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# The influence of age on transfer of pediatric trauma patients after initial transport to hospitals with a higher capacity for general emergency care

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**Objective:** The aim of this study was to investigate factors associated with the decision to transfer, rather than admit, pediatric trauma patients who were initially transported to emergency departments with a high capacity for general emergency care (regional emergency centers, RECs).

**Methods:** In this retrospective analysis of the 2014 emergency medical services (EMS) sample of injured pediatric patients, we included injured patients below 19 years of age who were transported by EMS to an REC. The main exposure variable was age, which was categorized into four groups by 5-year intervals. The primary outcome was the emergency department (ED) disposition of the patients (admission versus transfer). A multivariable logistic regression analysis was conducted to estimate the effect of age group on ED disposition.

**Results:** Data from 2,031 patients were analyzed. The transfer rate was 49.5%. In a univariate analysis, no statistically significant associations were found between severity or age group and ED disposition (19.9% vs. 18.6%,  $P=0.76$ ; 20.1% vs. 16.8%,  $P=0.49$ ; respectively). After adjusting for potential covariates, age group had a significant effect on transfer. When compared to 15-19 years old, the younger age groups had higher adjusted odds ratios (aORs) for transfer (0-4 years old, aOR 7.65 [95% CI, 1.24 to 47.38]; 5-9 years old, aOR 14.48 [95% CI, 2.08 to 100.55]; 10-14 years old, aOR 5.03 [95% CI, 10.5 to 26.79]).

**Conclusion:** Younger pediatric patients with moderate to severe trauma are more likely to be transferred to another hospital despite initial transportation to a REC.

**Keywords:** Trauma; Pediatric emergency medicine; Patient transfer

## INTRODUCTION

Trauma is a leading cause of mortality among infants and children over the age of one [1]. It is also a significant cause of physical disabilities that may pose a long-term impact

on quality-of-life for both children and their families [2,3]. To improve outcomes, regionalization of care for severe pediatric trauma was developed in several western countries, such as the United States, France, and Austria [4–6]. Inter-hospital transfer (IHT) is one of the crucial components in the success of the regionalized trauma systems. A recent meta-analysis of IHT effects in trauma patients revealed an inconsistency in pooled estimated mortality rates between transfer and direct admission groups [7].

Successful development of regional pediatric trauma care systems has necessitated a more meticulous investigation into the factors associated with IHT of pediatric trauma patients. Previous studies have reported that trauma severity or medical insurance status were predictive factors of transfer to a trauma center [8,9]. Whereas in pediatric trauma patients, age has been reported as a key determinant in the decision to transfer [10]. Most previous studies however, have focused only on patients who undergo transfer from non-trauma center [8–10]. Few studies have focused specifically on transfer from hospitals with a high capacity, despite the secondary triage in such hospitals was crucial factors to regionalization strategies.

Having identified these gaps in both research and practice within emergency departments (EDs), the aim of the present study was to investigate factors associated with IHT among pediatric trauma patients who were initially transported to ED with a high capacity for general emergency care (regional emergency centers, RECs).

## METHODS

### Ethics statement

The Institutional Review Boards (IRB) approved the study and waived the need for informed consent (IRB No: H-1509-119-705).

### Study setting

In Korea, EDs are designated as one of three types by the Ministry of Health and Welfare, according to their available resources and functional requirements. These three types are RECs, local emergency centers (LECs), and local emergency facilities (LEFs) [11]. RECs are the highest EDs within their corresponding regions that receive more government support, e.g., better resources and facilities, than LECs and LEFs. In RECs, it is not only emergency physicians that are present at all times, but also general surgeons, orthopedic surgeons, and neurosurgeons. During the study period (2014) there were 20 of these designated RECs in South Korea. Although a trauma system was developing stage in Korea, however, a pediatric-specific trauma system was not yet in place [12].

### Study design and data collection

This retrospective observational study involved the analysis of secondary data from a 2014 sample project database of emergency medical services-transported injured pediatric patients (EMS-IPP) in South Korea. The EMS-IPP sample database was constructed in three stages as follows:

Stage 1. Sampling of EMS-IPP from the database: Almost all pre-hospital care and transport were provided by the “119” ambulance services in South Korea. The 119 EMS headquarters’ were located across 17 different provinces, each of which was operated and maintained within the same structure as the electronic EMS database [13]. The database included patient demographic characteristics and information related to injury events [14]. The 2014 EMS-IPP sample database uses multi-stage cluster sampling designed to obtain a nationally representative sample of injured pediatric patients transported via EMS. In the first stage of sampling, hospitals were selected as primary sampling units (PSUs). PSUs were sampled by stratification of the level of EDs and geographical location. Within a PSU, the sample size according to age-group (5-year intervals) stratification was determined by the proportional distribution method. The samples size was limited to 3,500 which represented 5% of injured pediatric patients transported by EMS in Korea.

Stage 2. Probabilistic linkage of EMS samples and medical records: The medical record reviewers probabilistically matched patient records from EMS run-sheets with records from hospital registries based on demographics, clinical data, and the time/date of hospital arrival. In the absence of matched patients, we attempted matching using an alternate sampled patient list.

Stage 3. Medical record review: The medical record reviewers identified and extracted data on each patient’s injury diagnosis using the International Classification of Disease-10 code and relevant outcomes. The data were then reported using a structured data collection form. The final EMS-IPP sample database was constructed by linking the EMS run-sheets and medical record reviews. We established a data quality management committee for this project.

### Study subjects

We included pediatric patients with moderate to severe injuries, who were under the age of 19 and had been transported by EMS. We defined moderate to severe trauma in patients with an Injury Severity Score (ISS) higher than nine. The present study limited the sample to the admitted or transferred patients who had been initially transported to a REC. We excluded cases with missing information regarding injury severity.

### Variables and statistical analysis

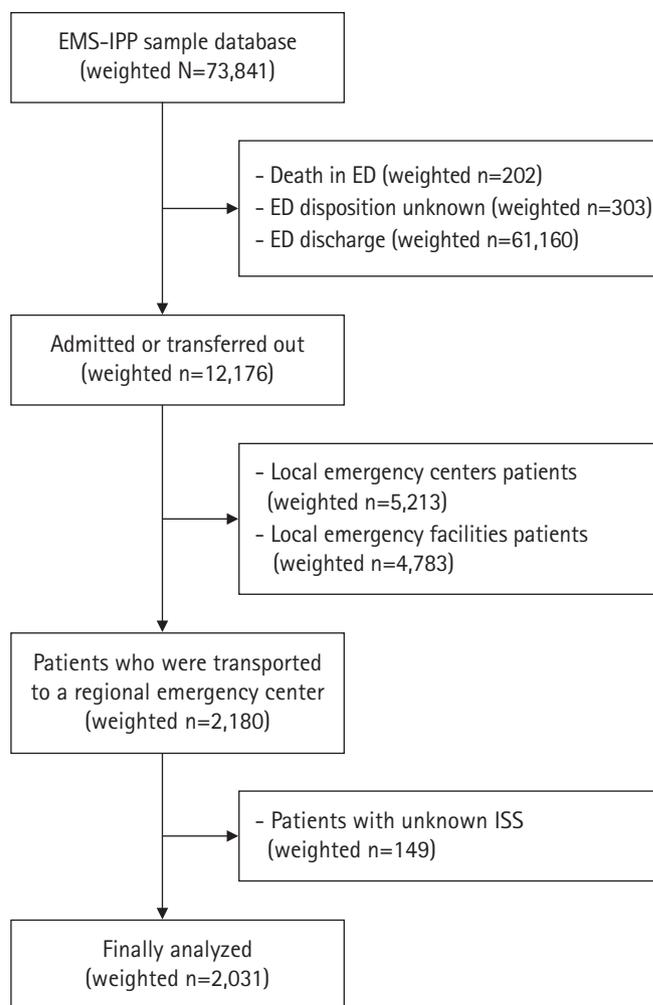
Patient demographics and details of injuries were collected, including injury mechanisms, injured body regions, and injury severity. The main exposure variable was age, which was categorized into four groups by 5-year intervals. Injury mechanisms were divided into three groups: fall, road traffic injury, and others. The Abbreviated Injury Scale (AIS) was originally used to categorize the body region of injury into nine groups. However, these regions were reclassified into three groups consisting of head and face, torso (chest and abdomen), and extremities and others. In case of patients with multiple trauma, we counted in duplicate for each body region. The sum of patients per injured region may be greater than the total number of patients. We classified ISS into two groups (moderate and severe) with a cutoff score of 16. Moreover, hospital level factors were also collected: day of arrival to hospital, urbanization level of hospital region (metropolitan or not), and whether it was a designated regional trauma center. The primary outcome was ED disposition, i.e., direct inpatient admission to the high-ED versus transfer to other acute care facility.

We calculated the total weighted number of patients by weighting the number of sampled patients according to the proportion of sex, age, and level of emergency center of EMS-IPP. The demographic findings and outcomes based on age group were described. Continuous data are reported as mean and standard deviation, or median and interquartile range; categorical variables are reported as counts and percentages. Two-sided tests were conducted, and  $P < 0.05$  was considered statistically significant. Multivariable logistic regression analysis was conducted to estimate the effect of age group on ED disposition. The adjusted odds ratios (aOR) and 95% confidence intervals (CI) were calculated after adjusting for potential risk factors at the patient level (sex, age group, mechanisms of injury, injured body region, and injury severity) and hospital level (day of arrival, hospital region and regional trauma center) as covariates.

## RESULTS

Of the weighted total of 73,841 injured pediatric patients in the EMS-IPP sample database, 12,176 patients were admitted to, or transferred from hospitals in South Korea. We limited the sample to patients who were transported to the REC. After excluding known information on ISS cases, 2,031 patients were evaluated (Fig. 1).

Table 1 summarizes patient characteristics by age group. Patients aged 15 to 19 years old constituted 49.5% of the total cases. As age increased, the severity of injury rate tended to increase.



**Fig. 1.** Flow chart of patient inclusion and exclusion from the analysis. EMS-IPP, emergency medical services-transported injured pediatric patients; ED, emergency department; ISS, Injury Severity Score.

The proportion of severe injuries was less than 10% for the 0- to 4-year-old group and 5- to 9-year-old group, but 27.2% for the 10- to 14-year-old and 53.5% for the 15- to 19-year-old group. In contrast, among patients under 14 years old, more than half were transferred to another hospital, and among the 15- to 19-year-old group, 34% were transferred.

Table 2 shows patient characteristics by ED disposition. Overall, 47.3% were transferred to other hospitals. The transfer group were younger and had more head injuries than the admission group. There was no statistically significant difference in injury severity between the admission and transfer groups ( $P = 0.34$ ).

After adjusting for potential covariates, age group had a significant effect on transfer. When compared to the 15- to 19-year-old group, the younger age groups had higher odds of transfer (0- to

**Table 1.** Demographic characteristics of the study population by age group

Characteristic	Total	Age group (yr)				P-value
		0–4 (n = 406)	5–9 (n = 206)	10–14 (n = 414)	15–19 (n = 1,005)	
Sex						0.08
Male	1,615	269 (66.4)	161 (78.2)	254 (61.3)	930 (92.6)	
Female	417	137 (33.7)	45 (21.8)	160 (38.7)	75 (7.4)	
Mechanism						0.06
Road traffic injury	1,554	236 (58.1)	124 (60.0)	332 (80.1)	863 (85.9)	
Fall	254	58 (14.2)	27 (13.1)	62 (15.0)	107 (10.7)	
Other	223	113 (27.8)	55 (26.9)	20 (4.9)	35 (3.5)	
Body region						
Head	1,406	285 (70.2)	111 (53.9)	320 (77.4)	690 (68.6)	0.78
Torso	458	56 (13.7)	85 (41.2)	56 (13.6)	261 (26.0)	0.21
Extremity and other	949	30 (7.3)	102 (49.3)	252 (60.8)	567 (56.4)	0.01
Injury Severity Score						0.46
< 9	1,644	375 (92.4)	179 (86.9)	303 (73.2)	788 (78.4)	
≥ 9	387	31 (7.6)	27 (13.1)	111 (26.8)	217 (21.6)	
Hospital region						0.12
Metropolitan city	970	290 (71.4)	146 (70.8)	159 (38.4)	376 (37.4)	
Non-metropolitan city	1,061	116 (28.7)	60 (29.2)	255 (61.7)	629 (62.6)	
ER visit day						0.05
Weekday	1,396	357 (87.9)	70 (34.0)	255 (61.6)	714 (71.1)	
Weekend	636	49 (12.1)	136 (66.0)	159 (38.5)	291 (28.9)	
Trauma center						0.26
No	1,901	387 (95.3)	202 (98.0)	400 (96.7)	912 (90.8)	
Yes	130	19 (4.8)	4 (2.0)	14 (3.3)	93 (9.2)	
Disposition						0.42
Admission	1,070	174 (42.9)	82 (39.6)	151 (36.4)	663 (66.0)	
Transfer	961	232 (57.1)	124 (60.4)	263 (63.6)	342 (34.0)	

Values are presented as number (%).  
ER, emergency room.

4-year-old group, aOR 7.65 [95% CI, 1.24 to 47.38]; 5- to 9-year-old group, aOR 14.48 [95% CI, 2.08 to 100.55]; 10- to 14-year-old group, aOR 5.03 [95% CI, 10.5 to 26.79]) (Table 3).

## DISCUSSION

Our study revealed that patient age was independently associated with IHT in moderately to severely injure pediatric trauma patients who were initially transported to a REC. There was no association between injury severity and transfer.

Interestingly, the tendency for transfer in young pediatric trauma patients with severe injuries was revealed in a previous study conducted in non-trauma centers [10]. However, despite that the subjects of this study were pediatric patients in a REC, the effects of age on transfer were similar to those in non-trauma centers. It suggests that a comprehensive review of the management capaci-

ty of RECs pediatric patients with severe trauma is necessary.

In order to develop a pediatric trauma system in the future, the current pattern of transfer practice in pediatric trauma patients should be considered. The results of this study are also applicable in guiding development and improvements in the field of pediatric trauma triage and transport protocols of EMS. Age is an important factor in the management of pediatric trauma patients, and the management of younger pediatric trauma patients requires sophisticated skills [15]. The ideal cutoff age for treatment in pediatric trauma centers is controversial. Studies that have evaluated outcome, including mortality among adolescents treated at adult or pediatric trauma centers, have shown conflicting results [16,17]. This cutoff age varies in different trauma systems based on local preferences and practice patterns. Institutional policies on the age limit for treatment in pediatric trauma centers ranged from 12 to 18 years [18–21]. Aside from age, patients

**Table 2.** Demographic characteristics of the study population by emergency department disposition

Characteristic	Total	Emergency department disposition				P-value
		Admission		Transfer		
		n	(%)	n	(%)	
Sex						0.46
Male	1,615	810	(75.7)	805	(83.8)	
Female	417	260	(24.3)	156	(16.3)	
Age group (yr)						0.42
0–4	406	174	(16.3)	232	(24.1)	
5–9	206	82	(7.6)	124	(12.9)	
10–14	414	151	(14.1)	263	(27.4)	
15–19	1,005	663	(62.0)	342	(35.6)	
Average (SD)		13.5	(± 11.5)	10.5	(± 11.0)	< 0.001
Mechanism						0.36
Road traffic injury	254	143	(13.4)	111	(11.5)	
Fall	1,554	756	(70.7)	798	(83.0)	
Other	223	171	(15.9)	53	(5.5)	
Body region						
Head	1,406	568	(53.1)	838	(87.2)	< 0.001
Torso	458	368	(34.4)	90	(9.4)	< 0.001
Extremities and others	949	625	(58.4)	325	(33.8)	0.11
Injury Severity Score						0.34
< 9	1,644	815	(76.2)	829	(86.3)	
≥ 9	387	255	(23.8)	132	(13.8)	
Hospital region						0.87
Metropolitan city	1,061	545	(50.9)	517	(53.8)	
Non-metropolitan city	970	525	(49.1)	445	(46.3)	
ED visit day						0.70
Weekday	1,396	710	(66.3)	686	(71.4)	
Weekend	636	360	(33.7)	275	(28.6)	
Trauma center						< 0.001
No	130	112	(10.5)	18	(1.8)	
Yes	1,901	958	(89.5)	944	(98.2)	

SD, standard deviation; ED, emergency department.

with torso injuries were likely to transfer to another hospital. This association between injured body region and transfer decision was similar to that of a previous study conducted within a non-trauma center [9].

In this study, we used nationwide EMS data sampled from a database. There were notable strengths in the database used in this study. First, the EMS-IPP sample database was highly representative of injured pediatric patients transported by EMS. It consists of mandatory registries for all patients accessed by EMS. Taking into consideration the time and cost of data collection, e.g., collecting information on in-hospital mortality, we applied a multi-stage cluster sampling method. We attempted not to compromise the representation of different regions and levels of ED

in the data. Second, it is challenging to link EMS data and hospital information, which includes the severity of injury or outcomes. The Act on the Protection of Personal Information of Korea prohibits the use of registration numbers for data linkage. In this study, we probabilistically matched pre-hospital EMS data with in-hospital medical records. This method was successful in previous studies and its reliability has been established for out-of-hospital cardiac arrest and severe trauma [22–25]. Third, the medical record reviewers who participated in the EMS-IPP sample database were trained and had experience on similar projects, such as medical record review and AIS coding in severely injured EMS patients [24,25]. We also operated a data quality management committee system for the reviewers to minimize in-

**Table 3.** Multivariable logistic regression analysis between transfer decision and variables

Variable	Adjusted OR	95% CI
Age group (yr)		
0–4	7.65	1.24–47.38
5–9	14.48	2.08–100.55
10–14	5.3	1.05–26.79
15–19	1	
Sex		
Male	1	
Female	2.39	0.53–10.81
Injury mechanism		
Road traffic injury	1	
Fall	0.43	0.06–3.05
Other	0.18	0.02–1.68
Body region		
Absence of head injury	1	
Head	0.37	0.10–1.33
Absence of torso injury	1	
Torso	6.35	1.58–25.61
Absence of extremity and other regional injury	1	
Extremity and other	1.69	0.46–6.18
Injury Severity Score		
<9	1	
≥9	0.6	0.14–2.54
Hospital region		
Metropolitan city	1	
Non-metropolitan city	0.57	0.18–1.82
ED visit day		
Weekday	1	
Weekend	0.62	0.18–2.12
Trauma center		
No	1	
Yes	5.3	0.99–28.26

OR, odds ratio; CI, confidence interval; ED, emergency department.

formation bias caused by ISS coding problems.

Several limitations were identified in the present study. First, our analysis did not include patient outcomes such as mortality or disability. This was due to the fact that, although our database included outcomes (such as in-hospital mortality and disability) upon discharge of admitted patients, it did not include outcomes for transferred patients. Second, our database did not include information on the hospitals to which patients were transferred, such as the level of ED or region. Third, we did not evaluate the reasons for the transfer. One example was patient or guardian preference with respect to economic considerations or distance from hometown. Another example is the temporary resource de-

pletion in the REC, i.e., a lack of intensive care units, for which information was not available through a review of medical records. Finally, as this was an observational study, there is a possibility of residual confounding effects.

In summary, our findings suggest that younger pediatric patients with moderate to severe trauma are more likely to be transferred to another hospital despite being initially transported to a REC.

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## CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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## REFERENCES

1. Heron M. Deaths: leading causes for 2015. *Natl Vital Stat Rep* 2017;66:1–76.
2. Martin-Herz SP, Zatzick DF, McMahan RJ. Health-related quality of life in children and adolescents following traumatic injury: a review. *Clin Child Fam Psychol Rev* 2012;15:192–214.
3. Winthrop AL. Health-related quality of life after pediatric trauma. *Curr Opin Pediatr* 2010;22:346–51.
4. Schweer L, Ose MB. Implementation of a regional pediatric trauma center. *AORN J* 1995;61:558–71.
5. Ducrocq SC, Meyer PG, Orliaguet GA, et al. Epidemiology and early predictive factors of mortality and outcome in children with traumatic severe brain injury: experience of a French pediatric trauma center. *Pediatr Crit Care Med* 2006;7:461–7.
6. Zoetsch S, Saxena AK. Equine-related injuries in pediatric and

- adolescent age: analysis and outcomes in a level 1 pediatric trauma center in Austria. *Pediatr Emerg Care* 2013;29:1053-4.
7. Williams T, Finn J, Fatovich D, Jacobs I. Outcomes of different health care contexts for direct transport to a trauma center versus initial secondary center care: a systematic review and meta-analysis. *Prehosp Emerg Care* 2013;17:442-57.
  8. Newgard CD, McConnell KJ, Hedges JR. Variability of trauma transfer practices among non-tertiary care hospital emergency departments. *Acad Emerg Med* 2006;13:746-54.
  9. Delgado MK, Yokell MA, Staudenmayer KL, et al. Factors associated with the disposition of severely injured patients initially seen at non-trauma center emergency departments: disparities by insurance status. *JAMA Surg* 2014;149:422-30.
  10. Ross DW, Rewers A, Homan MB, Schullek JR, Hawke JL, Hedegaard H. Factors associated with the interfacility transfer of the pediatric trauma patient: implications for prehospital triage. *Pediatr Emerg Care* 2012;28:905-10.
  11. Cha WC, Ahn KO, Shin SD, Park JH, Cho JS. Emergency department crowding disparity: a nationwide cross-sectional study. *J Korean Med Sci* 2016;31:1331-6.
  12. Cho HM. Proposal for stabilization of regional trauma centers in Korea. *J Korean Med Assoc* 2016;59:931-7.
  13. Shin SD, Ong ME, Tanaka H, et al. Comparison of emergency medical services systems across Pan-Asian countries: a web-based survey. *Prehosp Emerg Care* 2012;16:477-96.
  14. Lee SU, Suh D, Kim HB, et al. Epidemiology of prehospital emergency medical service use in Korean children. *Clin Exp Emerg Med* 2017;4:102-8.
  15. Kenefake ME, Swarm M, Walthall J. Nuances in pediatric trauma. *Emerg Med Clin North Am* 2013;31:627-52.
  16. Walther AE, Pritts TA, Falcone RA, Hanseman DJ, Robinson BR. Teen trauma without the drama: outcomes of adolescents treated at Ohio adult versus pediatric trauma centers. *J Trauma Acute Care Surg* 2014;77:109-16.
  17. Webman RB, Carter EA, Mittal S, et al. Association between trauma center type and mortality among injured adolescent patients. *JAMA Pediatr* 2016;170:780-6.
  18. Junkins EP Jr, O'Connell KJ, Mann NC. Pediatric trauma systems in the United States: do they make a difference? *Clin Pediatr Emerg Med* 2006;7:76-81.
  19. Petrosyan M, Guner YS, Emami CN, Ford HR. Disparities in the delivery of pediatric trauma care. *J Trauma* 2009;67(2 Suppl):S114-9.
  20. Little WK. Golden hour or golden opportunity: early management of pediatric trauma. *Clin Pediatr Emerg Med* 2010;11:4-9.
  21. Matsushima K, Schaefer EW, Won EJ, Nichols PA, Frankel HL. Injured adolescents, not just large children: difference in care and outcome between adult and pediatric trauma centers. *Am Surg* 2013;79:267-73.
  22. Ro YS, Shin SD, Song KJ, et al. A trend in epidemiology and outcomes of out-of-hospital cardiac arrest by urbanization level: a nationwide observational study from 2006 to 2010 in South Korea. *Resuscitation* 2013;84:547-57.
  23. Ahn KO, Kim SC, Park JO, Shin SD, Song KJ, Hong KJ. Validation of the criteria for early critical care resource use in assessing the effectiveness of field triage. *Am J Emerg Med* 2018;36:257-61.
  24. Kim S, Ro YS, Shin SD, Song KJ, Hong KJ, Jeong J. Preventive effects of motorcycle helmets on intracranial injury and mortality from severe road traffic injuries. *Am J Emerg Med* 2018;36:173-8.
  25. Kim J, Song KJ, Shin SD, Ro YS, Hong KJ, Holmes JF. Does pre-hospital time influence clinical outcomes in severe trauma patients? A cross sectional study. *Prehosp Emerg Care* 2017;21:466-75.