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Demographic characteristics of traumatic head injuries in pediatric patients: A single-center neuorsurgery clinic study

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MAIN POINTS

- Pediatric head injuries account for >80% of trauma-related deaths in children.
- Mortality rates are higher in patients with serious injury.
- Various factors, including demographic characteristics and the nature and severity of the injury, can play a significant role in the progression of pediatric head injuries.
- Our study showed that falls were the most frequently identified cause of pediatric head trauma.

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ABSTRACT

Aim: Traumatic brain injury (TBI) significantly contributes to mortality and disability in children aged 0-18 years. TBI is a potentially fatal health emergency, and when severe, children are at high risk of mortality and neurological morbidity. Our goal is to identify the various etiologies of head trauma in pediatric patients and provide examples of preventive measures to prevent further trauma. Our research also highlights the socioeconomic burden of patients with TBI.

Materials and Methods: The institutional electronic health record (HBYS) was queried for all pediatric patients admitted to the Neurosurgery Clinic in Kayseri City Hospital, diagnosed with traumatic head injury by the neurosurgery service, and registered for discharge between January 2021 and June 2025. This study investigated 180 pediatric head trauma cases. Patient nationality (Republic of Turkey or Other) and length of hospital stay (HLOS) were also used as demographic data.

Results: The mean age was 7.2±5.32 (min-max: 0-17) years. Of the 146 children, 146 were Turkish citizens. 15 of the children, 15 (8.3%) underwent cranial surgery, and 69 (38.3%) had a history of intensive care admission. The mean length of hospital stay was 2.73±3.03 (min-max: 1-18) days. The most common type of head trauma in children was linear fractures due to falls from heights and from the same level ($p<0.05$).

Conclusion: Implementing primary prevention strategies, preventing secondary neurological injuries, and collaborating with organized emergency teams can facilitate early intervention in patients with head trauma. Thus, early diagnosis and treatment of high intracranial pressure can reduce the adverse effects of TBI. These preventive measures can reduce morbidity and mortality in children. This study comprehensively examines the etiology and demographic characteristics of pediatric head trauma in a single center in the Central Anatolia Region.

Keywords: Traumatic head injuries, Length of hospital stay, Pediatric outcomes
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INTRODUCTION

Traumatic head injuries (THIs) represent a major global health issue, contributing substantially to morbidity and mortality across all age groups [1,2]. Among these, pediatric THIs are particularly concerning, as they account for more than 80% of trauma-related deaths [3–5]. Children's anatomical characteristics, including a larger head-to-body ratio compared to adults, make them more susceptible to severe neurological damage. Consequently, the developing brain tissue within the cranial fossa is at heightened risk of significant injury [6] .

Head trauma continues to represent one of the leading sources of socioeconomic burden worldwide from both medical and forensic standpoints. Despite noteworthy advancements achieved over time to curtail its prevalence, it continues to be a significant health concern, particularly among pediatric patients. In the pediatric population, it is the third most prevalent cause of mortality and morbidity [7]. The pattern and severity of head injuries exhibit significant age-dependent variation. Falls are the predominant cause of injury in infants and young children, and even incidents involving similar heights can result in severe cranial trauma [8,9]. High-energy mechanisms, such as vehicle or motorcycle accidents, become the primary cause of head injuries as children mature [10]. Falling from trees is also a possible cause of head trauma in children [11]. Linear skull fractures resulting from

falls constitute the most frequent form of injury in this age group. In contrast, the extent and nature of trauma determine the severity of injury in older children, with severe brain involvement being more prevalent following traffic collisions, motorcycle accidents, or major falls. Therefore, identifying the factors that influence the severity of head trauma and their relationship with critical outcomes, such as intensive care unit (ICU) admission and mortality, is imperative. This is essential for developing targeted approaches to improve clinical management and patient outcomes.

The Glasgow Coma Scale (GCS) is a widely used clinical tool that enables health care professionals to assess the neurological status of individuals who have suffered head trauma [12]. Research indicates that patients with severe head injuries tend to have extended hospitalizations and higher rates of intensive care unit admission [13-15]. Moreover, the mortality rate is markedly higher in patients with severe injuries than in those with mild or moderate head trauma. Several variables—including demographic characteristics, injury mechanism, and degree of severity—significantly influence the prognosis of pediatric head injuries [16]. Notably, a substantial portion of the current knowledge and published studies on trauma and its outcomes originates predominantly from Western countries, particularly North America and Europe.

Head trauma continues to be a major contributor to the global socioeconomic burden from medical and forensic standpoints. Despite advancements in preventive strategies and health care interventions over the years, it remains a prominent cause of mortality and morbidity, particularly among children. Head trauma ranks as the third most frequent cause of death and disability in the pediatric population. The underlying mechanisms and clinical severity of head injuries notably differ across age groups. Falls constitute the predominant cause of head trauma in infants and young children, and falls from relatively low heights may lead to severe cranial injuries in this vulnerable population.

MATERIALS AND METHODS

This study was conducted retrospectively following the approval of the local ethics committee of Kayseri City Hospital District on August 26, 2025, under protocol number 543. All research procedures complied with the ethical principles of the Declaration of Helsinki (1975) and its 1983 revision.

Study design

At Kayseri City Hospital, the institutional electronic health record "HBYS" was queried for all pediatric patients admitted to the Neurosurgery Clinic, the diagnoses of traumatic head injury were evaluated by the neurosurgery clinic, and discharge was documented between January 2021 and June 2025. Data from the past five years were preferred. The retrospective file review was conducted with deidentified data; therefore, institutional informed consent was not required from patients.

Study size

In total, 180 pediatric head trauma cases were analyzed in our study. The age range assessed during the analysis was 0-18 years. The nationality of the patients (Republic of Turkey or Others) was also used as demographic data in the study.

Variables

Injury characteristics included the following: Mechanism of injury (motor vehicle accidents include both drivers and passengers (inside and outside vehicles, motorcycle, bicycle accidents), falls from heights >1 m, falls from the same level ≤1 m, assaults/accidents, and others).

Injury type: Linear skull fracture, depressed skull fracture, brain contusion, epi-subdural hematoma, and traumatic subarachnoid hemorrhage. In children with multiple types of injuries, the worst head injury was considered the type of injury during the analysis. To diagnose head trauma, the patients underwent brain computed tomography (CT) (Figures 1 and 2).

Treatment variables included: Inpatient clinic (ward and intensive care), days spent in the intensive care unit, and total hospital stay. In the analysis, surgical procedures were included if surgical intervention was performed for any reason in patients with head trauma. The primary outcomes were the time of diagnosis and hospitalization.

Inclusion and exclusion criteria: We examined pediatric cases of isolated head trauma between the ages of 0-18. Only patients followed up in the Kayseri City Hospital Neurosurgery Service and Intensive Care were included in the study. Patients who had no pathological findings in their brain tomography scans but were sleepy or had confusion were observed in the emergency department for at least 8 h but were not admitted to the ward.

Statistical analysis

The obtained data were recorded and analyzed using SPSS version 22. The descriptive statistics included frequencies, percentages, mean values, standard deviations, median values, and maximum and minimum (min-max) values. Statistical analysis of categorical data included the Pearson chi-square test, and for values below five, the Fisher exact test. Data were checked for normal distribution using the Kolmogorov-Smirnov test. For quantitative data, the Kruskall-Wallis test (post-hoc Dunn test) was used for more than two independent groups, and statistical significance was set at $p<0.05$.

RESULTS

Of the 180 children included in the study, 49 (27.2%) were female and 131 (72.8%) were male. The mean age was 7.2±5.32 (min-max: 0-17) years. There were 146 Turkish citizens and 34 foreign nationals. The most common trauma mechanism

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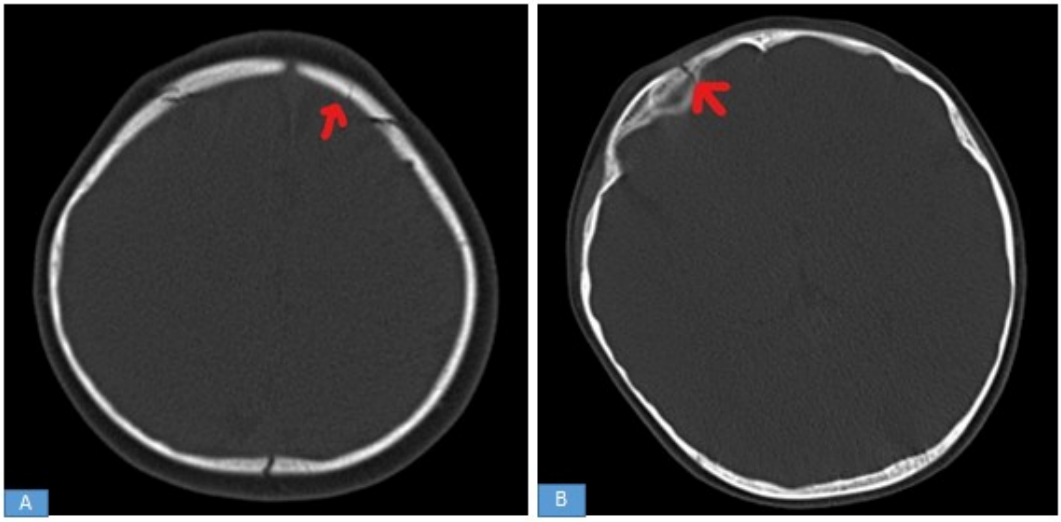

Figure 1. A frontal fracture is observed in the axial section of the brain tomography taken after the fall of a 0-year-old female patient. B: A fracture is observed in the right orbital roof in the axial section of the brain tomography taken after the fall of a 1-year-old male patient.

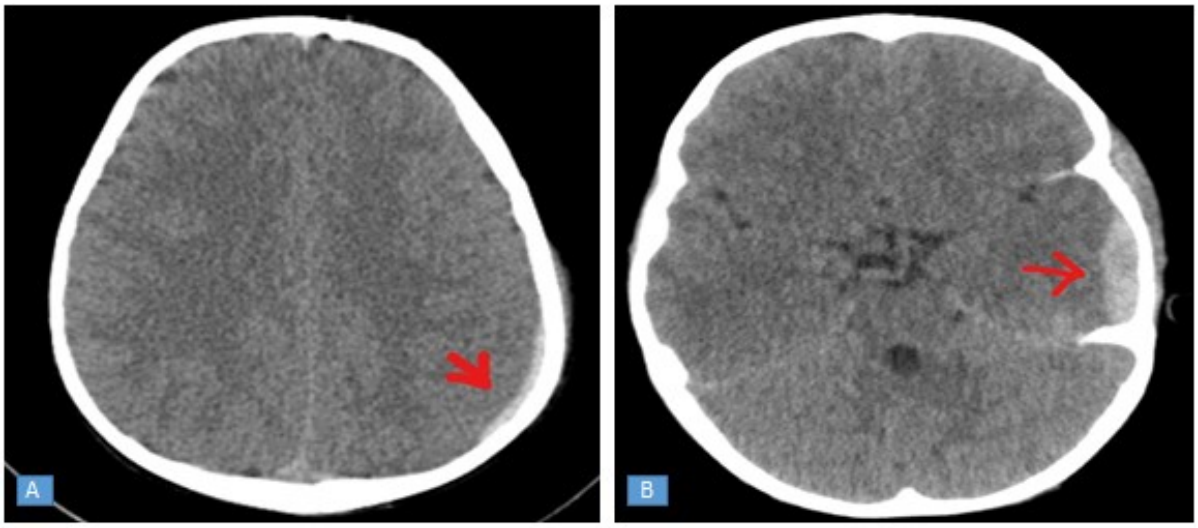

Figure 2. A 3-year-old male patient's post-traumatic brain tomography shows a left parietooccipital subdural hemorrhage in the axial section. B: A left temporal epidural hemorrhage in the axial section is seen in a 5-year-old male patient's post-traumatic brain tomography.

observed in children was falls (n: 95, 52.8%). Surgical intervention was performed in 15 of the children (8.3%), while 69 of them (38.3%) had a history of intensive care admission. Table 1 presents some variables according to the type of trauma.

When some variables were examined according to the type of trauma, no significant association was found with sex and nationality. Children who had traffic accidents had a significantly higher rate of intensive care visits ($p<0.05$). While the most frequently identified trauma type in children involved in motor vehicle accidents is epi-subdural hemorrhages, the most frequently identified trauma type in children falling from heights and the same level is linear fractures ($p<0.05$). Furthermore, the frequency of surgical intervention was significantly higher in children who had traffic accidents (Table 1).

The mean GCS score at the time of hospitalization was 14.48±1.34 (min-max: 8-15). The mean length of hospital stay was 2.73±3.03 (min-max: 1-18) days. Table 2 shows these variables by type of trauma. The median age of children who had traffic accidents was higher, and while GCS scores were significantly lower in children who had traffic accidents, the number of days spent in ICU was significantly higher (Table 2).

Rebleeding in the surgical area is a common postoperative surgical complication. In this case, a second surgical intervention may be necessary, and intensive care follow-up may be prolonged.

DISCUSSION

The key findings of our study include the observation that 131 male patients received follow-up and treatment for trauma, with falls being identified as the most prevalent cause. A considerable proportion of cases required intensive care

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Table 1. Trauma mechanism and numerical values.

Variables		All Patients		Trauma mechanism						P value
				Motor Vehicle Accidents (n:38)		Falls from Heights of >1 m (n:95)		Falls from the Same Level ≤1 m (n:47)		
		n	%	n	%	n	%	n	%	
Gender	Female	49	27.2	9	23.7	30	31.6	10	21.3	0.370*
	Male	131	72.8	29	76.3	65	68.4	37	78.7	
Nationality	The Republic of Turkey	146	81.1	32	84.2	74	77.9	40	85.1	0.504*
	Others	34	18.9	6	15.8	21	22.1	7	14.9	
Follow up	Inpatient service	111	61.7	15	39.5	59	62.1	37	78.7	0.001*
	Neurosurgery ICU	69	38.3	23	60.5	36	37.9	10	21.3	
Trauma mechanism	Epidural-subdural hemorrhage	30	16.7	12	31.6	15	15.8	3	6.4	<0.001**
	Linear fracture	99	55.0	8	21.1	61	64.2	30	63.8	
	Contusion	15	8.3	5	13.2	7	7.4	3	6.4	
	Cranial bone compression fracture (CBF)	24	13.3	9	23.7	5	5.3	10	21.3	
	Subarachnoid hemorrhage	12	6.7	4	10.5	7	7.4	1	2.1	
Surgery history	Yes	15	8.3	8	21.1	5	5.3	2	4.3	0.012**
	No	165	91.7	30	78.9	90	94.7	45	95.7	

*Pearson chi-square test, ** Fisher's exact test.

Table 2. Distribution of age, GCS score, and length of hospital stay according to the trauma mechanism.

Variables	Trauma mechanism						P value
	Motor Vehicle Accidents (n:38)		Falls from Heights of >1 m (n:95)		Falls from the Same Level ≤1 m (n:47)		
	Meant±SD	Median	Meant±SD	Median	Meant±SD	Median	
Age	10.65±4.46	11[a]	6.94±4.98	5[b]	4.91±5.31	3[c]	<0.001
Glasgow Coma Score	14.05±1.55	15[a]	14.62±1.08	15[b]	14.57±1.58	15[b]	0.001
Neurosurgery ICU days	4.21±3.88	3[a]	2.52±2.99	1[b]	1.97±1.71	1[b]	<0.001

*Kruskall-Wallis test (Dunn's test a,b,c; the difference is significant between groups that do not have the same letter on the same line).

management; specifically, 69 patients, accounting for 38.3% of the total cohort, were admitted to the neurosurgical intensive care unit. Notably, 23 of these admissions were due to motor vehicle accidents—a remarkably high figure within the pediatric patient population.

In our literature review, Tardif et al. conducted a retrospective, multicenter cohort study of 11,199 adult patients with a diagnosis of TBI who were registered with the Canadian trauma system between 2007 and 2012 [17]. Patients with TBI reported longer than expected hospital stays and days spent in intensive care (56% and 119%, respectively) than all other diagnoses. This study demonstrated the importance of considering patients with TBI as a distinct population when making resource allocation or quality improvement plans. In our study, the mean length of ICU stay for pediatric head trauma patients was found to be 4.21 ± 3.88 days. In our country, according to 2024 data values, the social security cost of a 24-hour (one-day) intensive care unit (ICU) stay and treatment is approximately 10,000 ₺ (300 $) according to 2024 data values.

Ninety-nine patients were hospitalized with a diagnosis of linear fracture, and their hospital observation period was often 24 h (one day). Filardi et al. reviewed skull X-rays of patients aged 2 years who were treated for mild TBI in tertiary hospital emergency departments between 2014 and 2017 [18]. For a TBI to be considered mild, it must result from low-energy mechanical trauma, meaning a fall from the patient's own height or from less than sixty inches away, and the patient's GCS level must be above "13." Patients with linear skull fractures and a normal computed tomography (CT) scan were observed in the emergency department for a maximum of 24 h. Furthermore, all patients with a confirmed fracture diagnosis were clinically followed up in outpatient neurosurgery consultations one month later.

When evaluating the imaging methods in THIs, the role of plain craniographs in detecting injuries in minor head traumas is limited, and more than half of cranial fractures are not detected on plain craniographs. Most children with minor head trauma present either asymptomatic or with minimal symptoms to the emergency department. Because neurolog-

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ical examinations are particularly challenging in children under 2 years of age, cranial computed tomography is the best imaging modality of choice. Consequently, a high frequency of cranial CT scans is performed in this age group [19].

Patients at high risk for traumatic brain injury, including those presenting within 24 hours of acute head trauma, those younger than 17 years of age, those with a GCS score of 13-15, those presenting with transient loss of consciousness, amnesia, disorientation, more than one vomiting, and irritability (aged 2 years and younger), were identified as high-risk. Patients with a GCS score <15 two hours after the trauma, suspicion of an open or depressed skull fracture, worsening headache, and restlessness during examination are considered high-risk. Patients with evidence of a skull base fracture, a potentially dangerous trauma mechanism, or a large, soft scalp hematoma were identified as intermediate risk [19]. Early brain computed tomography (CT) imaging may be crucial in patients with intermediate- and high-risk

The most frequently identified pediatric head trauma in our study (n: 95, 52.8%) was falls, and linear fractures were the most common type of TBI. The patients were kept under 24-hour observation and were also called for follow-up at the neurosurgery clinic 1 month later. In addition to the 24-hour inpatient observation period, outpatient clinic visit fees also increase the economic cost.

Hospital length of stay (HLOS) following traumatic brain injury (TBI) is a key indicator of injury severity, associated economic burden, and accessibility of acute post-traumatic care services. In a study conducted by Yue et al. data from 1,638 adult patients diagnosed with acute TBI between August 2019 and April 2022 were analyzed within a single-center cohort in the United States [20]. The mean hospital stay was 7.6 days (SD: 13.3 days) and the median length of stay was 3.0 days (IQR: 2-8 days). In our study, the mean hospital stay was 2.73±3.03 days (min-max: 1-18). These variables differed according to trauma type. Motor vehicle accidents were the most common in the intensive care unit (38.3), while patients who fell from the same level were admitted to the inpatient clinic (78.7).

Many patients with TBI undergo a lengthy rehabilitation period after severe head trauma. In the United States, more than 275,000 individuals with traumatic brain injury are hospitalized annually, with 60% of these being monitored in intensive care units [21,22]. Large multicenter studies have shown that the median HLOS for patients with TBI requiring acute care is 7–13 days [22,17], whereas the median HLOS for severely injured patients is 23 days [17]. In general, patients of the same age and sex with TBI have significantly longer hospital stays than individuals with different diagnoses.

Yue et al. estimated a higher mortality rate in patients with longer hospital stays (22% vs. 8%). This can be explained by the degree of TBI, other accompanying organ system injuries, and the debilitated condition of the patient [20]. This conclusion is inescapable, considering that 72% of patients underwent craniotomy/craniectomy and 33.3% underwent surgical procedures due to multiple traumas. In our study, 8 of the 15 patients who underwent surgical procedures had been in motor vehicle accidents, and the mean GCS score was 14.05, which was lower than that for other causes of trauma. This suggests a more severe TBI.

Limitations

Our study has some limitations. Our data were extracted retrospectively from the institutional "HBYS" system, and the level of detail inherent in HBYS-based studies is limited by incomplete data entry and data entry errors. Our target population consisted of patients with pediatric head trauma. Of these patients, only those who were followed and treated at a single center and only at the Neurosurgery Clinic were included in the study. Our study awaits validation in future large, multicenter retrospective and prospective studies.

CONCLUSION

We present a series of 180 children who were followed and treated for pediatric head trauma. All cases were followed and treated by the Neurosurgery Clinic according to the criteria of our center. Educating families are crucial to prevent future pediatric falls and to help the Social Security Institution alleviate the financial burden. We believe that our descriptive data will serve as a valuable example for readers.

Ethics Committee Approval: This study was approved by the Ethics Committee of the Kayseri City Hospital (approval number: 543; date: August 26, 2025) and in accordance with the principles stated in the 1975 Helsinki Declaration, revised in 1983.

Informed Consent: The retrospective file review was conducted with deidentified data; therefore, institutional informed consent was not required from patients.

Peer-review: Externally peer-reviewed.

Conflict of Interest: There is no conflict of interest.

Author Contributions: Conception: Y.G, S.G; Design: Y.G, S.G; Supervision: Y.G, S.G; Data Collection and/or Processing: Y.G, S.G, F.P, S.B; Statistical Analysis: B.O, Writing: Y.G, S.G.

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