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Factors Associated with Patients Transferred from Undesignated Trauma Centers to Trauma Centers

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Abstract

Background—Timely access to the appropriate level of care, both in the pre-hospital and hospital setting is necessary to optimize outcomes in severely injured pediatric trauma patients. However, a substantial portion of the pediatric population does not have adequate timely access to a verified Level 1 trauma center.

Objectives—To identify significant predictors of in-hospital mortality, and transfer to a higher level of care. This is the first statewide analysis that includes pediatric patients who are first seen at non trauma centers (NTC).

Methods—Mortality inter-hospital transfer to a higher level of care were analyzed for the first hospital of care. Clustering was accounted for by generalized estimating equations, p-values < 0.01 were considered significant.

Results—Younger age was significantly associated with mortality for all patients and with transfer for less severely injured children (ISS<15). The odds of mortality in NTCs were lower than in Level 1 TCs; however, the majority of NTC patients were transferred, artificially decreasing NTC mortality. The type of trauma (blunt or penetrating) was significantly associated with both mortality and transfer for more severe cases. Although insurance was not significantly associated with transfer, self-pay patients had significantly higher mortality odds.

Conclusions—The NTCs are transferring 98% of their patients, even those with very low ISS and high GCS. Further evaluation of the outcomes and characteristics of patients transferred from NTCs will provide important information to inform the triage guidelines to potentially safely avoid transfer of less severely injured patients from NTCs in their community.

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Author Contributions

Dr. Sergey Tarima contributed to the study design, was responsible for the bivariate and multivariate statistical analysis and preparation of the methods, results and interpretation of conclusions

Ms. Allison Ertl contributed to the literature review, assisted with data analysis and preparation of manuscript

Dr. Jonathan Groner contributed to the study design, acquisition of data, interpretation of results and manuscript preparation

Dr. Laura Cassidy is the Principal Investigator of the study and responsible for study design, oversight of project, interpretation of results and preparation of introduction and discussion.

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Levels of Evidence—This was large retrospective study with proper use of missing data techniques, minimum bias that adequately controlled for confounding using heterogeneous populations from hundreds of hospitals and sufficient statistical power suggesting an epidemiological evidence Level III study.

Keywords

Pediatric trauma; in-hospital mortality; inter-facility transfer

Introduction

When a child suffers a serious injury, timely access to the appropriate level of care, both in the pre-hospital and hospital setting, is essential for an optimal outcome. Nevertheless, over 17 million children across the U.S.-- 23% of the pediatric population -- are more than 60 minutes by either ground or air transport to the nearest pediatric trauma center, and only 23% of children in areas with the lowest population density have access within 60 minutes.[1] The Institute of Medicine has recognized the disparity in trauma care access and has strongly recommended coordination, regionalization and accountability in its goals for pediatric emergency and trauma care.[2] The American College of Surgeons Committee on Trauma (ACS COT) states that injured children have special needs that “may be optimally provided in the environment of a children’s hospital with a demonstrated commitment to trauma care.”[3] For example, children with severe traumatic brain injury have improved survival when treated centers that follow national treatment guidelines. [4] However, only a small proportion of acute care hospitals have the resources to be called a trauma center (TC), a designation by the individual states or by ACS verification, and even fewer are pediatric trauma centers (PTC). The large number of injured children, compared to the scarcity of PTCs across the United States, dictates that injured children will be cared for in a variety of hospital settings.

Major trauma centers, including pediatric trauma centers, are generally located in urban settings with a high population density. This places children in rural settings at increased risk for poor outcomes from severe trauma. An analysis of the 2000 Kid’s Inpatient Database (KID) reported that 89% of injured children receive their care outside of a pediatric hospital; [5] a more in-depth analysis of these patients is not possible because the KID database provides neither clinical data nor the trauma center level of the hospital. The National Trauma Data Bank® (NTDB) is an important resource; however, only trauma centers submit data to the NTDB; it does not capture a representative sample of data from non-verified/non-designated trauma centers (NTC), thereby limiting its usefulness in studying the outcomes of children injured in rural areas. Currently, no single inventory exists to identify where injured children receive care, and no national system has been established to capture clinical data on large samples of pediatric trauma patients with pre-hospital and inpatient data from both trauma and non-trauma centers (NTC).[6] Therefore, there is little information on characteristics, outcomes and treatments of children at the first point of care, their mortality and transfer rates from non-trauma centers to trauma centers.

While great strides have been made to improve trauma care for children, the focus has traditionally been on trauma centers because these centers have the most scrutiny (from the state of ACS verification process) and submit most of the data to national registries. The magnitude and scope of pediatric trauma on a state, regional or national level cannot be understood until data are collected and analyzed from non-trauma centers that are part of a statewide system. Opportunities for improvement are limited unless pediatric trauma care provided at all hospitals is included in the data.

The study reported here seeks to take a critical step to address this current gap in research by analyzing data from the Ohio Trauma Registry to describe characteristics and injury patterns of patients at the first center where they receive care. Outcomes are evaluated based on mortality at the inital site or transfer to a higher level of care. The Ohio Trauma Registry is unique because it captures data from approximately 87% of Ohio hospitals, as required by law, including 138 NTCs. This analysis provides a unique statewide perspective on the transfer patterns and mortality for pediatric trauma victims.

Methods

The analysis is novel because it focused solely on the patient experience at the first hospital of care. Two outcomes for every unique admission were analyzed: death and transfer. For the purposes of this study, "transfer" is defined as an inter-hospital transfer to a higher level of care such as a transfer from non-trauma center (NTC) to any level trauma center (TC), from a Level 3 to a Level 1 or 2 TC, and from a Level 2 TC to a Level 1 TC.

Data were analyzed on 16,965 unique pediatric trauma admissions to Ohio hospitals in 2007-2012. To ensure patients were not double counted, these data included information on the first hospital that received the trauma patient. This full cohort was used to investigate in-hospital mortality. To investigate transfers to hospitals with a higher trauma level verification, Level 1 trauma centers were excluded as were admissions with unknown transfer destinations. Therefore a total of 12,061 hospital admissions were included in the analysis of patients transferred to a higher level of care.

Hospital identifiers were not available in the original dataset; however hospital characteristics included hospital size as measured by the number of inpatient beds, NTC or TC and TC level for the admitting hospital. If a patient was transferred to another hospital then the NTC/TC indicator and the level of TC, if applicable, were available for this hospital as well. To protect the anonymity of the hospitals, pediatric trauma centers were not distinguished from adult trauma centers.

Other variables included patient race, age, gender year of admission (2007-2012), time from injury to admission, and distance to the nearest TC. Trauma and injury severity information was recorded by the type of trauma, the Mechanism of Injury (MOI), Injury Severity Score (ISS) and Glasgow Coma Scale (GCS). The GCS was recorded two times, by an EMS team and at hospital admission by emergency department (ED). ED GCS data were substantially more complete than EMS and used in the analysis.

Statistical analysis

To preserve confidentiality, hospital identifiers were not available and the analysis was unable to directly account for hospital effect. Nevertheless, to *partially* control for patient clustering within hospitals, a new variable was created by cross-tabulating arrival center type (level 1, 2, 3 or NTC), distance to the closest trauma center, and hospital size. This approach identified 189 clusters among all admissions. Then, small clusters with less than ten admissions were aggregated into a single group. Thus, this new variable ended up with 155 categories and was used to account for clustering. Each cluster (a proxy-center) had 10 to 1573 admissions.

All statistical analyses accounted for cluster effect in the bivariate analyses of association and multiple logistic regressions for both in-hospital mortality and transfer outcomes. All standard errors and p-values were based on logistic regression models fitted with generalized estimating equations. Statistical software R 3.0 was used for all data analyses.

Small missing groups were excluded from consideration so that the amount of excluded missing data was never higher than 1% of the sample. Large missing data categories were considered as a separate group denoted by "Unknown" and included in all analyses. All continuous variables were categorized into meaningful categories.

Because in-hospital mortality and transfer are competing risks we analyzed these outcomes in a side-by-side manner with bivariate and multivariable analyses respectively. The bivariate associations are unadjusted for potential confounding variables. Results for associations that adjust for potential confounding are also reported using the omnibus p-values, as were post-hoc analyses to compare odds of mortality or transfer at each level of a variable versus its reference group. To decrease the number of false discovery findings the significance level was set to 1% for declaring significant findings. Post-hoc p-values were investigated and interpreted only when the omnibus p-value were significant. Interactions were tested for significance if cell counts after cross tabulation included at least 10 subjects with and at least 10 subjects without an event (death or transfer to a higher level of care). To account for significant interactions with injury severities we created three strata and analyzed them separately. Patients with GCS = 3 defined stratum 1 (n=142), patients not included in stratum 1 with ISS less than 15 or an unknown ISS defined stratum 2 (n=15078), and all other patients (ISS of 16 or more) defined stratum 3 (n=1745). Among 142 patients with GCS=3, only 39 were not admitted to level 1 TC, which is too small of a number for the regression analysis of transfer as the outcome. Area under receiver operator curve (AUC) along with its standard error was reported for all logistic regressions.

Results

Almost half of the patients were initially seen at a NTC, followed by admissions to Level 1 TC, and then a Level 2 TC and a Level 3 TC. As shown in Table 1, of those who were first seen at Level 1 TC, only 8.5% were transferred. These patients were either transferred to a lower level or another Level 1. Of those initially seen at a Level 2 TC, more than half were not transferred, whereas only 8.8% of those seen at a Level 3 were not transferred and only 2.3% of those seen at a NTC were not transferred. Table 2 shows bivariate associations with

mortality and transfer to a higher level of care. These associations are unadjusted for potential confounding variables.

Mortality (unadjusted associations)

Results of the bivariate analysis did not show a significant association between in-hospital mortality and patient age categories. However the mortality gradually decreased with age from 3% for less than one year old patients to 1% for subjects 10-15 years of age. The association with a continuous age was highly significant ($p<0.0001$) (data not shown). Those admitted to a Level 1 TC had the highest mortality as did those admitted to larger hospitals as indicated by the number of beds. Patients with self-pay insurance had the highest unadjusted mortality. Of the known mechanisms, suffocation/submerge/foreign bodies had the highest unadjusted mortality (31%) followed by gun shots wounds (17%) and mortality significantly increased with increasing injury severity as demonstrated by the ISS and GCS. As the miles between the first hospital of care to the closest trauma center increased, mortality decreased. Patients had the highest mortality after 24 hours since admission.

Transfer (unadjusted associations)

Age was significantly associated with being transferred when not controlling for other confounders. The percentage of patients transferred was highest in the self-pay group. The percentage of patients transferred increased with decreasing trauma center level and with smaller hospital size. The majority of patients with penetrating injury were transferred (84%). The percentage of patients transferred decreased with increasing injury severity score and with increasing head injury severity as demonstrated by lower GCS. Patients were most likely to be transferred within 24 hours of admission. As the miles between the first hospital of care and nearest trauma center increased, the percentage of patients transferred increased.

Logistic Regression Analyses

GCS=3 (Table 3)

Table 3 shows the results of the logistic regression analysis predicting mortality of patients admitted with a GCS = 3. The type of admitting hospital was the only significant predictor of mortality. This analysis was limited by the small number of patients because 74 of the 101 subjects admitted to a Level 1 TC did not survive. There were five deaths and one transfer among the 11 admissions to a Level 2 TC, four deaths and six transfers among 11 admissions to a Level 3 TC, and there were four deaths and 14 transfers among 18 admissions to NTCs.

Tables 4 and 5 show the results of the multivariate analyses that control for potential confounders and post-hoc analyses to compare odds of mortality or transfer at each level of a variable versus its reference group. Post-hoc p-values were investigated only when the omnibus p-value were significant (<1%). The variables not bivariately significantly associated with mortality or transfer for ISS<15 or ISS>15 were not considered for inclusion in the regression models.

Unknown ISS and ISS<15 (Table 4)

The multiple logistic regression analysis of in-hospital mortality was based on 15,008 admissions to the first hospital of care. The analysis of transfers to a higher level of care hospital was based on 11,255 admissions.

Age was significantly associated with both mortality and being transferred to a higher level of care hospital. The odds for mortality were highest for 1-3 year old patients and then gradually decreased with age. This age group was also associated with the highest adjusted odds of transfer..

The associations of mortality and transfer with type of admitting hospital were highly significant for these less severely injured patients. The odds of mortality in NTCs were 5 times lower than in Level 1 TCs; however, the majority of NTC patients were transferred, artificially decreasing NTC mortality. The odds of transfer from a NTC were almost 60 times higher than the odds of transfer from a Level 2 TC. Similarly a 40% decrease in mortality odds in Level 2 TC compared to a Level 1 TC and Level 3 TCs have an almost 25 fold increase in the odds of transfer compared to Level 2 TCs.

The mechanism of injury had multiple categories with relatively low numbers; therefore, the data were collapsed to compare motor vehicle collisions (MVC) to all other mechanisms of injury. There was no significant association between MVC and mortality, but MVC admissions were more likely to be transferred. The type of trauma (blunt or penetrating) was not significantly associated with mortality or transfer for these less severely injured patients.

There was no significant association between distance to the nearest trauma center and mortality; however the p-value for association between distance to the nearest trauma center and transfer approached the significance threshold (p=0.0105). Insurance type was also not significantly associated with mortality or transfer to a higher level of care hospital.

Time from injury to admission was not significantly associated with mortality. However, time from injury to admission was significantly associated with transfer, with patients admitted on the second day after injury two times less likely to be transferred to a higher level of care.

ISS>15 (Table 5)

For the more severely injured patients indicated by an ISS >15, the multiple logistic regression analysis of in-hospital mortality was based on 1,732 admissions for the first hospital of care. The analysis of transfers to a higher level of care hospital was based on 708 admissions (Level 1 TCs were omitted).

The association between age and mortality was highly significant, with 1-3 year old patients having the highest adjusted odds of mortality. However, there was no association between age and transfer to a higher level hospital.

The association between the type of admitting hospital and mortality was borderline statistically significant (p=0.0108). Patients admitted to TC Levels 2 and 3 had higher mortality; however, these odds were not significantly different from TC Level 1. The odds

of mortality were lowest in the NTC. Analogous to patients with less severe injuries, centers with lower verification levels have significantly higher transfer rates which reduced mortality odds. The odds of transfer to a higher level of care were highly significant for Level 3 TCs and NTCs compared to Level 2 TCs.

The odds of mortality were three times higher for a MVC as compared to all other mechanisms of injury. Furthermore, patients involved in a MVC were approximately three times less likely to be transferred to a higher level trauma center. Unlike patients with less severe injuries, the type of trauma (blunt or penetrating) was significantly associated with both mortality and transfer for more severe cases. Penetrating injuries had 10 times higher odds of death and 10 times lower odds of transfer.

Consistent with less severe injuries, there was no significant association between distance to the nearest trauma center and either outcome (mortality or transfer) for more severe cases. Although insurance was not significantly associated with transfer, self-pay patients had significantly higher mortality odds. Time from injury to admission was not significantly associated with mortality or transfer to a higher level of care.

Discussion

Because most injured children are treated in centers that lack trauma center designation and do not consistently, if at all, report trauma-related data, there is a significant gap in knowledge about this health disparity regarding the volume, treatments, transfer patterns and outcomes of injured children. The study reported here takes a critical step to address this current gap in research by analyzing data from the Ohio Trauma Registry for trauma-related characteristics, transfer patterns and mortality of injured children treated at the first point of care which includes both TCs and NTCs. This study is unique because it captures data from approximately 87% of Ohio hospitals, as required by law, including 138 non-trauma centers. It includes valuable information used in triage decision-making, such as the GCS, which categorizes severity of head injury and contributes to the pediatric triage decision for children suffering head injuries. Analysis of these existing data elements is an important component in the evaluation of a model state or regional trauma system, and is also information vital to increasing the basic knowledge about the characteristics, magnitude and outcomes of pediatric trauma for children treated in a variety of settings. This study is novel, as there is currently no literature that describes pediatric trauma at the first point of care from a statewide perspective that includes a large number of non-trauma centers. Almost half of the traumatically injured pediatric patients initially went to a center without any trauma level verification, more than a quarter went directly to a Level 1 center, and the rest to a Level 2 or a Level 3 center. The overall mortality was 1.5% for 16,965 patients. Of the 8,341 patients seen at a NTC, only 2% were not transferred, 72% were transferred to a Level 1 TC, 21% to a Level 2 TC, 3% were transferred to a different NTC. The bivariate analysis identified statistically significant predictors of mortality and being transferred for individual factors; however, some of these variables were not significant in the multivariate analysis suggesting confounding. In addition there were some variables that were correlated and could not both be used in the multivariate analysis such as hospital size and trauma center level.

Patients with a lower ISS had the highest percentage of patients transferred suggests that the majority of the most severely injured patients are going directly to a Level 1 center; however those with minor injuries are still being transferred to trauma centers. For the purposes of the analyses GCS was categorized as 3, 4-8, and 9-15 to allow for comparisons of mortality. The majority of patients with a GCS between nine and 15 were transferred (83%). The majority of patients were transferred within 24 hours of injury (91.7%). Patients were more likely to be transferred as the distance to nearest trauma center increased.

Subgroup analyses were conducted to account for interactions with injury severity. Almost all of the patients with a GCS of 3 were first seen at a level one trauma center and the mortality rate was very high (61.3%). Therefore this group was considered as a separate stratum and only trauma center level was significantly associated with mortality. This indicates that the most severe head injuries are going directly to a level 1 trauma center. The subgroup analysis of severely injured patients confirmed that the younger patients have a higher mortality rate and there was no association between transfer and age, indicating that they were most likely going directly to a level 1 trauma center. Penetrating injuries also had a higher odds of mortality and lower odds of transfer. Younger patients (<4 years old) with a lower injury severity also had a higher odds of mortality and those < 7 had a higher odds of being transferred. While mortality was extremely low at NTCs almost all patients were transferred regardless of severity, resulting in some bias in the mortality rate.

A limitation to this analysis is that it could not distinguish between a pediatric Level 1 trauma center and an adult Level 1 trauma center. This was unavailable from the state trauma registry because there were other data such as distance to nearest trauma center, and when combined with the small number of pediatric trauma centers, could potentially threaten anonymity. From 2008 to 2010 there was a significant decrease in odds of being transferred when compared to 2007. In 2011 and 2012 the odds of being transferred were similar to 2007. Trauma center designation varies years to year and could have an effect on the analysis. Almost all of the patients seen at NTCs were transferred and the odds of being transferred to a higher level of care were also high Level 3 centers compared Level 2.

Trauma registries are generally implemented in verified or designated trauma centers as part of the requirement for verification. There is little or no incentive for NTCs to capture routine trauma data. Therefore most large retrospective analyses of trauma data use data collected through hospital and state registries or the NTDB. In this analysis almost half of the patients went directly to a NTC before being transferred. The information captured at these centers fills an important gap in trauma systems research. The results of these analyses suggest that patients who are first seen at a NTC have very low mortality and high rates of transfer. The mortality rate is highest at Level 1 centers who are receiving the most severely injured patients. It is interesting to note that the NTCs are transferring almost 98% of their patients, even those with very low ISS. Trauma centers are required to be available 24 hours a day, 7 days a week are designed to provide optimal care for severely injured patients requiring specialized services. This level of commitment by trauma centers requires significant investments in readiness.[7] Further evaluation of the outcomes and characteristics of patients transferred from NTCs will provide important information to inform the triage guidelines to

potentially safely avoid transfer of less severely injured patients from NTCs in their community.

Conclusions

The direct and indirect financial burden caused by trauma is a social cost that could be reduced by more effective mechanisms for resource allocation, triage and treatment, if adequate data were available to direct resource planning and outcomes evaluation. Research and data collection can dramatically improve outcomes in pediatric trauma, as with any other disease.

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Table 1

Trauma Level of Admitting Hospital by Discharge Destination (N=16,965)

	Admitting Hospital							
Discharge Destination	**TC level 1**		**TC level 2**		**TC level 3**		**NTC**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Not Transferred	4354	92.5%	1266	56.0%	146	8.8%	192	2.30%
TC Level 1	67	1.4%	423	18.7%	658	39.7%	6033	72.33%
TC Level 2	26	0.6%	453	20.0%	662	40.0%	1788	21.44%
TC Level 3	0	0.0%	0	0.0%	0	0.0%	29	0.35%
NTC	8	0.2%	45	2.0%	29	1.8%	251	3.01%
Died	195	4.1%	49	2.2%	19	1.1%	18	0.22%
Missing	57	1.2%	25	1.1%	142	8.6%	30	0.36%
Total	4707	100.0%	2261	100.0%	1656	100.0%	8341	100.00%

Table 2

Bivariate analyses of association with in-hospital mortality and transfer

Variable	Total	Died	P-value	Total Transferred[a*]	Transfer to a Higher Level[a]	P-value
Total	**16965**	**281**		**12061**	**9593**	
	N	**%**		**N**	**%**	
Age in Years			0.4307			<0.0001
<1	1500	3.1%		963	74.3%	
1-3	3189	2.7%		2381	83.3%	
4-6	2876	1.3%		2187	84.2%	
7-9	2665	0.9%		1996	80.2%	
10-15	6735	1.3%		4534	76.2%	
Missing[c]	43	0.0%		41	95.1%	
Gender			0.8974			0.4257
Male	10936	1.6%		7835	79.3%	
Female	6012	1.7%		4213	79.9%	
Missing[c]	17	11.8%		13	92.3%	
Insurance			<0.0001			0.0009
Commercial	7880	1.0%		6188	79.5%	
Government	5638	1.9%		3999	76.2%	
Self Pay	1354	3.3%		1067	83.3%	
Unknown	2093	2.4%		807	91.2%	
Admission Year			0.767			0.181
2007	2874	1.7%		1968	82.1%	
2008	2966	1.9%		1979	74.4%	
2009	2732	1.7%		1976	78.3%	
2010	2785	1.8%		2064	78.2%	
2011	2565	1.4%		1884	80.8%	
2012	3043	1.5%		2190	83.2%	
Admitting Hospital Trauma Level			0.0002			<0.0001
1	4707	4.1%		-	-	
2	2261	2.2%		2236	18.9%	
3	1656	1.2%		1514	87.2%	
NTC	8341	0.2%		8311	94.5%	
Hospital Size			0.0008			<0.0001
0-99 Beds	2929	0.3%		2922	94.6%	
100-299 Beds	7891	1.0%		6892	79.5%	

Variable	Total	Died	P-value	Total Transferred[a*]	Transfer to a Higher Level[a]	P-value
Total	**16965**	**281**		**12061**	**9593**	
	N	**%**		**N**	**%**	
300+ Beds	6121	3.2%		2223	59.6%	
Missing[c]	24	0.0%		23	95.7%	
Mechanism of Injury			<0.0001			0.4825
Gun Shot	132	17.4%		54	79.6%	
Motor Vehicle Collision	4656	2.8%		3006	75.5%	
Suffocation/ Submerge/ Foreign Bodies	90	31.1%		43	65.1%	
Other	7915	0.2%		6048	81.5%	
Unknown	4172	2.0%		2910	79.8%	
Type of Trauma			0.1027			0.0019
Blunt	15357	1.6%		11020	79.1%	
Penetrating	1608	2.2%		1041	83.8%	
Injury Severity Score			<0.0001			<0.0001
1-7	11622	0.6%		9031	83.9%	
8-14	3362	1.0%		2202	69.1%	
15-25	1337	4.9%		621	61.2%	
26-75	487	23.0%		106	23.6%	
Unknown	157	0.6%		101	91.1%	
Glasgow Coma Scale			<0.0001			0.0003
3	142	61.3%		39	53.9%	
4-8	129	7.8%		52	78.9%	
9-15	8882	0.1%		5364	83.0%	
Unknown	7812	2.2%		6606	76.9%	
Time from admission to event			0.0107[b]			<0.0001
< 24 hrs	10512	1.7%		10288	91.7%	
24-71.99 hrs	2860	2.5%		811	1.0%	
72+ hrs	3198	1.0%		808	0.7%	
Unknown	395	0.0%		154	91.6%	
Miles to the closest Trauma Center			<0.0001			<0.0001
0	4706	4.1%		-	-	
0.1-9.9	3343	1.4%		3196	56.7%	
10-29.9	5150	0.5%		5127	85.6%	
30+	3735	0.4%		3708	90.8%	

Variable	**Total**	**Died**	**P-value**	**Total Transferred[a*]**	**Transfer to a Higher Level[a]**	**P-value**
Total	**16965**	**281**		**12061**	**9593**	
	N	**%**		**N**	**%**	
Missing[c]	31	0.0%		30	86.8%	
Time from injury to admission			0.048			0.4257
< 24 hrs	15771	1.7%		11451	80.7%	
24+ hrs	1142	1.0%		581	57.7%	
Missing[c]	52	1.9%		29	58.6%	

[a]Admissions with unknown transfer destinations were excluded.

[b]P-value is based on the categories with nonzero mortality (the Unknown is excluded from the calculation).

[c]The groups denoted by “Missing” are excluded from P-value calculations.

*Excluding admissions to trauma center level 1.

Table 3

Results of Multivariate Logistic Regression Analyses of Factors Associated with In-hospital mortality for GCS=3

	Mortality (n=142)[a] AUC=0.65	
Variable	**OR (95% CI)**	**P-value***
Admitting Hospital Trauma Level		<0.0001
1	REF	
2	0.30 (0.08-1.21)	0.0922
3	0.18 (0.06-0.59)	0.0049
NTC	0.10 (0.03-0.34)	0.0002

Table 4

Results of Multivariate Logistic Regression Analyses of Factors Associated with In-hospital mortality and Transfer for Unknown ISS and ISS <15

	Mortality (n=15008)[a] AUC=0.78		Transfer (n=11255) AUC = 0.88	
Variable	**OR (95% CI)**	**P-value***	**OR (95% CI)**	**P-value***
Age in Years		**0.0043**		**<0.0001**
<1	2.24 (0.92, 5.43)	0.0760	1.62 (1.17, 2.24)	0.0039
1-3	3.08 (1.59, 5.99)	0.0010	1.90 (1.55, 2.34)	<0.0001
4-6	1.56 (0.76, 3.19)	0.2297	1.72 (1.40, 2.11)	<0.0001
7-9	0.76 (0.28, 2.02)	0.5813	1.21 (1.00, 1.46)	0.0575
10-15	REF		REF	
Admitting Hospital Trauma Level		0.0001		<0.0001
1	REF		-	
2	0.86 (0.43, 1.74)	0.6828	REF	
3	0.62 (0.22, 1.71)	0.3595	24.03 (15.33, 37.66)	<0.0001
NTC	0.16 (0.07, 0.38)	<0.0001	59.73 (42.64, 83.65)	<0.0001
Motor Vehicle Collision		0.2517		0.0007
No	REF		REF	
Yes	1.43 (0.78, 2.60)	0.2517	1.32 (1.12, 1.54)	0.0007
Miles to the closest Trauma Center[b]		0.5030		0.0105
0-9.9	1.42 (0.54, 3.77)	0.4838	0.62 (0.43, 0. 90)	0.0124
10-29.9	0.86 (0.33, 2.28)	0.6789	0.74 (0.58, 0.93)	0.0109
30+	REF		REF	
Type of Trauma		0.0312		0.9923
Blunt	REF		REF	
Penetrating	2.09 (1.07, 4.08)	0.0312	1.00 (0.77, 1.29)	0.9923
Insurance		0.0231		0.1903
Commercial	REF		REF	
Government	2.61 (1.35, 5.05)	0.0044	0.97 (0.82, 1.15)	0.7381
Self-Pay	3.08 (1.25, 7.64)	0.0154	1.23 (0.96, 1.57)	0.1028
Unknown	2.02 (0.88, 4.65)	0.1001	1.32 (0.86, 2.05)	0.2066
Time from injury to admission		0.0827		<0.0001
<24 hrs	REF		REF	
24+ hrs	0.34 (0.10, 1.15)	0.0827	0.55 (0.43, 0.72)	<0.0001

*Omnibus p-values are in shaded rows

[a]records with missing distance to the closest TC, missing time from injury to admission were removed; records with missing transfer information were removed from the analysis of Transfer

[b] Two categories of distance to TC (“0” and “0.1-9.9”) were merged together into “0-9.9” to avoid singular design matrix in the regression model fit. The effect of TC level 1 is accounted for by the type of admitting hospital.

Table 5

Results of Multivariate Logistic Regression Analyses of Factors Associated with In-hospital mortality and Transfer for $16 \leq ISS < 75$[*]

	Mortality (n=1732)[a] AUC = 0.71		Transfer (n=708)[a] AUC = 0.94	
Variable	**OR (95% CI)**	**P-value[*]**	**OR (95% CI)**	**P-value[*]**
Age in Years		**<0.0001**		**0.9490**
<1	2.53 (1.30, 4.94)	0.0067	0.75 (0.34, 1.67)	0.4852
1-3	3.81 (2.26, 6.40)	<0.0001	0.81 (0.40, 1.64)	0.5665
4-6	1.46 (0.74, 2.87)	0.2804	0.94 (0.42, 2.09)	0.8789
7-9	0.92 (0.48, 1.78)	0.8078	0.77 (0.27, 2.17)	0.6190
10-15	REF		REF	
Admitting Hospital Trauma Level		0.0108		<0.0001
1	REF		-	
2	1.52 (1.00, 2.32)	0.0538	REF	
3	1.72 (0.51, 5.82)	0.3870	50.67 (17.92, 143.28)	<0.0001
NTC	0.26 (0.08, 0.90)	0.0343	288.72 (108.75, 766.51)	<0.0001
Motor Vehicle Collision		<0.0001		0.0003
No	REF		REF	
Yes	3.07 (1.82, 5.18)	<0.0001	0.32 (0.18, 0.59)	0.0003
Miles to the closest Trauma Center[b]		0.0727		0.5039
0-9.9	1.52 (0.50, 4.65)	0.4657	0.88 (0.28, 2.74)	0.8291
10-29.9	0.36 (0.10, 1.34)	0.1316	0.64 (0.27, 1.55)	0.3277
30+	REF		REF	
Type of Trauma		<0.0001		0.0005
Blunt	REF		REF	
Penetrating	10.49 (4.87, 22.59)	<0.0001	0.10 (0.03, 0.37)	0.0005
Insurance		0.0003		0.8663
Commercial	REF		REF	
Government	0.81 (0.52, 1.25)	0.3372	1.01 (0.56, 1.80)	0.9841
Self-Pay	2.09 (1.21, 3.58)	0.0080	1.44 (0.57, 3.61)	0.4439
Unknown	1.68 (0.88, 3.21)	0.1151	0.99 (0.26, 3.81)	0.9865
Time from injury to admission		0.2984		0.0326
<24 hrs	REF		REF	
24+ hrs	0.64 (0.28, 1.47)	0.2984	0.40 (0.17, 0.92)	0.0326

[a]records with missing distance to the closest TC, missing time from injury to admission were removed; records with missing transfer information were removed from the analysis of Transfer

[*]Omnibus p-values are in shaded rows

[b]Two categories of distance to TC ("0" and "0.1-9.9") were merged together into "0-9.9" to avoid singular design matrix in the regression model fit. The effect of TC level 1 is accounted for by the type of admitting hospital.

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