilitation. Psychological distress is an important predictor of cognitive ability, and cognitive ability mediates the relationship between psychological distress and functional outcome72. Thus, psychological distress maybe an important mediator of the worsened outcomes observed in minority populations and warrants further research to discern these complex relationships. One limitation to the study is that we did not have any measures of acculturation. In a study of African-American TBI patients, Kennepohl et al., determined that even after controlling for GCS, age, sex, years of education, and SES, decreased levels of acculturation were associated with poorer overall neuropsychological test performance, and thus, should also be included in future studies73.

**Impact of Rehabilitation**

While our study did not demonstrate any differences in functional outcomes, we also did not observe any differences in either in-hospital or post-hospital utilization outcomes. We initially hypothesized there would be differences in utilization outcomes which would subsequently mediate differences in functional outcomes. Thus, the findings do not refute our initial analysis, and may lend support to the theory that utilization outcomes are the mediators between functional outcomes. Numerous studies demonstrate the profound impact rehabilitation can make on long-term functional outcomes, while the exact intensity of rehabilitation services and their impacts have yet to be observed. A multi-center collaborative study incorporating intensive clinical, socioeconomic, demographical, past medical history, rehabilitation, and post-hospitalization care data is necessary to accurately ascertain a true estimate of racial disparities on outcomes.

**Limitations**

The current study had several limitations. Minority status has been used by several studies, but there are many known differences between racial and ethnic groups. Future analyses with larger datasets should focus on examining health care utilization and outcomes amongst specific ethnic groups, particularly amongst those groups known to have unique challenges within the US healthcare system, namely: Blacks and African Americans, Hispanics, and Asians. There are also reasons to be concerned of the external generalizability. Our study was conducted at just three large US academic medical centers and demonstrated at least one significant deviation from conventionally accepted demographic characteristics, in that white patients demonstrated more comorbidities than minorities. While this could be attributed to the dichotomization of race, it may also be a result of white patients being more likely to have seen a primary care physician. Another limitation to the interpretation of our data is the fact that though we were able to document disparities in psychological distress at the six-month time point, these differences may be attributed to disparities in psychological distress prior to injury, as we have no baseline measures for comparison.

Methodologically, odds ratios are known to be inaccurate estimators of risk when the probability of an outcome is high, thus, logistic binomial regression should be used in future studies to accurately ascertain the true risk of racial disparities in dichotomous outcome measures. There also is a great deal of variability in patient management between hospitals, generalized estimating equations should be used to account for clustering within individual hospitals in a sensitivity analysis.Due to the heterogeneity of traumatic brain injury, the outcome of interest may be different depending upon the severity cohort. For instance, the primary outcome of interest in the mild traumatic brain injury patients may be post-hospital care utilization, while for moderate to severe TBI, discharge disposition and the facilities’ in-hospital utilization of care may be of primary interest. For this reason, stratified analyses should be performed in future analyses by site, by TBI severity (mild, moderate, and severe), injury severity, and by ED disposition group (Discharge, Admission, ICU).There was a large amount of attrition at the 6-month time point and more sophisticated methods of handling missing data such as multiple imputation may be required to accurately ascertain the true relationship. Moreover, there was too much attrition to even conduct an analysis at 12 months and our data is likely subject to loss-to-follow-up bias.

One of the biggest limitations to this study was the fact that we were unable to control for the patient’s insurance status due to a lack of insurance data. Racial and ethnic groups are overrepresented amongst the uninsured9,74 and numerous studies have demonstrated that insurance status is an important predictor of discharge disposition, utilization, and outcomes amongst general trauma and TBI patients10,11. A systematic review demonstrated that there were disparities in various healthcare utilization measure as a function of insurance status in all seven studies examined12. Using the National Trauma Data Bank, Haider et al. determined that after controlling for major risk factors for poor outcomes, uninsured patients were 47% significantly more likely to experience mortality after sustaining a traumatic injury compared with insured patients. Moreover, there was an interaction demonstrated between insurance status and race such that uninsured Hispanic patients demonstrated the highest odds of death. Uninsured Hispanics were 2.3 times more likely to die compared to insured white patients43. Using the same dataset, Alban et al. demonstrated a similar protective and noted that the protective effect was greatest for patients with the most severe head injuries75. Insurance type also may play an important role in mediating this relationship. Gardizi et al. demonstrated that patients with government-funded insurances were more likely to experience disability compared with those with commercial insurance11. Thus, insurance status is an important mediator between the relationships between race, healthcare utilization, and both functional and neuropsychological outcomes, and future research efforts should focus on deconstructing the complex relationships between these factors.

**Conclusion**

The current analysis found no significant differences in in-hospitalization healthcare utilization, nor post-hospitalization healthcare utilization between minority groups and whites following TBI. Minority participants in the TRACK-TBI study did have increased TBI-related symptomatology at the three- and six-month time points and more psychological distress at the six-month time point compared to whites, even after controlling for known key confounders. This study was limited by several factors which should be considered in future studies. The management of TBI patients is an increasingly important public health issue and understanding factors involved in determining health outcomes is crucial to facilitate successful interventions and, ultimately, improving health outcomes for all TBI patients.

**APPENDIX: TABLES AND FIGURES**

**Table 1**. Baseline Participant Characteristics for TRACK-TBI Pilot Study Subjects

| Participant characteristics | Mean±SD or N (%) |
| --- | --- |
| Age (years) | 43.3±18.5 |
| Sex (male)Race / Ethnicity White Minorities Black Hispanic Asian American Indian/Alaskan Hawaiian/Pacific-Islander Multi-racial | 417 (71.9)394 (68)186 (32)45 (7.8)85 (14.6)22 (3.8)2 (.35)15 (2.6)18 (3.1) |
| Married Years of EducationEmployment Type Unemployed Part-Time Full-Time Other | 187 (33.5)14±5.9118 (21.5)92 (16.8)218 (39.8)120 (21.9) |
| GCS | 13.2±3.6 |
| ISSTBI Type Mild Moderate Severe | 11.8±11.4507 (87.3)29 (5)44 (7.6) |
| Intracranial HemorrhageSkull FractureED Positive Toxicology Screen | 286 (49.3)29 (5)53 (9.1) |
| ED Blood Alcohol Level (mg/mL) | 89.6±117.1 |
| History of Neurological Disorder | 158 (27.2) |
| History of Cardiac DisorderHistory of Endocrine DisorderHistory of Gastrointestinal DisorderHistory of Hematological Disorder | 195 (33.6)85 (14.7)97 (16.7)61 (10.5) |
| History of Pulmonological Disorder | 115 (19.8) |
| History of Psychological DisorderHistory of Developmental DisorderIn-Hospital Mortality | 168 (29)56 (9.7)18 (3.1) |

Abbreviations: GCS: Glasgow Coma Scale (marker of traumatic brain injury severity); ISS: Injury Severity Score; ED: Emergency Department.

**Table 2**. Baseline Participant Characteristics for Study Subjects by Minority Status

| Participant characteristics | Whites (n=471)Mean±SD or N (%) | Minorities (n=109)Mean±SD or N (%) | P-Value |
| --- | --- | --- | --- |
| Age (years) | 45.1±18.5 | 35.6±15.6 | <.0001 |
| Married Years of EducationEmployment Type Unemployed Part-Time Full-Time Other | 174 (36.9)13.9±2.987 (18.5)84 (17.8)192 (40.8)108 (23) | 20 (18.4)14.4±12.338 (34.6)14 (12.5)39 (35.6)19 (17.3) | .0003.439.004 |
| GCS | 13.1±3.7 | 13.8±2.7 | .467 |
| ISS | 12.4±11.3 | 11.8± 11.4 | .006 |
| Intracranial HemorrhageSkull FractureED Positive Toxicology Screen | 251 (53.3)103(21.9)44 (9.3) | 54 (49.3)22 (20.2)9 (8.3) | <.0001.700.723 |
| ED Blood Alcohol Level | 89.4±116.5 | 89.6±117.1 | .9339 |
| History of Neurological Dx | 130 (27.6) | 28 (25.7) | .686 |
| History of Cardiac DxHistory of Endocrine DxHistory of Gastrointestinal DxHistory of Hematological Dx | 176 (37.4)81 (17.2)86 (18.3)48 (10.2) | 19 (17.4)4 (3.7)11 (10.1)13 (11.9) | <.0001.0003.040.595 |
| History of Pulmonological Dx | 92 (19.5) | 23 (21.1) | .711 |
| History of Psychological DxHistory of Developmental DxIn-Hospital Mortality | 142 (30.1)40 (8.5)18 (3.8) | 26 (23.8)16 (14.7)0 (0) | .192.049.032 |

Abbreviations: GCS: Glasgow Coma Scale (marker of traumatic brain injury severity); ISS: Injury Severity Score; ED: Emergency Department; Dx=Disorder/Disease.

**Table 3**. Univariate analyses of In-Hospital Utilization Outcomes by Minority Status

|  |  |  |  |
| --- | --- | --- | --- |
|  | Whites (n=471) | Minorities (n=109) | P-value |
| Hospital Discharge Disposition (%) |  |  | .068 |
| Home | 64.2% | 73.8% |  |
| Rehabilitation | 16.2% | 11.5% |  |
| Other Hospital | 5.7% | 11.5% |  |
| Skilled Nursing Facility | 7.1% | 1.6% |  |
| Hospice | 1.7% | 1.6% |  |
| Neurosurgical Procedure (%) | 9.2% | 8.4% | .796 |
| Intracranial Procedural Volume | 2.0±1.3 | 1.7±.7 | .437 |
| Extracranial Procedural Volume | 2.4±2.1) | 3.4±3.2 | .144 |

**Table 4**. Multivariate Analyses of In-Hospital Utilization Outcomes by Minority Status

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Model 1a  | P-value | Model 2b | P-value |
| Hospital Discharge Disposition |  | .672 |  | .618 |
| Home | OR=1.2 |  | OR=1.4 |  |
| Rehabilitation | OR=1.7 |  | OR=1.9 |  |
| Neurosurgical Procedure | OR=.53 | .241 | OR=.50 | .225 |
| Intracranial Procedural Volume | IRR=1.1 | .732 | IRR=1.0 | .965 |
| Extracranial Procedural Volume | IRR=.71 | .097 | IRR=.76 | .211 |

a Model 1 adjusted for age, sex, patient type, mechanism of injury, and ED presentation with a positive drug toxicology screening, ED GCS, Injury Severity Score (ISS), presence of intracranial hemorrhage on CT, presence of skull fracture on CT, history of a cardiological, endocrine, gastro-intestinal, hematological, pulmonary, or renal disorder, history of a psychological disorder, history of a developmental learning disorder, and history of a neurological disorder

b Model 2 adjusted for all variables included in Model 1, plus years of education, employment type, and marital status

**Table 5**. Univariate analyses of Post-Hospital Utilization Outcomes by Minority Status

|  |  |  |  |
| --- | --- | --- | --- |
|  | Whites (n=471) | Minorities (n=109) | P-value |
| 3 Month Rehabilitation Type (%) |  |  | .160 |
| None | 63.4 | 71.4 |  |
| Outpatient | 17 | 17.9 |  |
| Inpatient/TBI Rehab | 19.6 | 10.7 |  |
| 6 Month Rehabilitation Type\* (%) |  |  | .02 |
| None | 54.3 | 65.3 |  |
| Outpatient | 23.3 | 19.1 |  |
| Inpatient/TBI Rehab | 22.2 | 8 |  |

**Table 6**. Multivariate Analyses of Post-Hospital Utilization Outcomes by Minority Status

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Model 1a  | P-value | Model 2b | P-value |
| 3 Month Rehabilitation Type |  | .998 |  | .946 |
| Inpatient | OR=.97 |  | OR=1.2 |  |
| Outpatient | OR=.96 |  | OR=1.1 |  |
| 6 Month Rehabilitation Type |  | .306 |  | .310 |
| Inpatient | OR=.43 |  | OR=.44 |  |
| Outpatient | OR=.37 |  | OR=.35 |  |

a Model 1 adjusted for age, sex, patient type, mechanism of injury, and ED presentation with a positive drug toxicology screening, ED GCS, Injury Severity Score (ISS), presence of intracranial hemorrhage on CT, presence of skull fracture on CT, history of a cardiological, endocrine, gastro-intestinal, hematological, pulmonary, or renal disorder, history of a psychological disorder, history of a developmental learning disorder, and history of a neurological disorder

b Model 2 adjusted for all variables included in Model 1, plus years of education, employment type, and marital status

\*p-value<.05

**Table 7**. Univariate analyses of Clinical and Functional Outcomes by Minority Status

|  |  |  |  |
| --- | --- | --- | --- |
|  | Whites (n=471) | Minorities (n=109) | P-value |
| 3 month TBI Symptoms | 2.4±1.5 | 2.7±1.5 | .153 |
| 6 month TBI Symptoms\* | 2.4±1.5 | 2.8±1.5 | .049 |
| 6 month GOS-E | 6.2±2.1 | 6.6±1.2 | .109 |
| 6 month CHARTS Physical Total | 95.3±19.1 | 98.5±11.8 | .191 |
| 6 month CHARTS Mobility Total | 92.4±15.1 | 93.6±13.9 | .546 |

**Table 8**. Multivariate Analyses of Clinical and Functional Outcomes by Minority Status

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Model 1a  | P-value | Model 2b | P-value |
| 3 month TBI Symptoms\* | OR=.83 | .016 | OR=.81 | .010 |
| 6 month TBI Symptoms\* | OR=.81 | .010 | OR=.80 | .009 |
| 6 month GOS-E | OR=.64 | .065 | OR=.69 | .142 |
| 6 month CHARTS Physical Total | β=.44 | .859 | β=-.24 | .923 |
| 6 month CHARTS Mobility Total | β=1.9 | .380 | β=1.2 | .580 |

a Model 1 adjusted for age, sex, patient type, mechanism of injury, and ED presentation with a positive drug toxicology screening, ED GCS, Injury Severity Score (ISS), presence of intracranial hemorrhage on CT, presence of skull fracture on CT, history of a cardiological, endocrine, gastro-intestinal, hematological, pulmonary, or renal disorder, history of a psychological disorder, history of a developmental learning disorder, and history of a neurological disorder

b Model 2 adjusted for all variables included in Model 1, plus years of education, employment type, and marital status

\*p-value<.05

**Table 9**. Univariate analyses of Neuropsychological Outcomes by Minority Status

|  |  |  |  |
| --- | --- | --- | --- |
|  | Whites (n=471) | Minorities (n=109) | P-value |
| 6 month BSI-18 Somatization | 54.4±10.3 | 56.8±12.2 | .104 |
| 6 month BSI-18 Depression\* | 52.6±11.0 | 55.8±12.1 | .036 |
| 6 month BSI-18 Anxiety | 52.2±11.0 | 55.0±12.8 | .081 |
| 6 month BSI-18 Total\* | 54.0±11.0 | 57.2±12.7 | .039 |
| 6 month SWLS Total\* | 21.9±7.8 | 19.6±7.8 | .027 |

**Table 10**. Multivariate Analyses of Neuropsychological Outcomes by Minority Status

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Model 1a  | P-value | Model 2b | P-value |
| 6 month BSI-18 Somatization | β=-2.8 | .055 | β=-2.4 | .095 |
| 6 month BSI-18 Depression\* | β=-3.1 | .038 | β=-2.4 | .109 |
| 6 month BSI-18 Anxiety | β=-1.9 | .204 | β=-1.2 | .416 |
| 6 month BSI-18 Total\* | β=-3.1 | .040 | β=-2.5 | .01 |
| 6 month SWLS Total\* | β=2.5 | .021 | β=1.8 | .083 |

a Model 1 adjusted for age, sex, patient type, mechanism of injury, and ED presentation with a positive drug toxicology screening, ED GCS, Injury Severity Score (ISS), presence of intracranial hemorrhage on CT, presence of skull fracture on CT, history of a cardiological, endocrine, gastro-intestinal, hematological, pulmonary, or renal disorder, history of a psychological disorder, history of a developmental learning disorder, and history of a neurological disorder

b Model 2 adjusted for all variables included in Model 1, plus years of education, employment type, and marital status

\*p-value<.05

|  |  |  |
| --- | --- | --- |
| **Behavior** | **Response** | **Score** |
| **Best Eye Opening Response** | SpontaneouslyTo speechTo painNo response | 4321 |
| **Best Verbal Response** | Oriented to time, place, and personConfusedInappropriate wordsIncomprehensible soundsNo response | 54321 |
| **Best Motor Response** | Obeys commandsMoves to localized painFlexion withdrawal from painAbnormal FlexionAbnormal ExtensionNo response | 654321 |
| **Total Score** | Best ResponseMild TBIModerate TBI (Comatose)Severe TBI | 1513-158-123-8 |

**Figure 1**. Glasgow Coma Scale

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