Review Article
J Korean Neurosurg Soc 65 (3) : 334-341, 2022
https://doi.org/10.3340/jkns.2021.0306
pISSN 2005-3711 eISSN 1598-7876

Pediatric Traumatic Brain Injury : The Epidemiology in Korea

Eun Suk Park,[1,*] Hui-Jun Yang,[2,*] Jun Bum Park[1]

Department of Neurosurgery,[1] Ulsan University Hospital, University of Ulsan College of Medicine, Ulsan, Korea
Department of Neurology,[2] Ulsan University Hospital, University of Ulsan College of Medicine, Ulsan, Korea

Traumatic brain injury (TBI) is one of the leading causes of death in the pediatric population in Korea. In addition, it can cause disability in children and adolescents, with physical and mental consequences. This causes a substantial burden on the health care system and occurs globally and not just in Korea. We searched and reviewed current data on the epidemiologic characteristics of pediatric TBI in Korea. Our review provides the recent epidemiological trend mainly focusing on incidence and mortality along with worldwide reported data. This review will be helpful to understand the global epidemiology of pediatric TBI and its differences between countries.

Key Words : Craniocerebral trauma · Epidemiology · Head injuries · Incidence · Mortality · Traumatic brain injury.

INTRODUCTION

Traumatic brain injury (TBI) is a common cause of death and disability in children and adolescents, with consequences ranging from physical disabilities to long-term cognitive, behavioral, and social disabilities[5,6]. This causes a substantial burden on the health care system worldwide[3,5,20]. Trauma in the pediatric population is known to be the leading cause of death in Korea along with childhood cancer[15]. Pediatric trauma patients frequently exhibit head trauma, and it is the most common cause of death among these patients[2,19].

Children are more vulnerable to head trauma due to their biological characteristics such as large heads relative to their body size, incomplete brain myelination, and incomplete closure of the cranial sutures[10,16]. Although it differs by age, the development of motor nerves in children is immature, so nerves can easily be damaged by various kinds of accidents[1]. Unlike adults, children do not have sufficient defense mechanisms, and their anatomical characteristics, such as a thin skull and underdeveloped subarachnoid descent, make them more susceptible to injury[9].

Since the pediatric population is more vulnerable to TBI due to their innate characteristics, a significant public health problem emerges. It is worthy of investigating the epidemiologic features of pediatric TBI. In this review, we summarize current data on the epidemiologic characteristics of TBI from

• Received : December 13, 2021 • Revised : February 18, 2022 • Accepted : February 26, 2022
• Address for reprints : **Jun Bum Park**
Department of Neurosurgery, Ulsan University Hospital, University of Ulsan College of Medicine, 877 Bangeojinsunhwando-ro, Dong-gu, Ulsan 44033, Korea
Tel : +82-52-250-7139, Fax : +82-52-250-7138, E-mail : parkjb@uuh.ulsan.kr, parkjb2100@gmail.com, ORCID : https://orcid.org/0000-0001-6005-9221

*Eun Suk Park and Hui-Jun Yang contributed equally to this work.

a worldwide perspective, including in Korea. This review aims to increase awareness of the nature and growing changes in this issue. We also emphasize the gaps in knowledge and highlight changing epidemiologic characteristics.

EPIDEMIOLOGY : INCIDENCE

Incidence of TBI is a measure of the risk for TBI within a specified period of time in a given study population. Reported epidemiologic data are mostly retrospectively retrieved from routinely surveyed administrative sources. The data is usually identified with International Classification of Diseases (ICD) codes. Inconsistency in the coding process always exists, which subsequently produces variability in the identification and definition of TBI among individuals. Accordingly, epidemiologic data reported in the literature should be interpreted with caution.

Incidence rates of pediatric TBI reported in Korea and around the world are summarized in Tables 1 and 2, respectively. The epidemiological pediatric TBI trends from 2008 to 2017 in South Korea, assembled using a population-based dataset of the National Health Insurance (NHI) system, are presented in Table 1. The NHI is a nationwide, unified, mandatory government-established health insurance system, and its database contains health information representative of the entire Korean population. Kim et al.[14] investigated the Korean TBI trend using the following ICD codes : concussion (S06.0), cranial fracture (S02.0, S02.1, S02.7, S02.8, and S02.9), or intracranial injury (S06.1–S06.9) They reported the crude incidence per 100000 persons and the age-adjusted incidence values in pediatric and adult patients. The number of patients who received medical care for TBI increased from 2008 to 2010 (278288 cases in 2008; 313455 cases in 2010), and then continuously decreased until 2016 (241957 cases). The age-adjusted incidence per 100000 persons in the total population showed same pattern (571.2 cases in 2008, 638.1 cases in 2010, and 469.8 cases in 2016). Pediatric TBI patient groups also showed a similar tendency. The youngest pediatric group (0–4 years old) showed a higher incidence than other pediatric groups (5–9 and 10–19 years old), indicating that the incidence rate decreased with increasing age (Fig. 1A). The incidence rate in the youngest pediatric group (0–4 years old) was 1308.5 per 100000 population in 2017. Other pediatric groups (5–9 and 10–19 years old) had 716.8 and 445.3 per 100000 of the incidence rate, respectively.

In the USA, the Centers for Disease Control and Prevention (CDC) regularly collect national TBI epidemiologic data[17]. In a CDC report published in 2017[17], a total of approximately 2.8 million TBI-related emergency room (ER) visits (approximately 2.5 million), hospitalizations (282000), and deaths (56000) occurred in the USA in 2013. The incidence rate of TBI of the total USA population in 2008 and 2013 was 531.9 and 777.5, respectively, showing that overall, TBI has increased during the study period. The pediatric TBI group showed a similar pattern. In the pediatric population, the youngest pediatric group (0–4 years old) showed higher incidence than other pediatric groups (5–14 and 15–24 years old). The adoles-

Table 1. The incidence and mortality rates of pediatric and total, age-adjusted patients with TBI patients in Korea

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TBI incidence*										
0–4 years old	1818.8	1920.8	1921.5	1788.0	1738.5	1677.0	1487.5	1344.6	1353.4	1308.5
5–9 years old	839.1	887.0	913.1	882.8	877.8	843.1	792.6	734.8	710.0	716.8
10–19 years old	530.6	564.4	612.8	574.4	563.1	474.2	501.5	460.0	426.6	445.3
Total, age adjusted	571.2	612.7	638.1	591.4	583.6	553.3	526.8	492.7	469.8	475.8
TBI mortality*										
0–4 years old	3.6	3.8	2.9	2.6	2.2	2.4	2.2	1.4	1.6	1.1
5–9 years old	1.6	1.9	1.4	1.1	1.1	0.7	0.6	0.3	0.7	0.4
10–19 years old	4.4	3.9	3.4	2.8	2.0	1.9	1.6	1.3	1.0	1.0
Total, age-adjusted	42.9	43.5	39.8	33.9	30.3	25.9	21.9	18.7	14.7	11.3

*Incidence and mortality represents a rate of the event per 100000 people. TBI : traumatic brain injury

Table 2. Worldwide incidence and mortality rates of pediatric TBI patients

Study	Region	Year of study	Data source	Age range (years old)	Reported incidence rate (per 100000)	Reported hospitalization rate (per 100000)	Reported mortality rate (per 100000)
Kim et al.[14] (2020)	Korea	2017	Nationwide population-based dataset	0–4	1308.5	ND	1.1
				5–9	716.8	ND	0.4
				10–19	445.3	ND	1.0
Hsu et al.[11] (2018)	Taiwan	2007-2008	Nationwide population-based dataset	0–14	ND	29.8	1.2
				15–24	ND	97.9	5.9
Cheng et al.[4] (2017)	China	2013	Nationwide population-based dataset	0–4	ND	ND	4.7
				5–14	ND	ND	2.2
				15–24	ND	ND	6.7
Taylor et al.[17] (2017)	USA	2013	Nationwide emergency department sample and national inpatient sample	0–4	1541.1	46.6	3.8
				5–14	814.8	21.1	1.8
				15–24	1001.9	64.3	14.4
Thurman[20] (2016)	Western countries	1990 to 2013	Systemic review	0–24	Median : 691 Range : 8.2–1652	74	9
Dewan et al.[5] (2016)	Worldwide countries	1980 to 2012	Systemic review	0–19	47–280	ND	2.8–3.75 1–7%

TBI : traumatic brain injury, ND : not described

cent group (15–24 years old) had a higher incidence than the children group (5–14 years old).

A systematic review by Thurman[20] in 2016 reported the incidence of pediatric TBI in western regions such as North America, Europe, Australia, and New Zealand. The reported incidence rate varied from 8.2 to 1652 per 100000 population. According to this comprehensive review, the median estimate of the annual incidence of pediatric brain injuries was 691 per 100000 population. A comprehensive literature review by Dewan et al.[5] was published in 2016. They searched the epidemiology reports worldwide and found the incidence of pediatric TBI ranges broadly and varies significantly by country. The incidence rate ranged between 47 and 280 per 100000 children. These two systematic reviews of worldwide data did not demonstrate incidence differences by age.

The worldwide incidence of pediatric TBI varies widely from country to country. The Korean pediatric TBI patients showed a decreased incidence rate with increasing age group. However, the American pediatric TBI patients had a decreased incidence rate until young adolescents (under 15 years old) and then rose again. This is probably due to differences between countries in their medical infrastructures, health care systems, and cultures. In Korea, the adolescent group (10–19 years old) had the lowest incidence of TBI, which was largely different from data from western countries. In Korea, adults 20 years old and more can drive a car, and adolescents generally get relatively strict supervision and attention from school. Hence, cultural differences such as these likely underlie the variability in incidence by country.

EPIDEMIOLOGY : CAUSE OF INJURY

Children are more susceptible to head trauma due to their biological and anatomical characteristics[1,9,10]. Identifying the causes of injury is essential to establish and prioritize prevention strategies. Generally, the most common principal causes of TBI are falls, being struck by or against an object, and motor vehicle crashes (MVC)[8,17,20]. Based on Korean national statistics data (Korean Statistical Information Service [KOSIS], https://kosis.kr/eng/) in 2020[15], MVC was the second most common cause of death after cancer in children under 10 years old. MVC was the most common cause of trauma, followed by assault and falls. In adolescents (10–19 years old),

 https://doi.org/10.3340/jkns.2021.0306

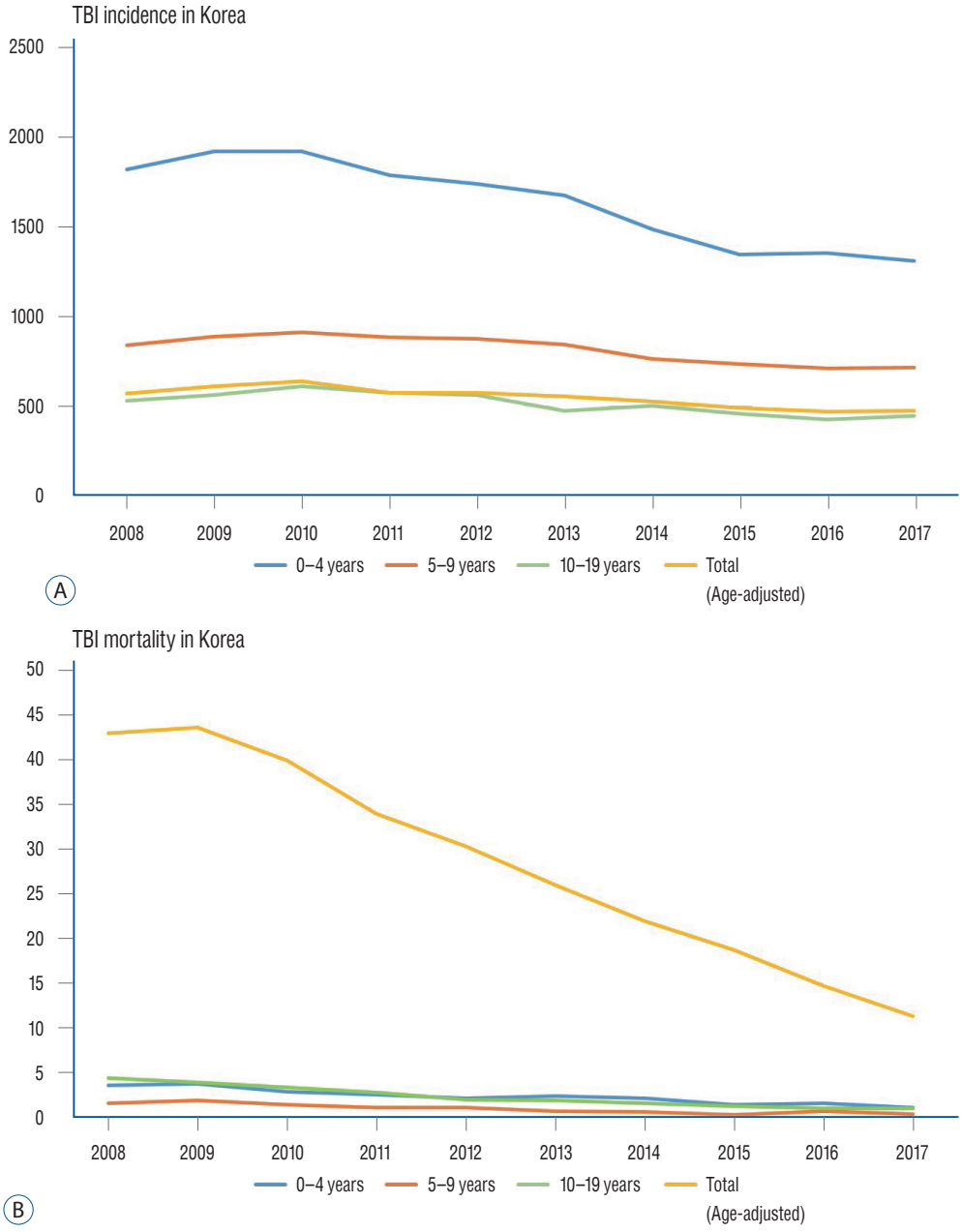

Fig. 1. The epidemiologic trend of traumatic brain injury (TBI) patients in Korea. A : The incidence rates of pediatric and total TBI patients in Korea. The youngest pediatric group (0–4 years old) showed a higher incidence than other pediatric groups (5–9 and 10–19 years old), indicating that the incidence rate decreased with increasing age. B : The mortality rates of pediatric and total TBI patients in Korea. Before 2012, adolescents (10–19 years old) had the highest mortality among the pediatric groups, but from 2012 the youngest children (aged 0–4 years old) showed the highest mortality.

MVC was the most common cause of trauma. It ranked third of all causes of death. Table 3 summarizes specific causes of pediatric TBI, using data from large Korean cohorts.

Kim et al.[13] prospectively analyzed Korean multicenter data from all children who attended the emergency department, which included 2856 pediatric patients under the age of 19 years old. With regard to the mechanism of injury, collision was the most common (n=1235, 43.2%), followed by falls (n=1105, 38.7%), MVC (n=243, 8.5%), and injuries by sharp objects (n=186, 6.5%). As the age increased, the number of injuries due to falls decreased, while the number of injuries due to MVC and sharp objects increased. Collision (44.3%) and MVC (26.4%) were the leading cause of injury among children aged 15–18 years. The prevalence of subtypes also varied

Table 3. Mechanism of injury in pediatric patients with traumatic brain injury in Korea

	Kim et al.[14] (2020)	Jeong et al.[12] (2017)
Year of study	2008 to 2009	2010 to 2014
Study data	Korean multicenter data	Korean multicenter data
Total number of patients	2856	256
Gender		
Male	1991	167
Female	865	89
Age range	0–18 0–4 years old, 1585; 5–9 years old, 713; 10–14 years old, 286; 15–18 years old, 272	0–18 <1 year old, 19; 1–5 years old, 76; 6–12 years old, 62; 13–18 years old, 99
Injury mechanism		
Collision	1235 (43.2)	-
Falls	1105 (39.0)	132 (51.6)
Motor vehicle collisions	243 (8.5)	-
Penetrating injury	186 (6.5)	-
Others	87 (3.0)	-
Traffic accidents	-	98 (38.3)
Assault	-	6 (2.3)
Leisure activity	-	5 (1.9)
Others/unknown	-	15 (5.9)

Values are presented as number (%)

among MVC victims. MVC was the most common among 0–4 years old (63.0%) and 5–9 years old (42.2%). Bicycle and motorcycle accidents were more common among children aged 10–14 years (31.4%) and 15–18 years (61.1%), respectively.

Jeong et al.[12] prospectively investigated Korean multicenter data of all children who were hospitalized in the neurosurgery department. A total of 256 pediatric patients under the age of 19 years were recruited and analyzed. Among injury causes, falls were the most common, followed by MVC. Age-based analysis revealed falls were the most common mechanism in infants, preschoolers, and schoolchildren, but adolescents showed a statistically significant higher rate of MVC.

In a CDC report in 2017, overall, males had higher age-adjusted rates of TBI (959.0) compared with females (810.8), and the most common principal mechanisms of injury for all age groups included falls (413.2, age-adjusted), being struck by or against an object (142.1, age-adjusted), and MVC (121.7, age-adjusted). In the pediatric patient group, fall-related TBIs occurred most frequently in the youngest pediatric group (0–4 years old). Similar to Korean data, MVC is more common in the adolescent group (15–24 years old).

Based on Thurman's systematic review on pediatric TBI patients in western countries[20], falls account for about two-thirds of injuries attended in emergency departments among children aged less than 5 years. MVC-related incidents account for comparatively small proportions of injuries attended in emergency departments in this patient group. Among children aged 5 to 14 years whose injuries are attended in emergency departments, falls remain the leading cause, followed by sports or recreation-related injuries and then by motor vehicle injuries. Among youths aged 15 years or older, MVC-related incidents are the leading cause of brain injury, followed by assault and then sports-related incidents.

According to Dewan et al.'s review[5], motor vehicle collisions (6–80%) and falls (5–87%) accounted for the majority of injuries, followed by abuse and other forms of non-accidental trauma (2–12%) and sports-related injuries (<1–29%). They found the mechanism underlying pediatric TBI showed wide differences by population and age group, and the differences between countries were particularly pronounced.

One study focused entirely on the causes of hospitalizations for traumatic brain injuries in infants and very young children

 https://doi.org/10.3340/jkns.2021.0306

aged less than 2 years[7]. The leading cause of TBI among infants aged less than 1 year was falls (72%), followed by assaultive or abusive head trauma (22%). The leading causes in 1-year-old children were falls (36%), followed by MVC (9%) and abusive head trauma (5%).

From the results reviewed above, the causes of TBI in the pediatric population mainly differ according to age. Falls are the most common injury in children under 5 years old. MVC affects the entire pediatric population; however, as ages increased, injuries due to falls decreased while MVC-related injuries increased. These are common findings throughout the world. We assume that inter-country differences come from cultural differences, customs, and laws. To prevent MVC-related injury, we need to review and strengthen the road traffic laws for child safety. Also, a careful analysis of the injury mechanism is essential. A more accurate definition of the MVC-related injury mechanism and its coding will be crucial in preparing preventive strategies and measures. To prevent falls, we need to collect and analyze the data to explain in greater detail the reasons for these traumatic situations.

EPIDEMIOLOGY : MORTALITY RATES

The mortality rate is a measure of the number of deaths in a given population, scaled to the size of that population per unit of time (usually 1 year). Tables 1 and 2 summarize mortality rates of pediatric TBI reported in Korea and worldwide, respectively.

Based on the nationwide population-based data collected by NHI service in Korea[14], a similar pattern was noticed among pediatric groups. In general, the mortality of pediatric groups was lower than in adult groups. Before 2012, adolescents (10–19 years old) had the highest mortality among the pediatric groups, but from 2012 the youngest children (aged 0–4 years old) showed the highest mortality (Fig. 1B).

According to a CDC report in 2017, TBI-related deaths accounted for 2.2% of all deaths in the USA. In general, the mortality of pediatric groups was lower than in adult groups. However, the adolescent group (15–24 years old) had much higher mortality than other pediatric groups (0–4 and 5–14 years old). Adolescent mortality was slightly lower than adult mortality, but in terms of overall numbers, the adolescent group accounted for 17.9% of all TBI-related ER visits, more than any other age group.

In Asian countries, Hsu et al.[11] investigated TBI epidemiology using the population-based data from Taiwan's NHI system. During 2007–2008, a total of 99391 patients were admitted with TBI. There were 4935 cases recorded as in-hospital mortality, and the standardized in-hospital mortality rate was 10.7 deaths per 100000 person-years. The in-hospital mortality rate in the pediatric patients group was 1.2 and 5.2 in the 0–14 and 15–24 year age groups, respectively. From their analysis, the authors found male sex, age older than 54 years, living in a rural area, lower monthly income, a Charlson comorbidity index greater than one, being a pedestrian hit by a motor vehicle, fall from a height, and having significant chest, abdominal, or lower extremity injury increased the risk of death during admission. Cheng et al.[4] investigated TBI mortality in China using a population-based dataset. In 2013, age-adjusted TBI mortality was 12.99 per 100000 population. They found a trend change in TBI mortality during the study period (2006–2013). They also found males and rural residents had a higher TBI mortality risk in the Chinese population.

In Dewan et al.'s review on globally-reported data[5], mortality rates ranged from 1–7% in most study samples or between 2.8–3.75 per 100000 children annually. Although there were discrepancies between countries, specific geographic predilections for mortality were not apparent in their review.

The above-reported mortality was varied. Innate biases of epidemiologic studies probably cause these results. Comparing mortality rates between different studies is complicated because of the significant variability in data collection techniques and the lack of standardization. In addition to these biases, mortality is affected by other factors such as the medical system and lifestyle of each country. Korea has national health insurance, covering most medical diseases and procedures, allowing Koreans easy access to medical services. Well-equipped medical infrastructure also enables easy medical accessibility. Especially, young children are more frequently brought to a hospital by their parents, even with a minor injury such as falling off the bed. In Korea, fatal injuries such as firearm-related TBI do not occur. Therefore, the interpretation of mortality in epidemiologic data requires careful evaluation and consideration of each country's circumstances.

GLOBAL DIFFERENCES AND STUDY LIMITATIONS

Based on our review above, the epidemiologic data reflects the cultural and environmental characteristics of the region. Even in the same country and the same environment, there are differences in epidemiologic results according to the time period and region. Inter-country differences are also affected by their differing medical systems and related laws. When we interpret the global epidemiologic data, we must carefully consider these factors.

In the review on TBI epidemiology by Theadom et al.[18], the authors commented on several considerations in the interpretation of epidemiologic data. First, the definition of TBI varies and is a matter of debate. Second, underreporting of the total number of people with TBI may be substantial. Third, epidemiologic monitoring of TBI is very seldom performed in a standardized way. Fourth, when data are collected, there is a chance to have coding errors due to different disease code classifications. Fifth, incidence rates of TBI do not always reflect prior occurrence or recurrence of TBIs. It is important to incorporate these considerations when reviewing and analyzing epidemiologic data. We also sensed the need to develop a database of neurosurgeon-led, multicenter, cooperative hospital-based registries, because improved standardization of epidemiologic data would enable more accurate comparisons and analysis.

CONCLUSION

In Korea, a short-term increase was observed in the TBI incidence from 2008 to 2010, followed by a continuous decrease in recent years. The youngest pediatric group (0–4 years old) showed a higher incidence than other pediatric groups (5–9 and 10–19 years old). The incidence rate decreased with increasing age. Falls were the most common injury in children under 5 years old causing TBI. MVC was a common injury in the entire pediatric age group. As age increased, injuries due to falls decreased, while MVC-related injuries increased. Pediatric TBI mortality showed a gradually decreasing trend. From 2012, the youngest children (0–4 years old) became the highest mortality group.

This review found that TBI incidence and mortality rates significantly vary between countries and populations. There are many biases in interpreting epidemiologic data. Awareness of these innate biases is essential to the investigation of epidemiologic data. We sensed the need to develop neurosurgeon-directed, multicenter, cooperative hospital-based registries in order to improve standardization of epidemiologic data and enable more accurate comparisons and analysis.

AUTHORS' DECLARATION

Conflicts of interest

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

Informed consent

This type of study does not require informed consent.

Author contributions

Conceptualization : JBP; Data curation : ESP; Formal analysis : ESP; Funding acquisition : ESP, HJY; Methodology : JBP, ESP; Project administration : JBP, ESP; Visualization : ESP; Writing - original draft : ESP; Writing - review & editing : JBP, ESP, HJY

Data sharing

None

Preprint

None

ORCID

Eun Suk Park https://orcid.org/0000-0002-5090-5284
Hui-Jun Yang https://orcid.org/0000-0002-3593-1134
Jun Bum Park https://orcid.org/0000-0001-6005-9221

• Acknowledgements

This work was funded by Ulsan University Hospital (Biomedical Research Center Promotion Fund 16-03).

We gratefully acknowledge Prof. Byung-Mo Oh (in the Department of Rehabilitation Medicine, Seoul National Univer-

sity Hospital) allows us to use their data. We also acknowledge Han-Kyoul Kim for his help in writing data.

References

1. Araki T, Yokota H, Morita A : Pediatric traumatic brain injury: characteristic features, diagnosis, and management. **Neurol Med Chir (Tokyo) 57 :** 82-93, 2017
2. Avraham JB, Bhandari M, Frangos SG, Levine DA, Tunik MG, DiMaggio CJ : Epidemiology of paediatric trauma presenting to US emergency departments: 2006-2012. **Inj Prev 25 :** 136-143, 2019
3. Brazinova A, Rehorcikova V, Taylor MS, Buckova V, Majdan M, Psota M, et al. : Epidemiology of traumatic brain injury in Europe: a living systematic review. **J Neurotrauma 38 :** 1411-1440, 2021
4. Cheng P, Yin P, Ning P, Wang L, Cheng X, Liu Y, et al. : Trends in traumatic brain injury mortality in China, 2006-2013: a population-based longitudinal study. **PLoS Med 14 :** e1002332, 2017
5. Dewan MC, Mummareddy N, Wellons JC 3rd, Bonfield CM : Epidemiology of global pediatric traumatic brain injury: qualitative review. **World Neurosurg 91 :** 497-509.e1, 2016
6. Eapen BC, Allred DB, O'Rourke J, Cifu DX : Rehabilitation of moderate-to-severe traumatic brain injury. **Semin Neurol 35 :** e1-e3, 2015
7. Eisele JA, Kegler SR, Trent RB, Coronado VG : Nonfatal traumatic brain injury-related hospitalization in very young children-15 states, 1999. **J Head Trauma Rehabil 21 :** 537-543, 2006
8. Feigin VL, Theadom A, Barker-Collo S, Starkey NJ, McPherson K, Kahan M, et al. : Incidence of traumatic brain injury in New Zealand: a population-based study. **Lancet Neurol 12 :** 53-64, 2013
9. Figaji AA : Anatomical and physiological differences between children and adults relevant to traumatic brain injury and the implications for clinical assessment and care. **Front Neurol 8 :** 685, 2017
10. Goldsmith W, Plunkett J : A biomechanical analysis of the causes of traumatic brain injury in infants and children. **Am J Forensic Med Pathol 25 :** 89-100, 2004
11. Hsu IL, Li CY, Chu DC, Chien LC : An epidemiological analysis of head injuries in Taiwan. **Int J Environ Res Public Health 15 :** 2457, 2018
12. Jeong HW, Choi SW, Youm JY, Lim JW, Kwon HJ, Song SH : Mortality and epidemiology in 256 cases of pediatric traumatic brain injury: Korean Neuro-Trauma Data Bank System (KNTDBS) 2010-2014. **J Korean Neurosurg Soc 60 :** 710-716, 2017
13. Kim HB, Kim DK, Kwak YH, Shin SD, Song KJ, Lee SC, et al. : Epidemiology of traumatic head injury in Korean children. **J Korean Med Sci 27 :** 437-442, 2012
14. Kim HK, Leigh JH, Lee YS, Choi Y, Kim Y, Kim JE, et al. : Decreasing incidence and mortality in traumatic brain injury in Korea, 2008-2017: a population-based longitudinal study. **Int J Environ Res Public Health 17 :** 6197, 2020
15. Korean Statistical Information Service : **Causes of Death Statistics in 2020.** Available at : http://kostat.go.kr/portal/eng/pressReleases/8/10/index.board?bmode=read&bSeq=&aSeq=414516&pageNo=1&rowNum=10&navCount=10&currPg=&searchInfo=&sTarget=title&sTxt=
16. Li L, Liu J : The effect of pediatric traumatic brain injury on behavioral outcomes: a systematic review. **Dev Med Child Neurol 55 :** 37-45, 2013
17. Taylor CA, Bell JM, Breiding MJ, Xu L : Traumatic brain injury-related emergency department visits, hospitalizations, and deaths - United States, 2007 and 2013. **MMWR Surveill Summ 66 :** 1-16, 2017
18. Theadom AFV, Reith CMF, Maas IR : Andrew epidemiology of traumatic brain injury in Winn H (ed) : **Youmans and Winn Neurological Surgery.** Philadelphia : Elsevier, 2017, pp2748-2754
19. Theodorou CM, Galganski LA, Jurkovich GJ, Farmer DL, Hirose S, Stephenson JT, et al. : Causes of early mortality in pediatric trauma patients. **J Trauma Acute Care Surg 90 :** 574-581, 2021
20. Thurman DJ : The epidemiology of traumatic brain injury in children and youths: a review of research since 1990. **J Child Neurol 31 :** 20-27, 2016