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Hospitalized Traumatic Brain Injury: Low Trauma Center Utilization and High Interfacility Transfers among Older Adults

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Abstract

Objective—Guidelines suggest that Traumatic Brain Injury (TBI) related hospitalizations are best treated at Level I or II trauma centers because of continuous neurosurgical care in these settings. This population-based study examines TBI hospitalization treatment paths by age groups.

Methods—Trauma center utilization and transfers by age groups were captured by examining the total number of TBI hospitalizations from National Inpatient Sample (NIS) and the number of TBI hospitalizations and transfers in the Trauma Data Bank National Sample Population (NTDB-NSP). TBI cases were defined using diagnostic codes.

Results—Of the 351,555 TBI related hospitalizations in 2012, 47.9% (n = 168,317) were directly treated in a Level I or II trauma center, and an additional 20.3% (n = 71,286) were transferred to a Level I or II trauma center. The portion of the population treated at a trauma center (68.2%) was significantly lower than the portion of the U.S. population who has access to a major trauma center (90%). Further, nearly half of all transfers to a Level I or II trauma center were adults aged 55 and older ($p < 0.001$) and that 20.2% of pediatric patients arrive by non-ambulatory means.

Conclusion—Utilization of trauma center resources for hospitalized TBIs may be low considering the established lower mortality rate associated with treatment at Level I or II trauma centers. The higher transfer rate for older adults may suggest rapid decline amid an unrecognized initial need for a trauma center care. A better understanding of hospital destination decision making is needed for patients with TBI.

Keywords

TBI; Traumatic Brain Injury; Field triage; Brain Trauma Foundation Guidelines; Field Triage Guidelines; ambulance; transport; older adults; children

Introduction

Traumatic brain injury is a major cause of disability in the U.S.[1] Among traumatic brain injury (TBI) cases treated by the health care system in 2011 in the United States, there were

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2,342,653 treated and released emergency department (ED) visits,[2] 267,764 treated and released hospitalizations[3] and 53,844 deaths.[4] Additionally, approximately 3.17 million people (1.1% of the U.S. population) live with a TBI-related disability.[5] Disability resulting from TBI can manifest as cognitive and or physical deficits, leading to an inability or a reduced ability to perform activities of daily living and may be associated with an increased need for ongoing medical care, services, support, and rehabilitation.[5]

TBI Severity and Hospitalization

Approximately 80% of the total number of TBIs seen in EDs are discharged without further treatment in a hospital.[6] These are typically patients who are classified with a mild TBI, with no evidence of intracranial injury exhibited through computerized tomography (CT) scanning and normal neurologic evaluation.[7] TBI patients with an abnormal neurologic evaluation attributed to the injury (with or without findings on CT scanning) are typically admitted to the hospital for further evaluation, management, and treatment in a hospital setting. Patients with traumatic intracranial lesions that require immediate neurosurgical evaluation and care are typically admitted to intensive care units in trauma centers where access to neurosurgical care is available. While neurosurgical care is available in many hospitals, Level I and Level II trauma centers are required to provide neurosurgical trauma care available and accessible 24 hours a day. Thus, the initial transport decision made by prehospital providers is a critical part of the treatment path for the patient with a TBI.

Transfers

Any delay in getting a patient with a TBI requiring hospitalization to the appropriate destination may be harmful. Good outcomes have been attributed to quicker access to definitive care for aggressive and early treatment of patients with severe TBI, and the prevention of secondary brain injury.[8,9] Current guidelines for the prehospital management of TBI recommend direct transport of TBI patients to a facility that offers CT scanning, neurosurgical care, intracranial pressure (ICP) monitoring, and other treatment capabilities.[10] These services are routinely available in a Level I or II trauma center. TBI patients who were directly transported to a trauma center were shown to have significantly lower mortality, by 50%, compared to those patients who were transferred to a trauma center.[11,12] Furthermore, it was found that a delay in transport to a Level I trauma center resulted in higher mortality.[13] Literature has shown that the older adult population has not been receiving optimal trauma care,[14] but no literature has been found on TBI treatment paths by age.

Secondary Brain Injuries

Long-lasting neurological damage to the brain is not only caused by the primary impact or injury, but can also occur through secondary brain injury due to cerebral edema and increased ICP.[15] Adherence to the Brain Trauma Foundation (BTF) guidelines involves an interdisciplinary commitment to brain injury management with multiple, detailed recommendations, including the routine use of ICP monitoring, the avoidance of steroids, discontinuation of antiepileptic drugs, appropriate ventilation for an ICP, and maintaining a cerebral perfusion pressure threshold.[16,17] Successful adherence to these guidelines is most likely in a Level I or II trauma center, and forms a component of a comprehensive, inclusive trauma system, where such staffing and resources are a part of the trauma center facility verification process.[18] A study of 413 designated trauma centers found significant improvement in utilization of TBI guidelines between 1991 and 2006, and recommended transfer of hospitalized TBI to advanced trauma centers using treatment guidelines.[16] Overall, care in trauma centers where the BTF guidelines are followed has been shown to have a positive impact in reducing TBI patients' lifelong disability.[19,20]

In efforts to reduce transfers and provide optimal patient care, the Field Triage Guidelines,[21] noted that direct transport to a trauma center was a special consideration for adults aged 55 years and older and that people with a head injury using anticoagulants are at a high risk of rapid deterioration. Recent studies have reconfirmed these special considerations by suggesting a change in the physiological criteria for older adults[22] and that older adults, in general, are often under-triaged.[23] The literature indicates that older age is known to negatively influence TBI outcomes[24]; however, not much is known about the treatment paths for TBI for any population.

Purpose of Study

Approximately 90% of the U.S. population has access to a Level I or II trauma center by air or ground ambulance within one hour of transport time. Such coverage is visually displayed by the Trauma Information Exchange Program maps.[25] Access to the critical care offered in these trauma centers is important because of the access to the neurosurgical care associated with a Level I or II trauma center. According to established policy, the majority of TBI cases that require hospitalization would benefit from trauma center care. This is also consistent with the American College of Surgeons (ACS) recommended resource needs for a trauma center.[18] We examined cases of TBI that required hospitalization. Given the high levels of disability associated with TBI and the possible deterioration of patients who are injured badly enough to require hospitalization, we hypothesize that the majority of those patients (near 90% of the population) would be treated in a Level I or II trauma center. Also, we expect to see a higher percentage of transfers to Level I and II trauma centers among of older adults. Other age groups were be examined. This effort is the first study to use a population-approach to examine treatment source for all hospitalized TBI and to examine TBI hospitalization treatment paths by age groups. Chi-squared tests were run to determine if the differences were significant. Age groups were collapsed into 55 and older and younger than 55.

Method

TBI was defined using the Centers of Disease Control and Prevention definition,[6] based on diagnostic codes from the International Classification of Disease, 9th Revision, Clinical Modification (ICD-9-CM). ICD-9-CM codes defining TBI include those for skull fracture (800.0–801.9 and 803.0–804.9), intracranial injury (850.0–854.1), injury to optic nerves and pathways (950.1–950.3), shaken baby syndrome (995.55), and unspecified head injury (959.01). Two sets of data were used to determine the proportion of TBI hospitalizations that occur in a Level I or II trauma center. Data from the 2012 National Inpatient Sample (NIS)[26] were used to calculate the total number of U.S. TBI related hospitalizations, including trauma centers and non-trauma centers. The NIS is part of the Healthcare Cost and Utilization Project (HCUP), sponsored by the Agency for Healthcare Research and Quality (AHRQ).

Because hospital trauma center designation data are not available in the NIS, the 2012 National Trauma Databank National Sample Project (NTDB-NSP) data file was used to determine how many TBI hospitalizations were treated at a trauma center. The NTDB-NSP is a subsample of the entire National Trauma Databank that is managed by the ACS Committee on Trauma and is representative of all Level I and II trauma centers in the U.S.[27] The definition of trauma center included both State designated trauma centers and ACS designated trauma centers. Hospital admissions, in the NTDB-NSP, were determined by identifying patients being discharged from the ED using any of the following discharge options: floor bed (general admission, non-specialty unit bed), observation unit (unit that provides less than 24-hour stays), telemetry/step-down unit (less acuity than ICU), operating room, intensive care unit (ICU), transfer to another hospital, and self-discharge against medical advice.

The non-merged NIS produced the total number of Hospitalized TBIs. The NIS was used obtain a denominator to estimate the proportion of all TBI hospitalizations that were treated at a trauma center because the NTDB-NSP data only provides data for hospitalizations at Level I or II trauma centers. Meanwhile, the NTDB-NSP produced the number of hospitalized TBIs seen at a Level I or II trauma center, also defined as a major trauma center. This allowed us to capture a national picture of the total population treated at a major trauma center. For definitional purposes, Level III and IV trauma centers were identified as non-trauma centers because of the unique role Level I and II trauma centers have in treating TBI. The use of two datasets was necessary because trauma center designation was not available in the NIS data. Additional details, such as primary transports and transfers to a Level I or II trauma center (variables “transfer” and “tmode”), and the proportion of patients by age within transfer status were assessed using the NTDB-NSP data. Examining the proportion of cases influenced by the Field Triage Guidelines was done by collapsing the various ways a person can arrive at a hospital (privately owned vehicle, police and walk-ins) and comparing those proportions to Emergency Medical Services (EMS) transports. The weighted frequency counts, percentages and the proportions of patients between groups were compared using PROC SURVEYFREQ procedure. All statistical analysis was performed using SAS Systems for Windows, version 9.3 (SAS Institute, Cary, NC).[28]

Results

A Flow chart was created to display where hospitalized TBI patients were treated (Figure 1). The total estimated number of people with TBIs requiring hospitalization in 2012 was 351,555 (95% CI = 332,670–370,440). The total number of hospitalized trauma center admissions was 239,603 (95% CI = 226,731–252,473), or 68.2%. This number included 71,286 (95% CI = 69,329–73.241) TBI patients transferred to a trauma center, resulting in a transfer percentage of 20.3% among the total TBIs requiring hospitalization.

Our expectation that near 90% (*n* = 316,400) of all hospitalized TBI would be treated in Level I or II trauma centers was not supported. However, only 68.2% of hospitalized TBI (transfers and non-transfers) was treated at a trauma center. A Chi-Squared frequency test between these expected and observed results showed a significant difference.

An analysis of trauma center admissions by transfer status and age among hospitalized TBIs was performed. Among patients aged 18 years and under, 15,491 (95% CI = 14,673–16,309), or 65.1% were taken directly to a trauma center and treated, and 8,307 (95% CI = 7,788–8,826), or 34.9% were transferred to a trauma center for treatment. For patients age 18–29 years, 37,537 (95% CI = 36,160–38,915), or 78.3% were treated directly at a trauma center and 10,400 (95% CI = 9,695–11,105), or 21.7%were transferred to a trauma center for treatment. The 18–29 age group had the smallest proportion of transfers. The largest number of trauma center patients treated directly (without transfer) was the 30–54 age group (*n* = 57,895, 95% CI = 56,064–59,727), or 77.1%; meanwhile, 17,237 (95% CI = 16,312–18,162), or 22.9% in this age group were transferred. The largest proportion of transferred patients to a trauma center were those age 55 years and older (*n* = 35,342{95% CI = 33,857–36,827}, or 38.1%). This was compared to 57,393 (95% CI = 55,527–59,258), or 61.9%, of the non-transferred patients in this age group. Also, for patients who were seen by a trauma center, the age group of 55 and older contained the largest number of patients requiring direct or eventual treatment.

After dichotomizing patients into age cohorts: those under age 55 and those 55 and older, a two-by-two table was constructed (not shown). A significantly higher proportion (38.1%) of patients age 55 years and older were transferred to a trauma center, compared to the combined younger patients in the combined age groups of patients aged 0–54 who were transferred (24.5%) ($\chi^2 = 5{,}058.1$, $p < 0.001$). Nearly half of all patients transferred to a trauma center for treatment were for patients' age 55 years and older though this age group only accounts for less than 40% of all hospitalized TBI cases examined (Figure 2).

Because there are many ways that patients can arrive at a hospital, we examined the proportion of patients that arrived by formal EMS services (i.e., ground ambulance, helicopter, fixed wing aircraft) compared to other means (i.e., privately owned vehicle, police, and walking in). The total number of direct transports to a trauma center was 168,317. For age groups 18–29, 30–54, and 55 plus the percent of patients that arrived to a trauma center ranged from 89.1–93.2%. However, EMS transport occurred for 79.8% of the patients aged 18 or younger. A larger number of patients in this age group were taken to the hospital via privately owned vehicle (see Figure 3).

Discussion

The overall results show that only 68.2%of the patients hospitalized with TBI were treated in a trauma center where routine access to neurolosurgical care was available. Considering that 90% of the U.S. population lives within one hour of a Level I or II trauma center, there appears to be an under-utilization of trauma center care for TBI care within the health care system. Many of these patients would likely benefit from direct EMS transport to Level I or II trauma center care.

Direct transport to a Level I or II trauma center yields the best patient outcomes, compared with patients hospitalized at a non-trauma center, of Level III or IV trauma center then transferred to a Level I or II trauma center.[11,12] Nearly half of all transfers to a Level I or II trauma center were for those aged 55 and older (n = 35,342, 49.6%). These results may reflect an unrecognized initial need for trauma center care, the need to provide stabilization and resuscitation at a non-trauma center prior to transfer to the appropriate Level I or II trauma center, or other factors. The high transfer rate associated with this age group may be a result of patient deterioration due to anticoagulation usage.[29] Other possible reasons include the high cost of malpractice insurance and lower reimbursements as reasons contributing to a 44% increase in the transfer of TBI patients over a 5 year period to Level I and II trauma centers[30] and the transfer of uninsured patients.[31]

In addition to older adults, the pediatric population (18 years and younger) also had a high number of transfers (34.9%). A secondary data analysis shows that children arrive to a hospital by private transportation two times more often than adults (20.2%). These arrivals occur because parents or family members drive their children to a hospital. These patients do not benefit from EMS services and the application of the Field Triage Guidelines, which help guide the person to the optimal destination facility.

Level I and II trauma centers have 24-hour, 7 days a week neurosurgical staffing coverage. Yet, the current practice of skilled neurosurgeons being required for invasive skull procedures has been debated in a recent study by Barber et al.[32] This study, consisting of patients within a single trauma center, revealed that the placement of ICP monitors may be performed safely by both neurosurgeons and non-neurosurgeons in a trauma center.[33] Given the high transfer rate to definitive care Level I or II trauma centers, as found in this present study, the Barber study results may not be generalized to all non-trauma center environments due to staffing differences at non-trauma centers. Additionally, it has been suggested that the undersupply and varied distribution of neurosurgeons across the U.S. create an inconsistency in the care of patients who are directly transported to Level I or II trauma centers.[34] While treatment at any facility is beneficial, these study results show that older adults are disproportionately impacted by triage decisions and may not fully benefit from optimal treatment as suggested by existing guidelines.[17,18,21]

Other explanations of under-utilization include the fact that a disproportionate number of older adults may live in rural populations where access to advanced care is not easily accessible and triage transport practices determine whether treatment will be administered at community hospitals or Level III and IV trauma centers. Another possible explanation is that a large percentage of transfer patients may be coming from rural communities that do not have routine access to neurosurgeons. One study reports that 7 of the 60 patients that had an expanding epidural or subdural hematoma were considered too unstable to transport and needed an emergency craniotomy in the form of a burr hole decompression.[35] These patients were later transferred to a trauma center. The authors of the study concluded that the emergency services provided by non-neurosurgeons saved lives and reduced morbidity in properly selected cases, when timely access to a neurosurgeon was not possible.

The disproportionate transfer of older adults to Level I or II trauma centers suggests that transport processes may need to be reexamined. While not always possible, direct transport to a trauma center would likely result in a more efficient use of resources. Some literature points to the reluctance of taking older adults to a trauma center.[36–39] In a recent study on motor vehicle crashes, it was found that older occupants were less likely to be transported directly to a trauma center than younger ones (47% vs. 55%). Similarly, Scheetz found undertriage rates of 26% among adults aged 65 and older, and that most of the undertriaged had a TBI.[35] Evidence that special care is needed for older adults was demonstrated by Roudsari et al. In this study, it was shown that CT utilization had increased twofold over a 10-year period for older adult patients with fall-related injuries, including non-TBIs.[37]

Anticoagulant use may be contributing to the transfers to trauma centers. The number of adults aged 65+ is increasing rapidly and many people in this population are taking some form of anticoagulant medication.[38] A recent study indicated that nearly half of all medication taken among men 75–85 years old was anticoagulant medicines.[39] There is substantial evidence for the need to reverse the effect of anticoagulant drugs in order to minimize the increased risk from intracranial hemorrhage, and to thereby reduce the associated morbidity and mortality of TBI, particularly in older adults.[38–44] The Field Triage Guidelines used by prehospital personnel to aid transport decision-making, recommend the transportation of anticoagulated patients with head injuries to a healthcare facility capable of timely and thorough evaluation, as well as initial management, including the reversal of anti-coagulation.[21] The resources available for this initial management are most often concentrated in the higher level trauma centers.

Trauma Centers within an established trauma system also offer a continuum of care that particularly benefits TBI patients. Referral for rehabilitation services or access to on site rehabilitation is associated with Level I or II trauma center patient care.[45] Routine referral to additional services is more likely to occur when a State has an established trauma system.[46]

This study has several limitations. First, the two sets of data do not allow for the identification of a chief medical complaint, and, therefore, it is unclear if the primary cause of the hospital admission was for TBI or for some other injury. Second, because the NIS is a survey of abstracted hospitals, the number of TBI hospitalizations is an estimate. We assumed that the population receiving a TBI was demographically similar to the population who had access to trauma center care. As with any surveillance system that utilizes ICD codes to ascertain cases, inaccurate estimates can occur. Some TBI researchers working with the CDC ICD coded definition of TBI have noted this.

Conclusion

Because of the lower than expected proportion of older adults with TBI seen at Level I or II trauma centers, actionable research is needed to determine the underlying barriers behind the initial transport of these patients to a Level I or II trauma center. High transfer rates between non-trauma centers and Level I and II trauma centers were also found among children, because parents sometimes transport children to a non-trauma center. With nearly half of all the transfers occurring for older adults, improvements are needed in the system of care.

There may be a number of reasons for this such as anticoagulation practices, lack of universal agreement on the severity of mild TBI, insurance practices, or rural access to care. These potential barriers to advanced trauma care require further research with a focus on why older adults with a TBI are over-represented in trauma transfer rates and a focus on changes in systems of care that might improve their outcomes. These study results could inform future revisions of the field triage guideline.

Due to the lack of specific available data, we could not use nationally representative data to directly answer why older adults are being transferred at a higher rate to trauma centers. Future national datasets that designate specific facility features will help identify specific barriers to optimal treatment for TBI. This is a critical question that future research should answer.

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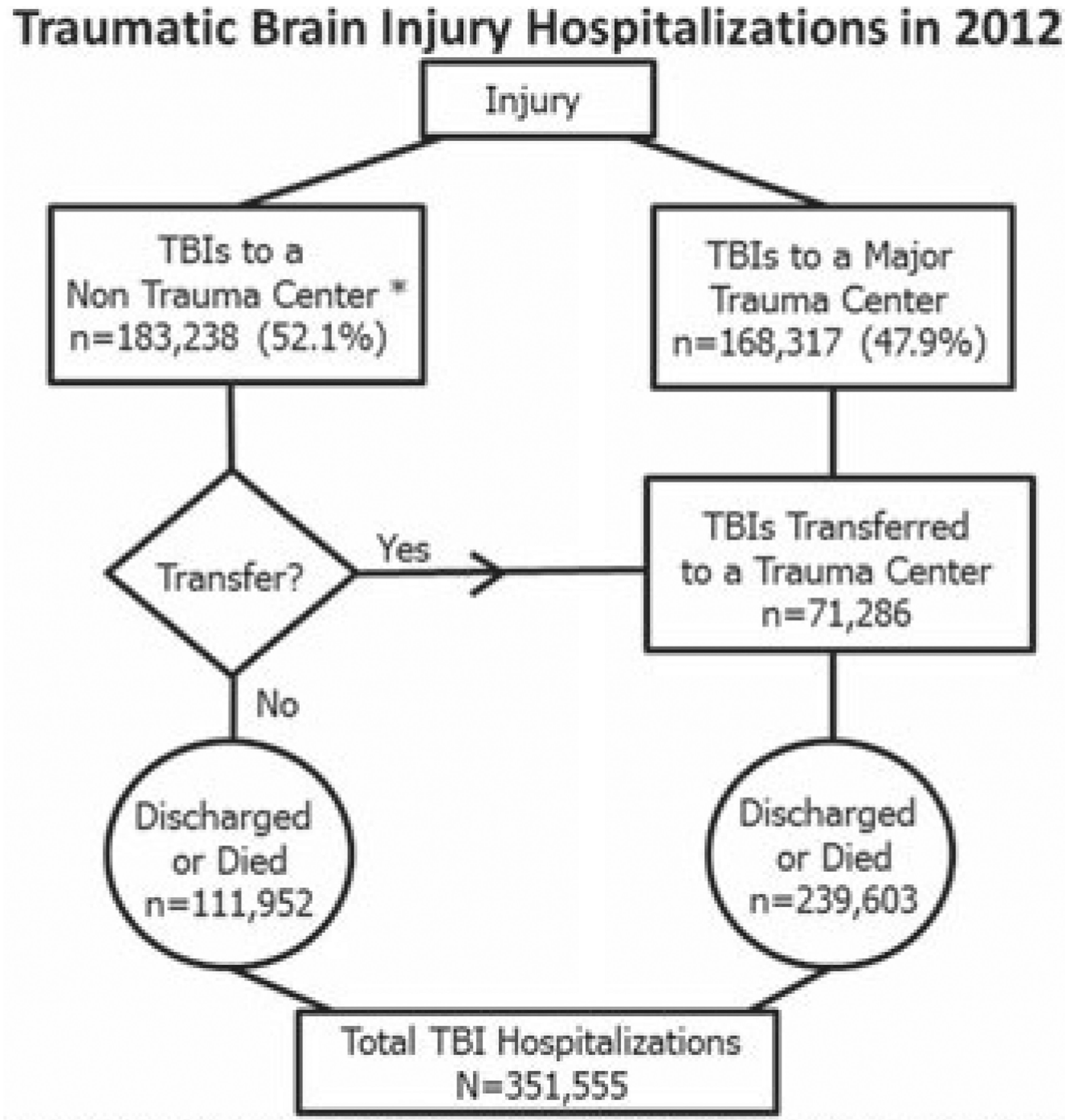

Figure 1.

Traumatic brain injury hospitalizations in 2012. *For definitional purposes, Level III and IV trauma centers were identified as non-trauma centers because of the unique role Level I and II Trauma centers have in treating TBI.

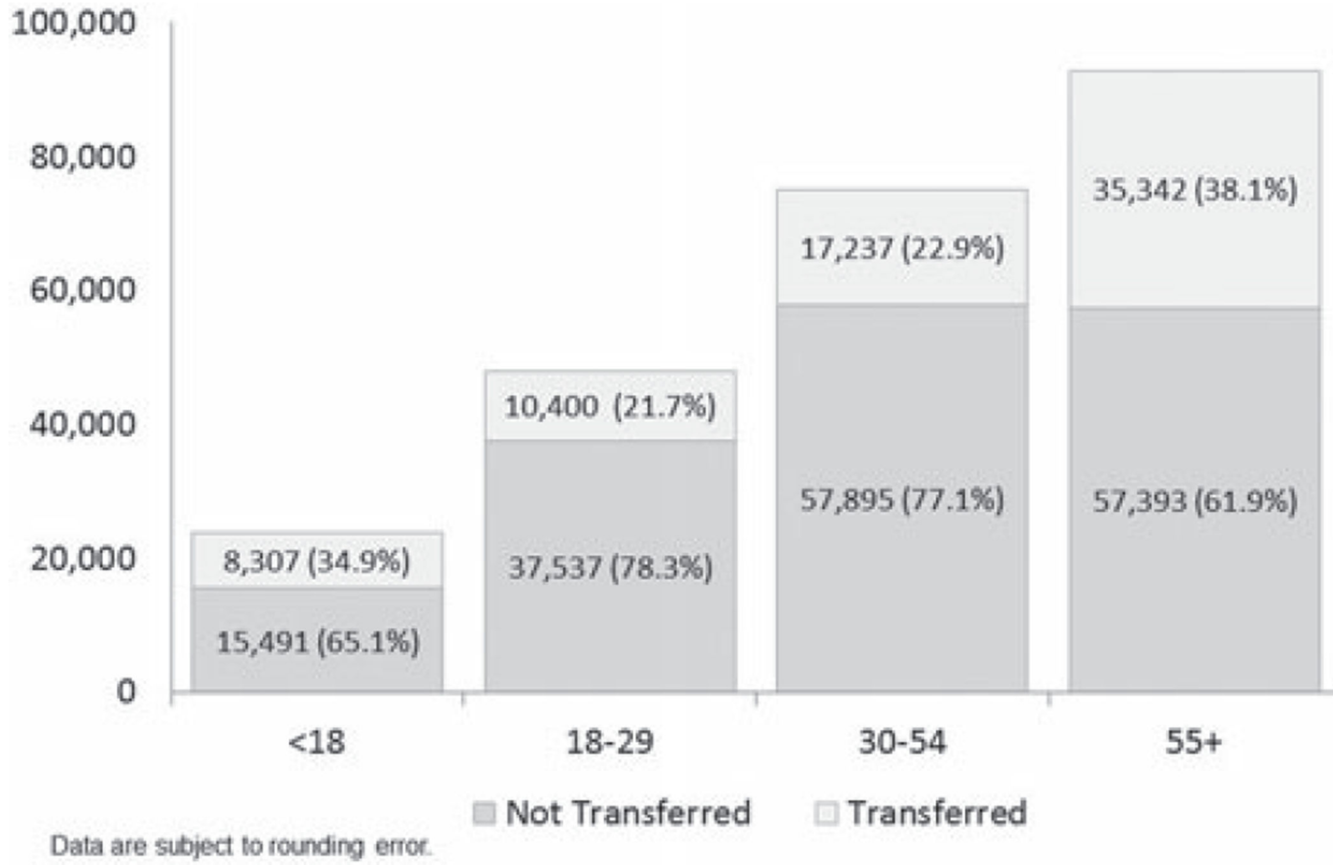

Figure 2.
Traumatic brain injury hospitalizations within major trauma centers by transfer status and age in 2012.

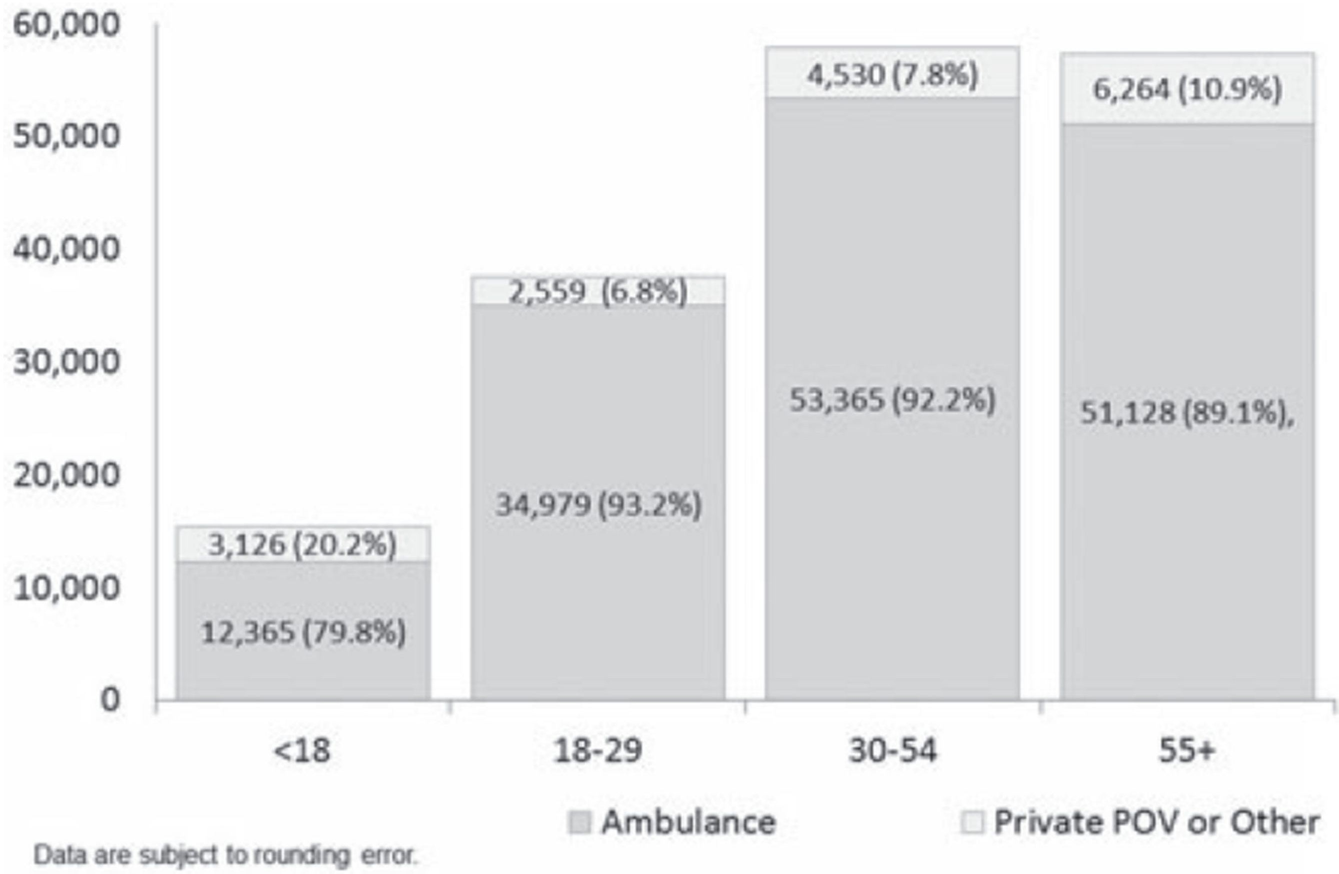

Figure 3.
Traumatic brain injury hospitalizations with in major trauma centers by mode of arrival and age in 2012.