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Emergency Medical Services (EMS) versus non-EMS transport among injured children in the United States

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Abstract

Objectives—This study aimed to assess the proportions of injured children transported to trauma centers by different transportation modes and evaluate the effect of transportation mode on inter-facility transfer rates using the U.S. national trauma registry.

Methods—We analyzed data from the 2007–2012 National Trauma Data Bank (NTDB) to study trends of EMS versus non-EMS transport. Multivariable logistic regression was used to evaluate the association between transport mode and inter-facility transfer.

Results—There were 286,871 pediatric trauma patients in the 2007–2012 NTDB; 45.8% arrived by ground ambulance, 8.6% arrived by air ambulance, and 37.5% arrived by non-EMS. From 2007–2012, there was no significant change among each transportation mode. Moderate to severely injured patients (ISS>15) comprised 13.3% of arrivals by ground ambulance, 26.7% of arrivals by air ambulance, and 8.3% of arrivals by non-EMS; those who used EMS were significantly less likely to be transferred to another facility than patients who used non-EMS transport. Moderate and severe pediatric patients arriving by non-EMS to adult trauma centers were more often transferred than those arriving at mixed trauma centers (45.8% and 6.8%, respectively).

Conclusions—Over one third of US pediatric trauma patients used non-EMS transport to arrive at trauma centers. Moderate to severely injured children benefit from EMS transport and

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professional field triage to reach the appropriate trauma facility. Our study suggests that national efforts are needed to increase awareness among parents and the general public of the benefits of EMS transportation and care.

Keywords

pediatrics; transportation; ambulance; inter-facility transfer; injured children

Introduction

Each year in the United States, about 7.4 million children 1–17 years old are treated for nonfatal injuries at U.S. emergency departments and 7,000 die from unintentional injuries.¹ In the past 4 decades, regionalized trauma care has been promoted in the U.S. as the best approach for matching patient needs with the available resources and provider expertise to achieve optimal patient outcomes.^{2–5} Previous research has shown that trauma centers achieve better outcomes among severely injured patients than non-trauma centers; however, it has been found that about one-third of patients with severe injuries were treated at non-trauma centers or level III trauma centers.^{3,6} Transportation to the hospital via Emergency Medical Service (EMS) is important in caring for trauma patients for several reasons.

EMS personnel are trained professionals who have the best knowledge about which hospitals injured patients should be transported to in order to receive optimal treatment.⁷ Patients using non-EMS transport may travel to the nearest hospital rather than the most appropriate. In addition, using EMS protects patients who have sustained a spinal cord injury, and can relay the need for a trauma team activation to the necessary healthcare specialists in the ED.⁸ However, the Centers for Disease Control and Prevention (CDC) has estimated that only 18% of injured patients in the U.S. were transported by EMS in 2008; this has not been well studied in pediatric trauma patients.¹ In one suburban pediatric emergency department, only 13% of high-acuity patients had arrived by ambulance, and a national study using the National Hospital Ambulatory Medical Care Survey (NHAMCS) confirmed this underutilization of EMS in the pediatric community, finding a 3-fold decrease in pediatric patients arriving by EMS compared to adult patients.^{9,10}

Pediatric trauma patients may require special age-appropriate treatment and medical equipment that are not universally available at non-trauma or adult trauma centers.¹¹ Despite these unique needs, Shah et al. found that many high-urgency pediatric patients arrive via non-EMS, lacking the specialized judgment of EMS providers.¹² In comparing non-trauma centers and level I–III trauma centers, one study found that 98% of non-trauma center patients are transferred to a higher level trauma center; this study, however, did not distinguish between pediatric and adult trauma patients.¹³

A recent analysis of the NHAMCS has shown that within the past 10 years, there has been no change in the percentage of patients using EMS transportation.¹⁴ The specific patterns and needs of pediatric trauma patients, however, have not been well-studied. The purpose of our study was to look specifically at pediatric trauma patients and assess the proportion who are transported by different transportation modes, identify risk factors for not using EMS transportation, and evaluate how non-EMS transportation affects outcomes after injury.

Findings from this research study are of national significance and will provide scientific evidence to fill knowledge gaps in pediatric emergency care for injured children in the United States.

Methods

Data Source and Study Population

The National Trauma Data Bank (NTDB) is the largest US trauma registry assembled. We utilized NTDB data from 2007–2012. The study population was injured children (=15 years) defined by the ICD-9-CM diagnosis codes 800-959.^{15,16} Patients who had injuries due to the following conditions were excluded: late effects (905-909); superficial injuries (910-924); foreign bodies (930-939); burns (940-949).¹⁷

The NTDB contains variables describing the different transportation modes (ground versus helicopter versus fixed-wing ambulance), in addition to non-EMS transportation modes (private or public vehicle or walk-in, police). We included patient demographics, insurance status and the following injury characteristics: injury mechanism, injury type (penetrating vs. blunt) and injury severity. We used Injury Severity Scores (ISS) in the NTDB (generated by the ICD 90 Mapping Program). We included patients arriving from the scene of injury, and excluded inter-facility hospital transfers. We described hospitals by mean pediatric trauma patient volume, and trauma center type (adult, pediatric, or mixed center). The NTDB only includes data from hospitals with trauma center designation (either by American College of Surgeons verification or state designation).

Statistical Analyses

We assessed the trends of each transportation mode utilized by injured U.S. children during 2007–2012. To identify risk factors associated with EMS versus non-EMS transport, we used multivariable logistic regression models to calculate odds ratios of being transported by EMS personnel. The dependent variable was transportation to the hospital by EMS or non-EMS. The independent variables included patient, family, and hospital characteristics.

We then restricted our analysis to moderately and severely injured children because these children are at highest risk of mortality and adverse outcomes and should be immediately transferred to higher level trauma centers if initially transported to non-trauma hospitals. To assess and compare potential outcomes between those who were transported by EMS versus non-EMS, we used multivariable logistic regression models where the dependent variables included transfer to another facility (Yes/No), in-hospital mortality, and length of stay. The independent variable of interest was EMS versus non-EMS transport. Potential confounders included age, gender, race, insurance, mechanism of injury, ISS, trauma center type, and mean pediatric volume of the hospital. Statistical significance was indicated by two-sided P-values <0.05.

Results

A total of 286,871 pediatric patients under 15 years old from the NTDB were included in this study (Table 1). From 2007–2012, pediatric patients were more likely to use ground

ambulance than any other form of transportation to get to the ED (45.8%). The second most common form of transportation was private/public vehicle/walk-in (37.5%). There was no significant difference in transportation mode between 2007 to 2012.

Patient characteristics by transportation mode

Table 2 shows patient characteristics by transportation mode. Most patients were male (65.0%) and over half were white (57.4%). The majority of injuries were blunt (94.9%) and the most common mechanism was a fall (44.1%). The most common ISS was between 4–8 (53.6%).

Patients who used non-EMS were more likely to be children between the ages of 5–10 (35.5%), males (63.8%), and white (61.8%). Non-EMS transported pediatric trauma patients were more likely to be transported to an adult trauma center (48.1%) and EDs of hospitals with average pediatric inpatient volumes between 1–126 patients (41.2%). Patients most likely to use ground ambulance were trauma patients between 11–15 years old (47.1%), transported to adult trauma centers (43.4%), and to EDs of hospitals with average pediatric inpatient volumes of 1–126 (31.5%). The majority of pediatric trauma patients who used air ambulance were involved in road accidents (71.8%) and sustained blunt injuries (96.1%).

Transfer rates in moderate and severe pediatric trauma patients

Table 3 shows transfer rates by trauma center type and transportation mode for moderate and severe pediatric trauma patients (ISS>15). Over 27% of these pediatric patients using adult trauma centers (ATCs) were transferred to another facility. Patients who were transported via ground and air ambulance were less likely to be transferred compared to patients who used non-EMS transportation. Patients transported via ground ambulance were less likely to be transferred compared to non-EMS transported patients (adult trauma center: AOR 0.69, 95% CI 0.61–0.78; mixed trauma center: AOR 0.42, 95% CI 0.31–0.56), and patients who were transported via air ambulance were also less likely to be transferred compared to non-EMS transported trauma patients (adult trauma center: AOR 0.30, 95% CI 0.25–0.37; mixed trauma center: AOR 0.22, 95% CI 0.14–0.36). Those who arrived at pediatric trauma centers were extremely unlikely to be transferred (0.2%). There were too few patients who were transferred out of pediatric trauma centers to calculate meaningful transfer rates (n=8), so odds ratios are not reported.

Mortality and length of stay

Table 4 shows mortality rates and lengths of stay for moderate and severe pediatric trauma patients (ISS>15).

Compared to non-EMS transported pediatric trauma patients, in-hospital mortality was significantly higher in patients who used ground ambulance (AOR 5.41, 95% CI 3.96–7.39) or air ambulance (AOR 5.53, 95% CI 3.99–7.66). Patients who used ground or air ambulance had a longer LOS (6.6 ± 9.6 days, 9.5 ± 12.5 days, respectively) than non-EMS transported patients (2.8 ± 4.2 days, $P < 0.01$). 45.8% of patients used ground ambulance and 8.6% used air ambulance between 2007–2012 (Table 1). Multivariate models (Table 4)

showed that patients who used ground ambulance had a shorter LOS (1.95 days longer than private transport) compared to air ambulance (4.42 days longer than private transport).

Discussion

Our study investigated the proportion of injured US children who are transported by EMS versus non-EMS transportation from 2007 to 2012. Our finding that there had not been a significant change in transportation by EMS versus non-EMS from 2007 to 2012 supports previous research using the NHAMCS that there has been no change in EMS transportation usage in the past 10 years.¹⁴

Although inter-facility transfer is commonly used as an outcome measure, this factor is also under-studied in the pediatric population.^{8,18,19} Over 45% of pediatric trauma patients with moderate to severe injuries (ISS>15) transported via non-EMS to an adult trauma center required inter-facility transfer; in contrast, those who used EMS to reach an adult trauma center were less likely to require subsequent inter-facility transfer. As previously discussed, this may be due to proximity or field triage guidelines used by the trained EMS personnel. For children with minor injuries, EMS transportation may not be necessary;^{18,20–22} however, for parents of moderately injured children who forego EMS transportation due to the expensive cost and co-pay, communities may benefit from education about the increased capabilities of pediatric designated trauma centers to care for their children.

In looking at outcomes, our results suggest that non-EMS transportation did not have a significant negative impact on in-hospital mortality or LOS; these findings should be interpreted with caveats. One plausible reason could be that non-EMS transported patients were significantly more likely to be transferred out of the hospital.¹³ Trauma patients who originally arrived by EMS may be field triaged to the appropriate hospital and significantly less likely to be transferred out of the trauma center. Unfortunately, we do not know the final outcomes of these non-EMS transported patients after transfer from the trauma center. A second caveat is that pediatric trauma patients who used EMS were not matched by in-hospital mortality risk or underlying factors determining LOS, such as transportation time, an important factor in treating severely injured patients.^{8,22} The first hour after injury, or “golden hour,” is important in determining trauma outcomes, and although EMS transport ensures appropriate field triage, it may take more than one hour to receive care. Our study was not able to control for transport time because it was not reported by private transporters.

The large number of trauma centers and pediatric trauma cases in the NTDB are major strengths of this study; there are, however, several limitations in our study. The NTDB does not include non-trauma hospitals, thus the data may not be representative of all hospitals. The majority (77.78%) of cases in the NTDB are from a level I trauma center.²³ Data from non-trauma centers are necessary to assess how children with different injury severities are transported to different levels of trauma centers, and how EMS and non-EMS transportation affects inter-facility transfer rates and final outcomes. Currently, there is not a national data source to our knowledge that captures data on trauma center levels, inter-facility transfer rates, and subsequent outcomes. Future studies need to address this challenge and find a way to track trauma patients’ medical care encounters in the regional trauma system and link

patients' outcomes with trajectories of care. Another limitation is that travel time in those transported via non-EMS is not known. Thus, we do not know whether travel time was significant in determining transfer to an adult versus pediatric center.

Conclusions

Our study found that 37.5% of U.S. pediatric trauma patients reached the ED via non-EMS transportation, and over 45% of pediatric trauma patients transported via non-EMS to an adult trauma center required inter-facility transfer. Our findings underscore a need for national policy discussion about how to implement field triage guidelines and educate parents and caregivers on the importance of using professional EMS personnel for transportation of children with moderate to severe injuries.

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Table 1

Transportation mode by year among pediatric trauma patients, NTDB 2007–2012

Transportation mode	Year						
	2007	2008	2009	2010	2011	2012	Total
Private/Public Vehicle/Walk-in	10,749	14,919	17,686	20,168	21,559	22,468	107,549
Ground Ambulance	15,514	20,959	21,342	23,966	24,414	25,195	131,390
Helicopter Ambulance	3,608	4,540	4,081	4,184	4,159	3,959	24,531
Fixed-wing Ambulance	11	14	12	11	9	15	72
Police	311	343	334	200	158	214	1,560
Other	336	122	129	182	111	121	1,001
Missing	5,130	3,811	3,238	3,164	2,760	2,665	20,768
Total	35,659	44,708	46,822	51,875	53,170	54,637	286,871
% of private/public vehicle/walk-in	30.1	33.4	37.8	38.9	40.5	41.1	37.5
% of ambulance transported	53.7	57.1	54.3	54.3	53.8	53.4	54.4
% of ground ambulance	43.5	46.9	45.6	46.2	45.9	46.1	45.8
% of air ambulance	10.1	10.2	8.7	8.1	7.8	7.3	8.6

Table 2
Characteristics of pediatric trauma patients by transportation mode, NTDB 2007–2012

	Private/Public Vehicle/Walk-in		Ground Ambulance		Air Ambulance	
	# patients	%	# patients	%	# patients	%
Total	107,549	100.0	131,390	100.0	24,603	100.0
Age						
<1	15,111	14.1	10,193	7.8	1,342	5.5
1–4	23,805	22.1	21,461	16.3	3,931	16.0
5–10	38,129	35.5	37,818	28.8	7,157	29.1
11–15	30,504	28.4	61,918	47.1	12,173	49.5
Gender						
Male	68,638	63.8	86,681	66.0	15,863	64.5
Female	38,812	36.1	44,648	34.0	8,730	35.5
Race						
(1)White	66,450	61.8	67,612	51.5	17,087	69.5
(2)Black	15,347	14.3	28,539	21.7	2,189	8.9
(3)Other	25,752	23.9	35,239	26.8	5,327	21.7
Mechanism						
Fall	70,383	65.4	41,646	31.7	4,309	17.5
Road accident	17,858	16.6	66,839	50.9	17,658	71.8
Struck by/against	14,797	13.8	14,363	10.9	1,499	6.1
Cut/pierce	3,187	3.0	3,492	2.7	426	1.7
Firearm	970	0.9	4,678	3.6	542	2.2
Other	354	0.3	372	0.3	169	0.7
Injury type						
Blunt	103,387	96.1	123,211	93.8	23,634	96.1
Penetrating	4,162	3.9	8,179	6.2	969	3.9
Severity (ISS)						
1–3	15,426	14.3	24,940	19.0	3,092	12.6
4–8	68,668	63.8	55,391	42.2	7,301	29.7

	Private/Public Vehicle/Walk-in		Ground Ambulance		Air Ambulance	
	# patients	%	# patients	%	# patients	%
9–15	9,748	9.1	22,245	16.9	5,314	21.6
16–24	8,214	7.6	12,515	9.5	3,924	15.9
25–75	706	0.7	4,997	3.8	2,662	10.8
Payment						
Private	51,171	47.6	56,570	43.1	11,002	44.7
Public	36,704	34.1	43,597	33.2	7,666	31.2
Self-pay	6,671	6.2	10,854	8.3	2,045	8.3
Other	13,003	12.1	20,369	15.5	3,890	15.8
Trauma center type						
(1)Adult center	51,775	48.1	57,006	43.4	7,637	31.0
(2)Pediatric center	18,745	17.4	20,503	15.6	4,601	18.7
(3)Mixed center	28,009	26.0	47,579	36.2	11,640	47.3
Mean pediatric volume						
(1)1–126	44,298	41.2	41,378	31.5	4,077	16.6
(2)127–330	24,004	22.3	36,283	27.6	6,929	28.2
(3)331–743	20,438	19.0	31,643	24.1	7,947	32.3
(4)744–1453	18,809	17.5	22,086	16.8	5,650	23.0

Table 3

Transfer rates by trauma center type and transportation mode, moderate and severe pediatric trauma (ISS>15), NTDB 2007–2012

	# Patients	Transfer-out	% Transfer	AOR*	95% CI
Total	30,748	4,365	14.2		
Adult center					
Private/Public Vehicle/Walk-in (ref.)	4,168	1,910	45.8	1.00	
Ground Ambulance	7,935	1,878	23.7	0.69	(0.61 – 0.78)
Air Ambulance	2,145	187	8.7	0.30	(0.25 – 0.37)
Sub total	14,248	3,975	27.9		
Pediatric center					
Private/Public Vehicle/Walk-in	1,408	1	0.1		
Ground Ambulance	2,200	3	0.1		
Air Ambulance	984	4	0.4		
Sub total	4,592	8	0.2		
Mixed center					
Private/Public Vehicle/Walk-in (ref.)	2,440	166	6.8	1.00	
Ground Ambulance	6,278	182	2.9	0.42	(0.31 – 0.56)
Air Ambulance	3,190	34	1.1	0.22	(0.14 – 0.36)
Sub total	11,908	382	3.2		

* Adjusted by age, gender, race, insurance, mechanism of injury, ISS, mean pediatric volume of the hospital.

Mortality rates and length of stay, moderate and severe pediatric trauma (ISS>15), NTDB 2007–2012

Table 4

Mortality	Raw data			Multivariate modeling*		
	# Patients	Died in ED or in hospital	% Death	AOR	95% CI	P value
Private/Public Vehicle/Walk-in (ref.)	6,379	67	1.1	1.00		
Ground Ambulance	14,923	1,715	11.5	5.41	(3.96 – 7.39)	<0001
Air Ambulance	6,277	775	12.3	5.53	(3.99 – 7.66)	<0001
Length of stay in hospital	Raw data			Multivariate modeling**		
	# Patients	Mean LOS	SD	Parameter estimate	95% CI	P value
Private/Public Vehicle/Walk-in (ref.)	6,365	2.8	4.2	0.00		
Ground Ambulance	14,879	6.6	9.6	1.95	(1.61 – 2.29)	<0001
Air Ambulance	6,265	9.5	12.5	4.42	(4.01 – 4.84)	<0001

* Logistic regression model, adjusted by age, gender, race, insurance, mechanism of injury, ISS, trauma center type, and mean pediatric volume of the hospital

** Linear regression model, adjusted by age, gender, race, insurance, mechanism of injury, ISS, trauma center type, and mean pediatric volume of the hospital