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Is direct transport to a level I trauma center associated with better outcomes in patients with traumatic brain injury compared to patients that are transferred to trauma level I from other hospitals

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Is direct transport to a level I trauma center associated with better outcomes in patients with traumatic brain injury compared to patients that are transferred to trauma level I from other hospitals

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By

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List of Abbreviations

Abbreviation	Explanation
EMS	Emergency Medical Services
TBI	Traumatic Brain Injury
NTDB	National Trauma Data Bank
ISS	Injury Severity Score
AIS	Abbreviated Injury Scale
OEMS	Office of Emergency Medical Services
VSTR	Virginia State Trauma Registry
ICD	International Classification of Disease
AMA	Against Medical Advice
GCS	Glasgow Coma Score
NSQIP	National Surgical Quality Improvement Program
SDM	Standardized Mean Difference

Abstract

Transferring patients with traumatic brain injury (TBI) to trauma level I hospital from other lower level hospitals has been shown to increase the mortality compared to when patients are directly transported to trauma centers. Despite the results from studies and the field triage recommendation of transporting the TBI patients to trauma center, nearly half of the TBI cases are transported to other hospitals before transferring to the trauma center. A retrospective analysis of patients with TBI in the state of Virginia was carried out to access if direct transport of patients with TBI to trauma center improves the outcome compare to the inter-facility transfer patients. Patients were categorized into two groups; direct transport and inter-facility transfers. Hospital discharge disposition was considered as the measure of outcome. A proportional odds cumulative logistic regression was utilized on propensity score matched patients and on unmatched patients. Of the 2,695 patients included, 74.9% of the patients were in the direct transport group and 25.1% in the inter-facility transfer group. Propensity score matching was able to match 79.6% of the patient included in the study. Before matching, unadjusted odds ratio was not significant for inter-facility transfers patients and direct transport patients (OR =1.12, P = 0.239). However, adjusted odds ratio was found to be significant (OR=0.63, P < 0.001) with direct transport group as reference group. After matching, both adjusted and unadjusted odds ratio showed that the inter-facility transfer were likely to have better outcome compared to direct transport. Based on the finding, transporting TBI patients to hospitals other than trauma level I subsequently transferring to trauma level I is better both for the patients and the emergency medical service (EMS) agencies as they reduce the travel time by not directly transporting patients to trauma level I hospitals.

Keywords: Traumatic brain injury, inter-facility transfer, Triage, Emergency medical service

Introduction

The Emergency Medical Service (EMS) provides the initial care needed during medical emergency. EMS providers respond to different kinds of medical emergencies and triage the patient to appropriate hospital based on their condition. Each agency that responds to medical emergencies has protocols they follow which serves as a guide to appropriate triaging. Execution of the protocols when triaging patients is vital to trauma system performance (Johnson, 2016). This is particularly important in traumatic injuries as time is an important factor that can influence the patient outcome.

Hospital emergency surgeons are vocal about transporting the patient to trauma hospital if the patient meets the Trauma Triage Criteria (Sasser et al., 2014). This is not always possible for EMS agencies that provide service in rural areas and is an issue in parts of the country where trauma centers are not accessible within an hour drive. Transporting patients to the nearest hospital with subsequent transfer to trauma hospital is necessary in such scenario (Sugerman et al., 2012). However, doing so increases the time between the symptom onset and the initiation of treatment. Traumatic brain injury (TBI) requires immediate treatment (American College of Surgeons, 2015). The TBI produces mechanical injury to neurons which triggers a secondary injury that could last for weeks to months. Shorter therapeutic time window is said to have a limiting effect on secondary injury as the pharmaceutical agents are more effective in controlling the rate of neurons death when given early (Mohamadpour et al., 2019).

There are studies that compare the outcome of patients with TBI. One such study of patient with severe TBI using data from National Trauma Data Bank (NTDB) found that being transferred to trauma hospital (level I and level II) had lower risk of death. However, the study also found that patients that were transferred had lower injury severity score (ISS) and lower Abbreviated Injury Scale (AIS), and were less likely to have sustained penetrating trauma (Sugerman et al., 2012). Another study found that the 2-weeks mortality was marginally higher among patients with TBI who were transferred to trauma center from other facilities compared to those transported directly to trauma level I or level II (Härtl et al., 2006). This study also found that the time window between the symptom onset and admission to trauma center did not have an effect on two weeks mortality.

The studies cited above have focused on survival of the patient as primary outcome; however, hospital discharge disposition provides broader group of patients with varying degree of recovery. This study used hospital discharge disposition as an indicator for assessing if direct transport to trauma center contributed to better patient condition during discharge compared to inter-facility transfers. Unlike using mortality as an indicator which does not include the survivors, hospital discharge disposition includes broader group of patients with varying severity. We hypothesized that TBI patients transported directly to the trauma level I hospital have better hospital outcome compared to the ones that are transferred to trauma level I from other hospitals as inter-facility transfer.

Methods

This was a retrospective study of patients that suffered a TBI and were treated at trauma level I hospital in the state of Virginia. All hospitals in the state of Virginia are required to provide the information on patients if they are admitted into the hospital for a traumatic injury to the Virginia State Trauma Registry (VSTR) and is maintained by the Virginia Department of Health Office of Emergency Medical Services (OEMS). The data used in the study was provided by OEMS between January 1st, 2017 and December 31st, 2018.

The study sample consisted of all the trauma incidents that were diagnosed as TBI using the diagnostic ICD-10 codes provided in the trauma registry. The ICD -10 used for acquiring the population was S06 (intracranial injury), S02.0 (Fracture of vault of skull), and S02.1 (Fracture of base of Skull). Patients were excluded if the zip code of the incident location matches the zip codes of the five trauma level I hospitals in the state of Virginia. Patients treated at a trauma level I hospital, aged 15 years and above, and were admitted to the hospital were included for the analysis. Trauma guideline classifies patient below the age of 15 as pediatric trauma (Sasser et al., 2014). Patients that were transferred from trauma level I hospital to other hospitals were excluded. Patients having multiple injuries with AIS score of ≥3 in body regions other than head were excluded to ensure the primary injury for the study population is TBI. Excluding patients with non-head AIS ≥ 3 was previously used in a study which studied patients with TBI to see if transporting to trauma level I or level II show any reduction in mortality in a state's trauma system (Sugerman et al., 2012). Patients who were transported directly to trauma level I from incident location were classified as 'Direct Transport' and those who were transported to a trauma level I hospital from another hospital were classified as 'Inter-facility Transport'.

Hospital discharge disposition was used as the outcome variable and was categorized based on where the patient went after discharge. The categories consisted of patients who needed minimal to no medical care, who needed short term or long term medical care, and who needed hospice care or were dead. The group that did not need further medical care contained patients who left against medical advice (AMA) discharge, correctional facility or in law enforcement custody, discharged home with/without service, inpatient rehabilitation facility, and psychological visit. The group that needed short or long-term care contained patients discharged to an intermediate care facility, long term care facility, and nursing home. The patients who needed hospice care or died were combined as the least favorable outcome.

Patient age, sex, race, AIS severity ("The Abbreviated Scale," 1971), and comorbidity were considered as potential confounders. AIS severity was measured at the time of arrival at the trauma level I hospital. Sex was represented by male, and female and race was represented by Whites, African American, Asian, and others. AIS severity score ranges from 1 to 6; where the severity of injury increases with the increase in AIS score. AIS severity was classified into two groups; minor (AIS <3) and major (AIS≥3). Comorbidities were grouped into four categories; none, minor, moderate, and major. These categories were used as ordinal variable with the values ranging from 0 to 3, where higher number indicates that the comorbidity pose greater risk to the patient with TBI. Comorbidities were grouped based on how much a particular type of comorbidity affects the patient with TBI in their treatment/recovery (Table 1). The registry lists a wide range of co-morbidities ranging from common and, usually less severe ones such as hypertension to severe patient illnesses such as active chemotherapy or recent stroke. As the number of individual co-morbidities in a specific sample such as the TBI population is low, grouping of co-morbidities was based on clinical importance into minor, moderate, and severe. The concept of giving different weights to co-morbidities is well established in the medical literature and used in many tools for risk adjustment such as the Charlson Comorbidity Index (Charlson et al., 1987) and the American College of Surgeons NSQIP Risk Calculator (Bilimoria et al., 2013), though the variables included in the trauma registry do not allow for the complete calculation of any of these major indices (Samuel et al., 2015). GCS motor value ranges from 1 to 6; where the severity of the patient decreases with the increase in GCS motor. GCS total ranges from 3 to 15; where the higher value indicates less severe patient.

Table 1. Grouping of comorbidity into three categories

Minor (1)	Moderate (2)	Major (3)
Current Smoker	Alcohol use disorder	Anticoagulant therapy
Hypertension	Chronic obstructive pulmonary disease	Bleeding disorder
	Chronic renal failure	Cerebrovascular accident
	Diabetes mellitus	Chemotherapy for cancer within 30 days
	Functionally dependent health status	Cirrhosis
	Mental/personality disorder	Congestive heart failure
	Steroid use	Dementia
	Substance abuse disorder	Disseminated cancer
		Myocardial infarction

Statistical Methods

Means and standard deviations (SD) or frequencies and percentages were reported for all the patient and injury characteristics. Each characteristic was assessed similarity between the direct transport and inter-facility transfer group using a t-test for continuous variable and chi-square test for categorical variables. T-test was used for continuous variable as by central limit theory the sample means can be approximated by normal distribution for large sample size (Casella & Berger, 2002). Standardized mean differences (SDM) for the covariates were also obtained to assess their balance between the comparison groups (Austin, 2009b). A SDM of zero is considered as having a perfect balance of a covariate between the transfer and direct transport group. As SDM moves farther from zero, more imbalance exist between the direct transport and inter-facility transfer groups. Summary statistics were also obtained for the patient and injury characteristics by the hospital discharge disposition and were assessed for a relationship with the hospital discharge disposition using one-way analysis of variance (ANOVA) for continuous variable and chi-square test for categorical variable.

Propensity score matching was performed to reduce the bias due to confounding variables. The propensity score for each patient was calculated using multivariable binary logistic regression with age, AIS severity, comorbidity, and race as variables in the model. GCS was not used in the propensity score model due to its relationship with the AIS severity, as both the measures explain the severity of the patient. Logits of the propensity score were calculated which was then used for matching the patients between the direct transport and inter-facility transfer groups. Logits of the propensity score were used for their superior estimate over propensity score (Austin, 2009a). One patient from the transferred group was matched up to 3 patients from the group of patients that were directly transported to trauma level I (1:3 matching) using nearest neighbor matching without replacement with caliper of 0.2 times the SD of logit (Austin, 2009a). One-to-many matching was performed to match maximum patients possible which improve the efficiency of analysis (Woodward, 2013). The summary statistics for the direct transport group and inter-facility transfer group were calculated on the matched data. The SDM of the variables were calculated on the matched population to assess the imbalance between transfer groups.

The primary analysis to assess the relationship between the direct transport group and inter-facility transfer group with the hospital discharge disposition groups was performed using a proportional-odds cumulative logit model. This model was used to account for the ordinal nature of the outcome variable (Lee, 1992). Odds ratios were calculated to describe and interpret the relationship between the hospital discharge disposition and patient and injury characteristics. Adjusted and unadjusted odds ratios with 95% confidence interval (CI) were calculated using the initial unmatched dataset. Odds ratio of greater than 1 would indicate that the patients that were directly transported to trauma level I hospital are more likely to have better outcome compared to the patients that were transferred to the trauma level I hospital from other hospitals. Age, sex, race, patient admission type, AIS severity, and comorbidity were used for calculating adjusted odds ratio. The same methods were used to calculate the odds ratio and 95% CI using propensity score matched data. Unadjusted odds ratio with 95% CI for transport type of patient was calculated with random effect to account for variation introduced in the matching procedure. Patient sex was not included in the analysis using the propensity score matched data because it was not found to be different between the direct transport and inter-facility transfer group and was not used for propensity score matching. The primary analysis was repeated on matched data using optimal matching to compare the results. The missing data were considered to be missing at random. All analysis was performed with SAS, version 9.4 (SAS Institute Inc., Cary, NC).

Model Description:

Let the discharge disposition be denoted as y where it can take one of the three values of disposition categories. Let the discharge disposition of either needing a hospice care or dead be denoted as 0, discharge disposition needing short term or long term care be denoted as 1, and discharge disposition needing no medical care be denoted as 2.

Then the cumulative probability of being in the category of zero is given by

$$P(Y \leq 0|x) = \pi_0(x)$$

$$P(Y \leq 1|x) = \pi_0(x) + \pi_1(x)$$

Where *x* is the independent variable represented by two categories, direct transport and inter-facility transport, and π_j are the associated probabilities of having an outcome *j*.

Let x=0 when transport is directly transported and x=1 when transport is inter-facility transfer.

Then a cumulative logit for *j* outcome as a function of the transport modality is defined as

$$logit[P(Y \leq j|x)] = \alpha_j + \beta * x$$

When *j = 0*, the discharge disposition of either needing hospice care or dead

$$logit[P(hospice\ care\ or\ dead)] = log\ \frac{P(hospice\ care\ or\ dead)}{P(short\ or\ long\ term\ care) + P(no\ medical\ care\ needed)}$$

$$logit[P(hospice\ care\ or\ dead)] = \alpha_{hospice\ care\ or\ dead} + \beta * x$$

When *j=1*, the discharge disposition of short term or long term care

$$logit[P(short\ or\ long\ term\ care)] = log\ \frac{P(hospice\ care\ or\ dead) + P(short\ or\ long\ term\ care)}{P(no\ medical\ care\ needed)}$$

$$= \alpha_{short\ or\ long\ term\ care} + \beta * x$$

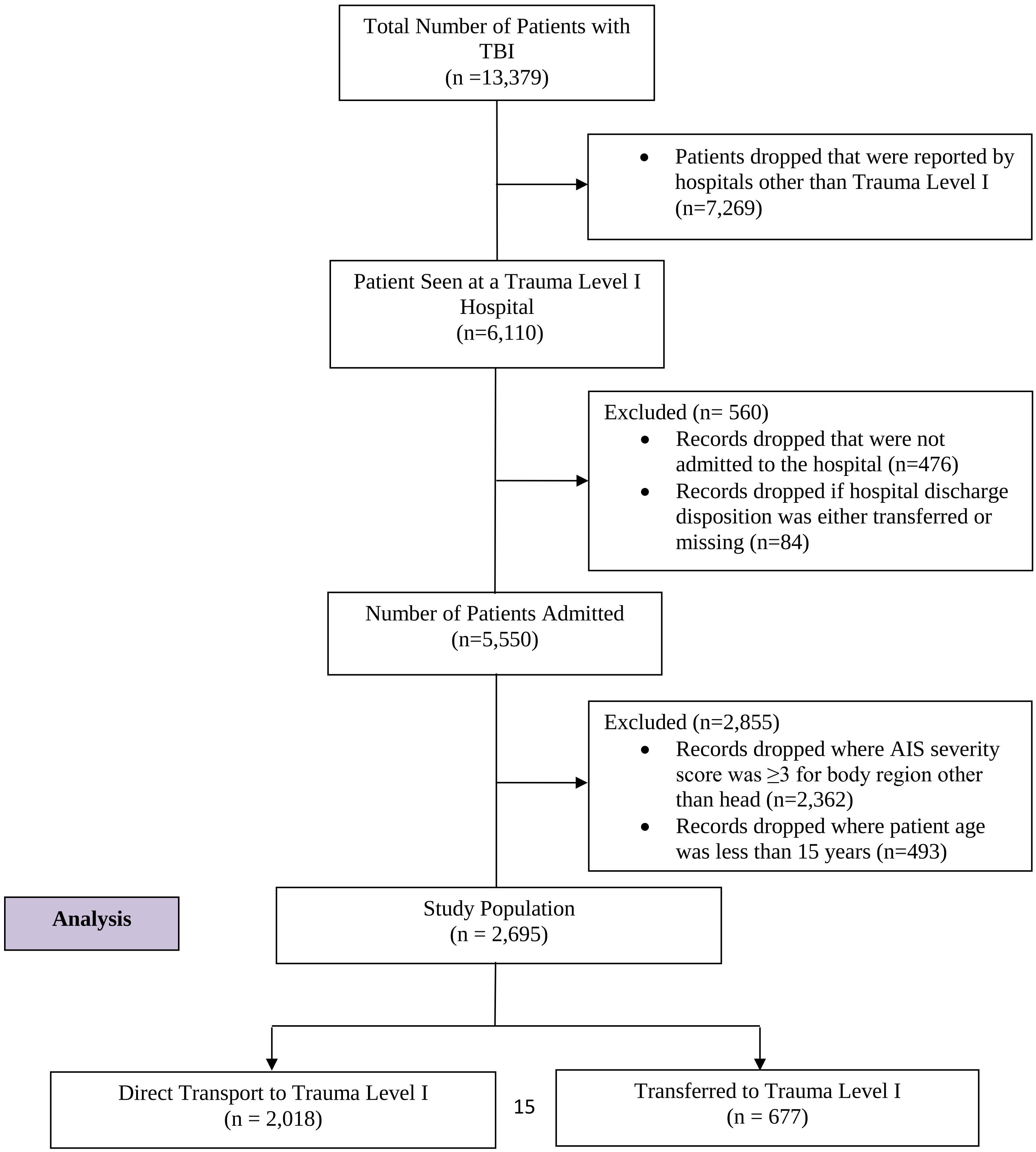
Where x = 0 when directly transported to trauma hospital and 1 for inter-facility transfer.

The odds ratio can be calculated as exponential of the β. The value of OR > 1would mean a transfer patient is less likely to be associated with better outcome.

Result

For the selected time period, there were 13,379 patients with TBI that were seen in an ED in the state of Virginia. Of those 7,269 were seen at the hospitals that were not trauma level I and were excluded from the study. Patients were also dropped if they were not admitted to the hospital (n=476), and if the patient's hospital discharge disposition was either transferred out of trauma level I hospital or was missing (n=84). There were 493 patients who were below 15 years of age and were excluded from the study. Patients with multiple injuries with AIS score of ≥3 in body regions other than head were excluded (n=2,362). Number of patients eligible for the study was 2,695, where 2,018 (74.9%) were transported directly to a trauma level I hospital and 677 (24.1%) were transferred patients to the trauma level I. This information is summarized in figure 1.

Figure 1. Patient flow chart



The mean age of the sample was 57.7 (SD=23.1) years, 59.8% were male, and 71.2% of the patients were White (Table 2). The patients in the direct transport group were younger than the patients in the inter-facility group (SDM= 0.50, P < 0.001). There were more patients with minor AIS severity (AIS < 3) in direct transport group, but the patients with major AIS severity (AIS ≥3) were the larger proportion in inter-facility group (SDM= 0.07, P < 0.001). Age was found to have the largest standardized difference (0.5) indicating greater imbalance, and GCS motor had the smallest standardized difference indicating fewer imbalances between the direct transport and inter-facility transfer groups (Table 3).

Table 2. Overall patient characteristics

Covariates	Total Patients (N=2,695)
Age [a]	
Mean (SD)	57.7 (23.1)
Gender [b]	
Female	1,083 (40.2%)
Male	1,611 (59.8%)
AIS Severity [c]	
Minor	1,190 (44.4%)
Severe	1,491 (55.6%)
Comorbidity [a]	
Mean (SD)	1.4 (1.2)
GCS Motor [a]	
Mean (SD)	5.4 (1.5)
GCS Total [a]	
Mean (SD)	13.2 (3.7)
Race	
White	1,918 (71.2%)
Black	434 (16.1%)
Other	245 (9.1%)
Asian	98 (3.6%)

[a] Continuous variables presented as mean (SD); [b] Missing: n=1; [c] Missing: n=14;
SD = standard deviation, GCS = Glasgow coma score, AIS=abbreviated injury scale

Table 3. Patient characteristics and their standardized differences by hospital admission type

	Direct Transport (N=2,018)	Transferred (N=677)	p value	SDM
Age [a]			<0.001	0.50
Mean (SD)	54.8 (22.8)	66.0 (21.7)		
Gender [b]			0.597	0.07
Female	805 (39.9%)	278 (41.1%)		
Male	1,212 (60.1%)	399 (58.9%)		
AIS Severity [c]			<0.001	0.07
Minor	997 (49.8%)	193 (28.5%)		
Severe	1,007 (50.2%)	484 (71.5%)		
Comorbidity [a]			<0.001	0.18
Mean (SD)	1.4 (1.1)	1.6 (1.2)		
GCS Motor [a]			0.108	0.05
Mean (SD)	5.4 (1.5)	5.4 (1.5)		
GCS Total [a]			<0.001	0.07
Mean (SD)	13.1 (3.8)	13.4 (3.6)		
Race [d]			<0.001	0.07
White	1,407 (69.7%)	511 (75.5%)		
Black	359 (17.8%)	75 (11.1%)		
Other	191 (9.5%)	54 (8.0%)		
Asian	61 (3.0%)	37 (5.5%)		

[a] Continuous variables presented as mean (SD); [b] Missing: n=1; [c] Missing: n=14; [d] Standardized difference calculated using race as White vs. Other
SD = standard deviation, GCS = Glasgow coma score, AIS=abbreviated injury scale

There were 1,981 (73.5%) patients who did not need further medical care, 465 (17.3%) patients needed short term or long term medical care, and 249 (9.2%) patients either needed hospice care or were dead. Among the patients that did not need further medical care, 1,496 (75.5%) were direct transport and 485 (24.5%) were inter-facility transfers. Among the patients who needed short term or long term medical care, 337 (72.5%) were direct transport and 128 (27.5%) were inter-facility transfers. In the discharge disposition group where the patients either needed hospice care or were dead, 158 (74.3%) were direct transport and 64 (25.7%) were inter-facility transfers. The mean age of the patients among the discharge disposition group was different ($P < 0.001$). Summary statistics of the patient and injury characteristics with the discharge disposition categories are tabulated (Table 4).

Table 4. Patient characteristics by hospital discharge disposition type

	No Further Medical Care Needed (N=1,981)	Short/long Term Medical Care Needed (N=465)	Hospice Care Needed or Dead (N=249)	p value
Age [a]				<0.001
Mean (SD)	52.3 (22.4)	75.2 (14.8)	67.3 (21.3)	
Gender [b]				<0.001
Female	752 (69.4%)	241 (22.3%)	90 (8.3%)	
Male	1,228 (76.2%)	224 (13.9%)	159 (9.9%)	
AIS Severity [c]				<0.001
Minor	1,029 (86.5%)	142 (11.9%)	19 (1.6%)	
Severe	945 (63.4%)	316 (21.2%)	230 (15.4%)	
Comorbidity [a]				<0.001
Mean (SD)	1.3 (1.1)	1.8 (1.2)	1.7 (1.3)	
GCS Motor [a]				<0.001
Mean (SD)	5.6 (1.2)	5.6 (1.2)	3.2 (2.3)	
GCS Total [a]				<0.001
Mean (SD)	13.8 (3.1)	13.5 (3.1)	7.6 (5.1)	
Race				<0.001
White	1,351 (70.4%)	377 (19.7%)	190 (9.9%)	
Black	351 (80.9%)	54 (12.4%)	29 (6.7%)	
Other	207 (84.5%)	20 (8.2%)	18 (7.3%)	
Asian	72 (73.5%)	14 (14.3%)	12 (12.2%)	

[a] Continuous variables presented as mean(SD); [b] Missing: n=1; [c] Missing: n=14;
SD = standard deviation, GCS = Glasgow coma score, AIS=abbreviated injury scale

Before matching, having a more severe outcome was not found to be different for the patients who were inter-facility transfer compared to the patients that were direct transport (OR = 1.12, 95% CI: 0.93, 1.36). Adjusted for the patient and injury characteristics, the patients who were transferred to the trauma level I from other hospitals were more likely to have better outcomes compared to the patients who were directly transported to the trauma level I hospital (OR = 0.63, 95% CI: 0.51, 0.78) (Table 5).

Table 5. Adjusted and non-adjusted odds ratios before matching

Covariates	Unadjusted Odds Ratio (95% CI)	P-Value	Adjusted Odds Ratio (95% CI)	P-value
Transfer Patient				
Direct - Transfer	1.12 (0.93, 1.36)	0.239	0.63 (0.51, 0.78)	<0.001
Age (every 10 years)	1.56 (1.49,1.64)	<0.001	1.49 (1.41, 1.57)	<0.001
Gender				
Female –Male	0.75 (0.64, 0.89)	<0.001	1.09 (0.90, 1.32)	0.385
Race				
White - Other	0.57 (0.47, 0.70)	<0.001	0.77 (0.62, 0.96)	0.022
AIS Severity				
Minor - Major	3.92 (3.22, 4.76)	<0.001	2.85 (2.31, 3.51)	<0.001
Comorbidity	1.45 (1.34, 1.56)	<0.001	1.07 (0.99, 1.16)	0.108

AIS=abbreviated injury scale

Propensity score matching produced a matched sample of 2,145 from the pool of 2,695 patients. Six hundred and seventy-seven (n=677) patients from transferred group were matched with 1,468 patients from direct transport group. The SDMs calculated for the variables after matching were found to be smaller in magnitude than before matching (Table 6). A box plot for the distribution of the logit of propensity score before and after is in Figure 2. Both the box plot and the standardized difference show improved balance after matching.

Table 6. Patient characteristics and their standardized differences by hospital admission type after matching

	Direct Transport (N=1,468)	Transferred (N=677)	Total (N=2,145)	p value	Standardized Difference
Age				<0.001	0.23
Mean (SD)	61.1 (21.5)	66.0 (21.7)	62.7 (21.7)		
AIS Severity				0.002	0.08
Minor	519 (35.4%)	193 (28.5%)	712 (33.2%)		
Severe	949 (64.6%)	484 (71.5%)	1,433 (66.8%)		
Comorbidity				0.105	0.08
Mean (SD)	1.5 (1.2)	1.6 (1.2)	1.5 (1.2)		
GCS Total					
Mean (SD)	12.9 (3.8)	13.4 (3.6)	13.1 (3.8)	<0.001	0.11
GCS Motor					
Mean (SD)	5.3 (1.6)	5.4 (1.5)	5.4 (1.5)	<0.001	0.07

	Direct Transport (N=1,468)	Transferred (N=677)	Total (N=2,145)	p value	Standardized Difference
Gender				0.618	0.08
Female	805 (39.9%)	278 (41.1%)	1,083 (40.2%)		
Male	1,212 (60.1%)	399 (58.9%)	1,611 (59.8%)		
Race				0.759	0.08
White	1,099 (74.9%)	511 (75.5%)	1,610 (75.1%)		
Other	369 (25.1%)	166 (24.5%)	535 (24.9%)		

SD = standard deviation, AIS=abbreviated injury scale, GCS = Glasgow coma score

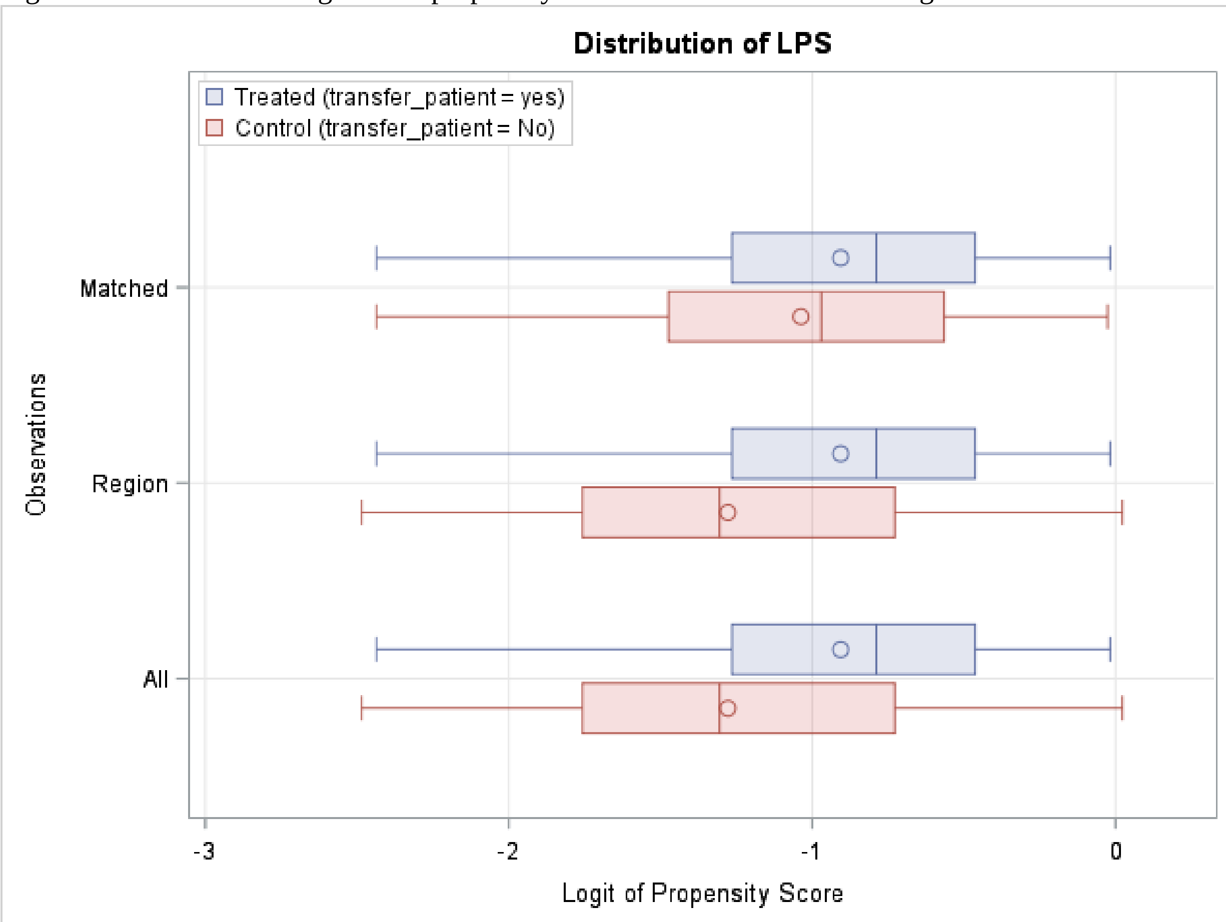
After matching, patients transferred to trauma center from other hospitals were more likely to have better outcomes than those that were transported directly to trauma center. Unadjusted for other characteristics, odds of having a discharge disposition of at least the short or long-term care needed group was 0.64 times the odds of having a discharge disposition of little to no medical care needed group for inter-facility transfer patients compared to direct transport patients (95% CI = 0.52, 0.79, P < 0.001). The adjusted odds ratio for comparing direct transport and inter-facility group was 0.62 (95% CI = 0.51, 0.77, P < 0.001). The odds of having a discharge disposition of at least the short or long-term care needed group was 0.62 times the odds of having a discharge disposition of little to no medical care needed group for inter-facility transfer patients compared to direct transport patients (Table 7). Similar analysis performed on matched data using optimal matching had similar results.

Table 7. Adjusted and non-adjusted odds ratios after matching

Covariates	Unadjusted Odds Ratio (95% CI)	P-Value	Adjusted Odds Ratio (95% CI)	P-value
Transfer Patient				
Direct - Transfer	0.64 (0.52, 0.79)	<0.001	0.62 (0.51, 0.77)	<0.001
Age (every 10 years)	1.47 (1.40,1.56)	<0.001	1.44 (1.36, 1.53)	<0.001
Race				
White - Other	0.67 (0.54, 0.84)	<0.001	0.78 (0.62, 0.99)	0.039
AIS Severity				
Minor - Severe	2.65 (2.15, 3.28)	<0.001	2.42 (1.94, 3.02)	<0.001
Comorbidity	1.37 (1.27, 1.48)	<0.001	1.07 (0.99, 1.17)	0.102

AIS=abbreviated injury scale

Figure 2. Distribution of logit of the propensity score before and after matching.



Discussion

The purpose of this study was to assess if inter-facility transfer of patients with TBI had at least the similar hospital outcome compared to the patients that were transported directly to trauma level I. The demographics of the patients described in this study are consistent with other studies with White and males separately being the majority of the sample (Table 2). About 75% of the patients were directly transported to the trauma center and the remaining 25% were inter-facility transfers. Before matching between the direct transport group and inter-facility group, unadjusted odds of having an outcome was not different between the direct transport and inter-facility transport. However, the adjusted odds of having a least favorable outcome was lower for inter-facility transfer group compared to direct transport group

(Table 5). After matching, both the unadjusted and the adjusted odds of having a least favorable outcome was lower for inter-facility transfer group compared to direct transport group (Table 7).

Results of this study demonstrate that the field triage of patients with TBI is important and is found to be affecting the outcome of the patient. It is demonstrated that stabilizing patients with TBI contribute to having better outcome compared to the patients that were directly transported to the trauma center, which inconsistent with the recommendation of the current guideline for pre-hospital triage of trauma patient (Sasser et al., 2014). The finding of this study on whether direct transport of patient with TBI contributes to having a better outcome compared to inter-facility transfer is inconsistent from some of the similar studies. A previous study found no difference between the transferred and direct transport by the patient disposition (Sugerman et al., 2012), however they found the mortality of the patients to be higher in transferred patients. Another study where patients with TBI admitted to trauma level I and level II were analyzed to assess if 2 weeks mortality was any different between the direct transport to trauma hospital and inter-facility transfer found the mortality was significantly higher in transferred patient compared to direct transport (Härtl et al., 2006). The study by Sugarman et al. categorized the discharge disposition into two categories, home and other. The study did not account for the ordinal nature of the discharge disposition. Both studies by Härtl et al. and Suggarman et al. used data from trauma level I and level II hospital while this study only used data from the trauma level I. Härtl et al. also used the length of time from incident to admission to trauma hospital as one of the confounder while this information was not available for this study. This study also differed in the method in accounting for the confounding of different patient and injury characteristics; Härtl et al. and Sugarman et al. in their study adjusted for the confounders by including in the model while this study used propensity score mathcing which is known to reduce the confounding bias the better than the adjustment (Woodward, 2013).

Transporting TBI patients to non-trauma hospital could be traced to different circumstances; geography, weather, long transport distances, etc. While transporting patients with TBI directly to trauma center can still be triage guideline, but this research have shown that it is not necessary to do so if there are stabilizing hospitals that are closer than the trauma level I hospital. EMS agencies when transporting patients to trauma level I hospital most likely bypass other hospitals unless the incident is in the same city as the trauma level I hospital. These lengthy transportations impact the number of 911 calls the agencies can respond. This study provides evidence that it is better to stabilize the patients and transfer them to trauma level I. The study recommends eliminating the transport of patients with TBI to trauma level I bypassing other hospitals, which would allow EMS agencies to serve more volume.

There are number of limitations to this study. The sample used is limited to patient with TBI and cannot be implied to other traumatic injuries. The lack of information about where the patient was picked up from is one of the limitations as the patients discharged to nursing home could possibly be from nursing home to start with. In such scenario, those patients should have been grouped into no limitation in physiological function group, but they are included in the intermediate physiological function; this could potentially change the composition of the outcome categories. Having no information on how long the patients from inter-facility group spent in stabilizing hospital and the incident time limited the ability of grouping of patient by the time from trauma incident to admission to trauma hospital which has been discussed in other literature as potential confounder (Härtl et al., 2006). This study also lacks the information on the number of deaths at the hospitals that are not trauma level I hospitals. Having this information would increase the number of patients with the discharge disposition of either the hospice care or dead, which is the most severe outcome of the three outcome groups. Since, these patients died at the hospitals that are not trauma level I, they would belong to the inter-facility transfer group as they went to hospitals other than the trauma level I from the scene location. This change in the composition of the hospital discharge disposition could have an effect that could potentially change the direction of the result.

Statistical limitations

This study has some statistical assumptions. Proportional odds cumulative logit model used assumes that there is same magnitude of effect for each logit. In other words, it assumes that there is same degree of ordinal nature between any adjacent pair of outcome. This might not always be true and in particular, the discharge disposition used as outcome measure for this study is difficult to truly assign as ordinal having equal magnitude between adjacent values.

This study though uses the data from Virginia trauma database; we believe the results can be generalized in any other states having similar state trauma system. The results here provide evidence that demonstrates that there is no need of directly transporting the patients with TBI to trauma level I hospital bypassing other hospitals.

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Appendix

Figure 3. Distribution of logits for direct transport and inter-facility transfer before matching

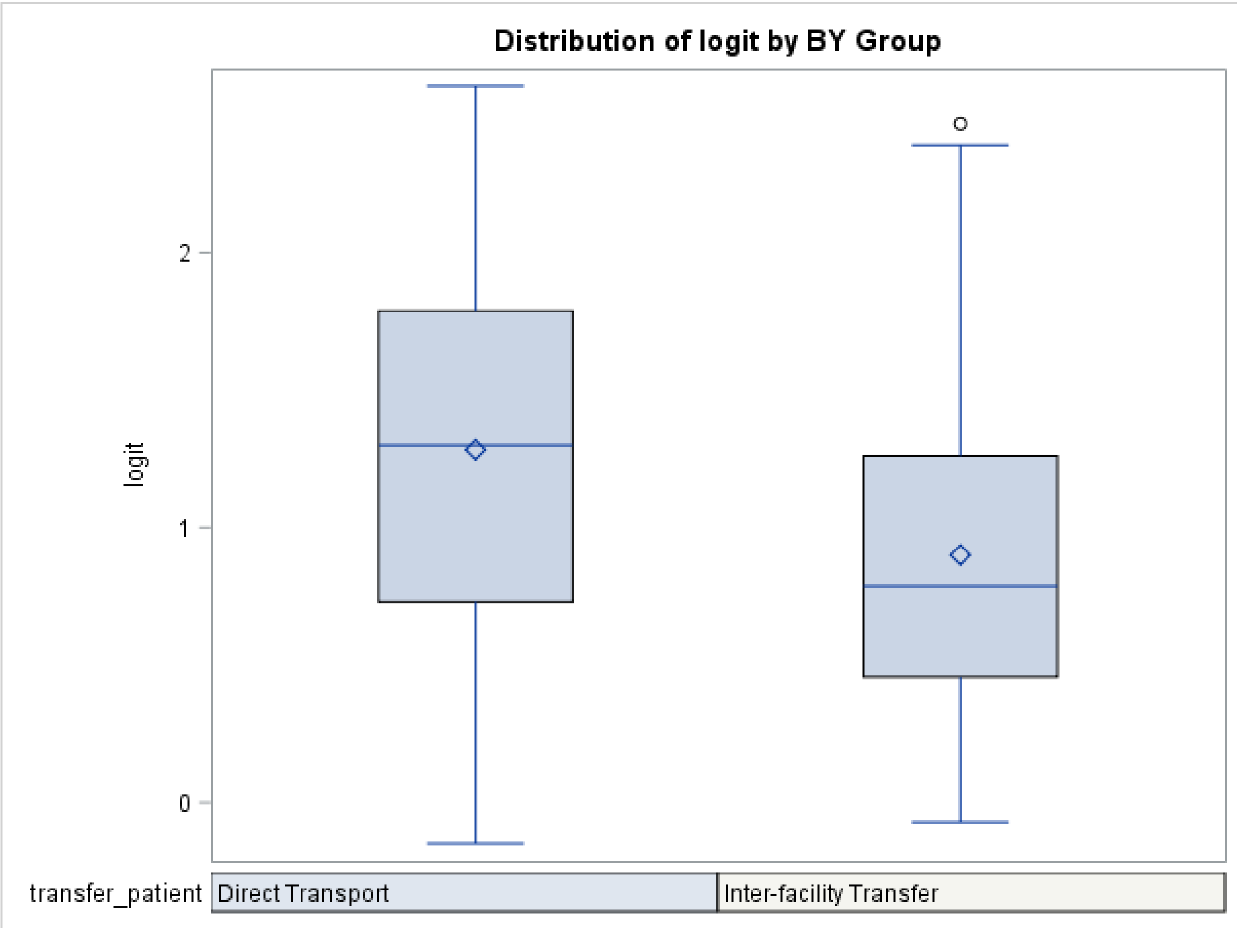

Figure 4. Distribution of logits for direct transport and inter-facility transfer after matching