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# Clinicopathological Characteristics of Traumatic Head Injury in Juvenile, Middle-Aged and Elderly Individuals

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**Background:** Traumatic head injury is a leading cause of death and disability worldwide. How clinicopathological features differ by age remains unclear. This epidemiological study analyzed the clinicopathological features of patients with head injury belonging to 3 age groups.





**Material/Methods:** Data of patients with traumatic head injury were obtained from the Department of Cerebral Surgery of the Affiliated Hospital of Guizhou Medical University and the Guizhou Provincial People's Hospital in 2011–2015. Their clinicopathological parameters were assessed. The patients were divided into 3 age groups: elderly ( $\geq 65$  years), middle-aged (18–64 years), and juvenile ( $\leq 17$  years) individuals.

**Results:** Among 3356 hospitalizations for traumatic head injury (2573 males and 783 females, 654 died (19.49%), the highest and lowest mortality rates were in the elderly and juvenile groups, respectively. Fall was the most common cause in juvenile and elderly individuals (32.79% and 43.95%, respectively), while traffic injury was most common in the elderly group (35.08%). The manners of injury differed considerably among the 3 age groups. Scalp injury, skull fracture, intracranial hematoma, and cerebral injury were the most common mechanisms in juvenile (67.32%), middle-aged (63.50%), elderly (69.56%) and middle-aged (90.44%) individuals, respectively. Scalp injury and skull fracture types differed among the groups. Epidural, subdural, and intracerebral hematomas were most common in juvenile, middle-aged, and elderly individuals, respectively. Cerebral contusion showed the highest frequency in the 3 groups, and concussion the lowest.

**Conclusions:** Patients with traumatic HI show remarkable differences in clinicopathological features among juvenile, middle-aged, and elderly individuals.

**MeSH Keywords:** **Age Factors • Head Injuries, Closed • Population Characteristics**

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## Background

Traumatic head injury (HI) is one of the most common causes of death and disability worldwide. The clinical and pathological features of HI are not only helpful for its diagnosis and treatment, but also can help analyze the wounding mechanism in the field of forensic medicine [1]. According to large-scale population statistics, more than 40% of autopsy cases for violent death are caused by central nervous system injury, and 2% of disability is caused by brain injury [2]. In recent years, HI cases have steadily increased in both developed and developing countries. Therefore, it is of great significance to assess the clinical and pathological characteristics of HI [3,4].

HI epidemiology is well reported worldwide [5,6]. However, differences in clinical and pathological features in HI among juvenile, middle-aged, and elderly individuals remain undefined. Thus, the purpose of this study was to assess the descriptive epidemiology and characteristic trends of HI among juvenile, middle-aged, and elderly subjects in the Department of Cerebral Surgery of the Affiliated Hospital of Guizhou Medical University and the Department of Cerebral Surgery of the Guizhou Provincial People's Hospital (both in Guiyang, China) in 2011–2015. The findings could help determine how HI occurs, and identify its cause and manner in different age groups.

## Material and Methods

### Subjects and grouping

The subjects were patients who underwent standardized systematic treatment for first-time hospitalization after HI. Medical records were obtained for the period from December 2011 to November 2015 in the Affiliated Hospital of Guizhou Medical University and the Guizhou Provincial People's Hospital for patients treated in the Department of Cerebral Surgery. Inclusion criteria were: complete medical records, including the diagnosis of craniocerebral trauma, brain contusion or skull fracture, and other diagnostic parameters related to traumatic HI. Exclusion criteria were: (1) rehabilitation treatment for HI; (2) hospital readmission for HI; (3) a previous history of HI and hospitalization for other reasons.

The subjects were divided into 3 groups, including the juvenile (0–17 years), middle-aged (18–64 years), and elderly (65 years and older) groups.

The data collected included general patient information (e.g., hospitalization, medical records, gender, age) and inpatient medical records (e.g., injury pattern, manner, and type; type and location of skull fracture; intracranial hematoma, cerebral injury).

The study was approved by the Ethics Committee of Guizhou Medical University.

### Methods

This was a retrospective study. By reviewing the medical records of all subjects, the required information was collected using a pre-established questionnaire. The data were input into computers and SPSS 21.0 software was used for analysis.

### Questionnaire content

General information included the patient number, sex, age, and mortality, among others. Causes of injury included blunt blow, fall, traffic injury, and high fall injury. Manners of injury included self-mutilation, injury by another person, and accident. Types of injury were scalp injury, skull fracture, intracranial hemorrhage, and brain injury, among others.

### Data collection

According to the above inclusion and exclusion criteria, eligible subjects were screened and their original hospitalization records retrieved to fill out the questionnaire.

### Statistical methods

All statistical analyses were performed with SPSS 21.0 (SPSS, Inc., Chicago, IL, USA). The chi-square ( $\chi^2$ ) test for R×C tables was used to compare the 3 age groups. Then, pair comparisons were performed by the  $\chi^2$  test for 2×k tables. The K-independent nonparametric test was used for each age group.  $P < 0.05$  was considered statistically significant.

## Results

### Sex and mortality

From December 2011 to November 2015 in the Department of Cerebral Surgery of Affiliated Hospital of Guizhou Medical University and in the Department of Cerebral Surgery of Guizhou Provincial People's Hospital there were 3356 patients with traumatic HI, including 2573 males (76.67%) and 783 females (23.33%). There were 3.29 times more males than females (Table 1). The male-to-female ratios in the juvenile, middle-aged, and elderly groups were 1.71, 5.30, and 2.37, respectively.

Among the 3356 cases of HI, 654 died (19.49%). The highest mortality rate was found in elderly individuals and the lowest in the juvenile group (Table 2).

**Table 1.** Sex ratios in different age groups.

Age	Sex		Total	P value	$\chi^2$ (P value)
	Male	Female			
≤17	544 (63.04%)	319 (36.96%)	863	P<0.05	162.78
18~64	1680 (84.13%)*	317 (15.87%)*	1997	P<0.05	
≥65	349 (70.36%)*#	147 (29.64%)*#	496	P<0.05	
Total	2573 (76.67%)	783 (23.33%)	3356	–	

\* P<0.05 versus ≤17; # P<0.05 versus 18~64.

**Table 2.** Mortality rats in different age groups.

Age	Cases	Mortality	P value	$\chi^2$ (P value)
≤17	863	73 (8.46%)	P<0.05	117.56
18~64	1997*	424 (21.23%)*	P<0.05	
≥65	496*#	157 (31.65%)*#	P<0.05	
Total	3356	654 (19.49%)	–	

\* P<0.05 versus ≤17; # P<0.05 versus 18~64.

**Table 3.** Injury patterns in different age groups.

Age	Injury patterns					Total	P value	$\chi^2$ (P value)
	Blunt blow	Fall	Traffic injury	Fall from height	Others*			
≤17	45 (5.21%)	283 (32.79%)	152 (17.61%)	195 (22.60%)	188 (21.78%)	863	P<0.05	271.35
18~64	249 (12.47%)*	442 (22.13%)*	560 (28.04%)*	259 (12.97%)*	487 (24.39%)	1997	P<0.05	
≥65	14 (2.82%)*#	218 (43.95%)*#	174 (35.08%)*#	34 (6.85%)*#	56 (11.29%)	496	P<0.05	
Total	308	943	886	488	731	3356	–	

\* Include sharp injuries, firearm injuries, and injuries of unknown patterns. \* P<0.05 versus ≤17; # P<0.05 versus 18~64.

**HI pattern and nature**

Fall was the most common type in the juvenile and elderly groups (32.79% and 43.95%, respectively), while traffic injury was the most common type in the elderly group (35.08%). The rate of blunt blow was highest in middle-aged individuals (12.47%) (Table 3). Accident was the most common cause of HI in the 3 age groups, with the highest proportion in the juvenile group (78.91%) followed by the elderly group (78.23%). Self-injury was the most common cause in elderly individuals (1.61%), and infliction by another person was most common in middle-aged subjects (8.66%) (Table.4).

**HI types**

For head injury types, cerebral injury was the most common, accounting for 79.38%, followed by intracranial hemorrhage (65.44%), skull fracture (58.10), and scalp injury (57.48%).

Scalp injury and intracranial hematoma were the most common types in the juvenile (67.32%) and elderly (69.56%) groups. Both cerebral injury and skull fracture were the most common type in middle-aged subjects (90.44% and 63.50%, respectively) (Table 5).

**Scalp injury**

Scalp hematoma was the most common type of scalp injury in juveniles (51.61%), while scalp laceration and contusion were the most common types found in the middle-aged (40.68%

**Table 4.** Manners of head injury in different age groups.

Age	Manner of injury				Total	P value	$\chi^2$ (P value)
	Self-injury	Trauma by other people	Accident	Unclear			
≤17	1 (0.12%)	24 (2.78%)	681 (78.91%)	157 (18.19%)	863	P<0.05	97.73
18~64	3 (0.15%)*	173 (8.66%)*	1355 (67.85%)*	466 (23.34%)	1997	P<0.05	
≥65	8 (1.61%)**	11 (2.22%)**	388 (78.23%)**	89 (17.94%)	496	P<0.05	
Total	12	208	2424	712	3356	–	

\* P<0.05 versus ≤17; # P<0.05 versus 18~64.

**Table 5.** Types of head injury in different age groups.

Age	Types of head injury				P value	$\chi^2$ (P value)
	Scalp injury	Skull fracture	Intracranial hematoma	Cerebral injury		
≤17	581 (67.32%)	506 (58.63%)	480 (55.62%)	465 (53.88%)	P<0.05	151.01
18~64	1144 (57.29%)*	1268 (63.50%)*	1371 (68.65%)*	1806 (90.44%)*	P<0.05	
≥65	204 (41.13%)**	176 (35.48%)**	345 (69.56%)**	393 (79.23%)**	P<0.05	
Total	1929 (57.48%)	1950 (58.10%)	2196 (65.44%)	2664 (79.38%)	–	

\* P<0.05 versus ≤17; # P<0.05 versus 18~64.

**Table 6.** Scalp injuries in different age groups.

Age	Scalp injuries				Total	P value	$\chi^2$ (P value)
	Scalp abrasion	Scalp contusion	Laceration of scalp	Scalp hematoma			
≤17	37 (6.37%)	122 (21.00%)	128 (22.03%)	294 (50.60%)	581	P<0.05	666.51
18~64	30 (2.62%)*	357 (31.21%)*	488 (42.66%)*	269 (23.51%)*	1144	P<0.05	
≥65	13 (6.37%)**	57 (27.94%)**	61 (29.90%)**	73 (35.78%)**	204	P<0.05	
Total	80	536	677	636	1929	–	

\* P<0.05 versus ≤17; # P<0.05 versus 18~64.

and 32.12%, respectively) groups. Scalp injury was found in 57.48% individuals, including 4.15% and 35.10% cases with scalp abrasion and laceration, respectively (Table 6).

### Skull fractures

In the 3 age groups, fracture of the calvaria was the most common skull fracture. Fracture of the skull base, cranium with skull base fracture, and craniofacial fracture were all the most common type in elderly patients (21.02%, 22.16%, and 8.52%, respectively) (Table 7).

Linear fracture was the most common type in middle-aged subjects (70.94%) and depressed fracture was the most common type in juveniles (37.31%). Comminuted and perforating fractures showed highest rates both in elderly patients (11.27% and 3.76%, respectively) (Table 8).

### Intracranial hematoma

Epidural hematoma was the most common type in the juvenile and middle-aged groups (54.17% and 37.56%, respectively), while subdural hematoma showed the highest rate in

**Table 7.** Proportions of skull fracture sites in different age groups.

Age	Skull fracture site					Total	P value	$\chi^2$ (P value)
	Fracture of the calvaria	Fracture of the skull base	Cranium with skull fracture	Craniofacial fracture	Unknown site			
≤17	340 (67.19%)	82 (16.21%)	74 (14.62%)	6 (1.19%)	4 (0.80%)	506	P<0.05	81.71
18~64	657 (51.81%)*	254 (20.03%)*	176 (13.88%)*	107 (8.44%)*	74 (5.84%)	1268	P<0.05	
≥65	76 (43.18%)*#	37 (21.02%)*#	39 (22.16%)*#	15 (8.52%)*#	9 (5.11%)	176	P<0.05	
Total	1073	373	289	128	87	1950	–	

\* P<0.05 versus ≤17; # P<0.05 versus 18~64.

**Table 8.** Types of skull fractures in different age groups.

Age	Types of skull fractures					Total	P value	$\chi^2$ (P value)
	Linear fracture	Depressed fracture	Comminuted fracture	Perforating fracture	Unknown			
≤17	199 (42.43%)	175 (37.31%)	30 (6.40%)	17 (3.62%)	48 (10.23%)	469	P<0.05	44.80
18~64	874 (70.94%)*	153 (12.42%)*	78 (6.33%)*	28 (2.27%)*	99 (8.04%)	1232	P<0.05	
≥65	104 (48.83%)*#	55 (25.82%)*#	24 (11.27%)*#	8 (3.76%)*#	22 (10.33%)	213	P<0.05	
Total	1177	383	132	53	169	1914	–	

\* P<0.05 versus ≤17; # P<0.05 versus 18~64.

**Table 9.** Types of intracranial hematoma in different age groups.

Age	Types of intracranial hematoma				Total	P value	$\chi^2$ (P value)
	Epidural hematoma	Subdural hematoma	Subarachnoid hemorrhage	Intracerebral hematoma			
≤17	260 (54.17%)	166 (34.58%)	31 (6.46%)	23 (4.79%)	480	P<0.05	111.85
18~64	515 (37.56%)*	507 (36.98%)*	208 (15.17%)*	141 (10.28%)*	1371	P<0.05	
≥65	78 (22.61%)*#	157 (45.51%)*#	80 (23.19%)*#	30 (8.70%)*#	345	P<0.05	
Total	853	830	319	194	2196	–	

\* P<0.05 versus ≤17; # P<0.05 versus 18~64.

elderly individuals (45.51%). Subarachnoid hemorrhage was the most common type in the elderly group (23.19%), while intracerebral hematoma was the most common type in middle-aged patients (10.28%). In the 3 age groups, intracerebral hematoma was the least common (Table 9).

### Cerebral injury

The rate of cerebral contusion was highest in the 3 age groups, while concussion was least common. Cerebral concussion was the most common type in the middle-aged group (2.55%).

Diffuse axonal injury and primary brain stem injury were also the most common types in middle-aged subjects (10.80% and 16.00%, respectively; Table 10).

### Discussion

To the best of our knowledge, this is the first population-based study assessing traumatic HI among juvenile, middle-aged, and elderly individuals that included both clinical and pathological characteristics. In addition, most previous studies analyzing

**Table 10.** Types of cerebral injury in different age groups.

Age	Types of cerebral injury				Total	P value	$\chi^2$ (P value)
	Cerebral concussion	Cerebral contusion	Diffuse axonal injury	Primary brain-stem injury			
≤17	11 (2.37%)	361 (77.63%)	35 (7.53%)	58 (12.47%)	465	P<0.05	20.41
18~64	43 (2.38%)*	1279 (70.82%)*	195 (10.80%)*	289 (16.00%)*	1806	P<0.05	
≥65	1 (0.25%)#	307 (78.12%)#	32 (8.14%)#	53 (13.49%)#	393	P<0.05	
Total	55	1947	262	400	2664	–	

\* P<0.05 versus ≤17; # P<0.05 versus 18~64.

HI compared elderly and young subjects. This study provides more detailed results by including middle-aged subjects. The findings could help determine how HI occurs as well as its cause and manner in different age groups.

#### **Incidence, sex distribution, and mortality**

The above findings revealed that HI was most common in middle-aged subjects, followed by juveniles and the elderly. These results were consistent with those reported by Secer and Salem [7,8] but differed from those of Siman and Younis [9,10]. Regarding sex differences in the 3 age groups, HI was more common in males than in females, with the largest proportion of males affected in the middle-aged group, corroborating previous findings [11,12]. It is possible that middle-aged men are more likely to work outdoors, and as a result are more likely to sustain injury at the workplace, while middle-aged women are usually housewives or are more engaged in indoor work. In addition, we found that the juvenile group had the lowest male-to-female ratio for HI, which might be because most juveniles were of school-age, with the risk of injury likely consistent in both males and females.

As with most previous studies, our results revealed higher mortality of elderly patients with HI compared with juveniles and middle-aged subjects. This might be associated with body weakening in the elderly, whose death might be associated with other diseases after head injury [1,3]. Furthermore, this study found the mortality rate of middle-aged patients was higher than that of juveniles. It might be that HI in middle-aged patients was mainly caused by traffic accidents, with motorcycle accidents accounting for a large proportion, causing more serious damage than falls in juveniles [13].

#### **Mechanism and manner of HI**

Traffic accident is considered by some to be the primary cause of HI, while others believe it is falls instead; the discrepancy might be related to patient age [14–18]. It was reported

that fall is the primary risk factor for HI in the elderly people [17,19], and Home et al. considered that children <5 years and adults ≥65 years of age are at greatest risk for fall-related injuries [20]. For adolescents and children, different views have been voiced. Some studies reported that traffic accidents are the primary risk factor [17,21,22], while others instead described fall as the most important factor [23,24].

In this study, the rate of fall-associated HI was highest in the juvenile and elderly groups, while traffic accident-related HI in elderly subjects accounted for the largest proportion. Falls here included falling down by pedestrians or cyclists, but not from height. These 2 ways are more common by juveniles and the elderly than in middle-aged subjects. HI caused by fall from height was more common among juveniles, which might be related to poor vigilance in this age group prone to accidental fall from height.

Consistent with previous reports, the above results showed that the most common cause of HI was accident in the 3 age groups, while self-inflicted injuries and those inflicted by other people only accounted for a small percentage [25–27]. However, it is worth noting that the proportion of HI caused by other people in middle-aged subjects reached 8.66%, which was significantly different from those of other age groups (P<0.05). It may be that most Chinese middle-aged individuals nowadays have to raise children and support the elderly, thus sustaining higher work and life pressures compared with the other age groups. As a result, they are more likely to fight and suffer head injuries. Furthermore, in this study, the highest proportion of self-inflicted injuries was found in elderly subjects, corroborating a previous report which indicates that more attention should be paid to the mental health of the elderly in order to reduce injury incidents [19].

#### **Patterns of head injury**

Scalp injury accounted for the largest proportion in the juvenile group and might be related to scalp tenderness in the young,

with falls more likely to cause scalp injury. Cerebral injury and skull fracture were the most common patterns in the middle-aged group, in agreement with previous findings that cerebral injury and skull fracture are positively correlated. The proportion of intracranial hematoma cases in the elderly group was the largest, corroborating previous reports.

### Types of scalp injury

Scalp injury is common in head trauma. It includes abrasions, bruises, lacerations, and scalp hematoma, which are important for developing injury assessment tools and analyzing injury mechanisms.

In this work, scalp hematoma was the most common type in juveniles, and laceration and contusion were the most common types in the middle-aged groups. Scalp abrasion was the least common type in the 3 age groups. Aghakhani reported that scalp injury was found in 76.2% and 75% of individuals with motor vehicle accident injury and fall, respectively; while scalp abrasion and laceration were found in 65.2% and 54.5% among scalp injuries, respectively [28]. In this study, scalp injury was found in 57.48% of individuals, including 4.15% and 35.10% cases with scalp abrasion and laceration, respectively. These values were lower than those reported by Aghakhani, probably because the latter authors assessed autopsy cases, while the current findings were based on clinical inpatient medical records, and some minor scalp injuries might have not been recorded by clinicians.

### Types of skull fractures

The shape of a skull fracture is helpful in determining the traumatic object and analyzing the mechanism of craniocerebral injury. The incidence of skull fracture is an effective method to judge the incidence of craniocerebral injury. Epidemiological data on fractures in different age groups are scarce, and there have been few reports comparing different types of skull fractures in different age groups.

In this study, linear fracture was the most common type in the 3 age groups, with the highest proportion found in middle-aged subjects, consistent with previous findings [29].

The proportions of depressed and comminuted fractures in the juvenile and elderly groups were the largest, while the difference in perforated fracture rates among the 3 groups was not significant.

In the 3 age groups, the proportions of calvarial fractures were the highest, while craniofacial fractures showed the lowest rates.

### Types of intracranial hematoma

It was reported that epidural hematoma occurs in 25% to 45% of severe TBI cases [30]. In this study, epidural hematoma occurred in 48.86%, 37.57%, and 25.49% of juvenile, middle-aged, and elderly subjects, respectively, somewhat in disagreement with previous reports. However, these figures not only included cases of severe head injuries, but also the moderate and mild types.

Irie et al. reported that HI peaks at the age of 18, and gradually decreases with increasing age [31]. This study found a similar trend, with HI rates in the juvenile, middle-aged, and elderly groups reduced successively.

As shown above, the trend of traumatic subarachnoid hemorrhage was opposite to that of epidural hemorrhage, whose proportion in the elderly was the largest, sequentially followed by the middle-aged and juvenile groups. The proportion of subarachnoid hemorrhage in elderly patients in this study was higher than reported previously (30.59% vs. 12.7%), while the rate of traumatic subdural hemorrhage was lower (37.13%) than the 42.9% reported previously [32]. Intracerebral hemorrhage proportions were not significantly different among the 3 age groups.

### Types of cerebral injury

The proportions of cerebral concussion in the 3 age groups were very low, likely due to underestimation. Concussion symptoms might not be known to many injured individuals, who might not be able to completely describe their condition after injury [33]. The highest proportion of cerebral injury was brain contusion in the 3 groups. The proportions of cerebral concussion between the juvenile and middle-aged groups, and the proportions of cerebral contusion between the juvenile and elderly group were similar. Diffuse axonal injury and primary brain stem injury showed little difference between juvenile and elderly groups, while the differences were larger when compared to the middle-aged group.

Menon et al. and Aghakhani et al. reported that brain contusions were found in 35% and 74.3%, respectively [28,34]. In this study, 78.47% were obtained in juveniles, with 67.35% in middle-aged subjects and 72.82% in the elderly, which are values closer to findings by Aghakhani et al.

### Limitations

Limitations of this study should be mentioned. First, hospital records were reviewed, with no outpatient data collected. Thus, this study might have underestimated the total number of HI cases. To obtain a complete picture, Emergency

Department data are vital, as many mild HI cases are solely treated there. Secondly, no information on the pre-injury health status was available, as well as risk factors of injury and qualitative outcome data. Finally, because of the retrospective nature of the current study, we did not have complete control over the assessed variables, with missing or incorrect data in many instances.

Despite these limitations, the present results provide a valuable reference for relevant studies. To the best of our knowledge, studies assessing differences in the proportions of clinical and pathological types of head injury in various age groups are rare. In particular, differences in various types of HI, such as scalp injury, skull fracture, intracranial hemorrhage, and brain injury, have rarely been reported for different age groups. This study might provide new insights into HI and trigger further studies of HI epidemiology in juvenile, middle-aged, and elderly individuals.

## References:

1. Matthew L, Margaret F, Robyn G: Minor injuries in older adults have different characteristics, injury patterns, and outcomes when compared with younger adults: An Emergency Department correlation study. *Int Emerg Nurs*, 2015; 23(2): 168–73
2. Masson, Françoise MD: Epidemiology of severe brain injuries: A prospective population-based study. *J Trauma*, 2001; 51(3): 481–89
3. Langlois JA, Rutland BW, Thomas KE: Traumatic brain injury in the United States: Emergency department visits, hospitalizations, and deaths. Atlanta (GA): Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, 2004
4. National Institutes of Health Consensus Panel Issues Report: Consensus development conference on diagnosis and treatment of early melanoma. *J Am Acad Dermatol*, 1993; 28(2Part1): 278
5. Ferrell RB, Tanev KS: Traumatic brain injury in older adults. *Curr Psychiatry Rep*, 2002; 4: 354–62
6. Flanagan SR, Hibbard MR, Gordon WA: The impact of age on traumatic brain injury. *Phys Med Rehab Clin N Am*, 2005; 16: 163–77
7. Secer HI, Gonul E, Izci Y: Head injuries due to landmines. *Acta Neurochir (Wien)*, 2007; 149(8): 777–81; discussion 782
8. Salem AM, Jaumally BA, Bayanzay K et al: Traumatic brain injuries from work accidents: A retrospective study. *Occup Med (Lond)*, 2013; 63(5): 358–60
9. SimanTM, Radomislensky I, Knoller N et al: Incidence and injury characteristics of traumatic brain injury: Comparison between children, adults and seniors in Israel. *Brain Inj*, 2016;30(1): 83–89
10. Younis R, Younis M, Hamidi S et al: Causes of traumatic brain injury inpatients admitted to Rafidia, Al-Ittihad and the specialized Arab hospitals, Palestine, 2006–2007. *Brain Inj*, 2011; 25(3): 282–91
11. Numminen HJ: The incidence of traumatic brain injury in an adult population-how to classify mild cases? *Eur J Neurol*, 2011; 18(3): 460–64
12. Mauritz W, Wilbacher I, Majdan M et al: Epidemiology, treatment and outcome of patients after severe traumatic brain injury in European regions with different economic status. *Eur J Public Health*, 2008; 18(6): 575–80
13. Tokdemir M, Kafadar H, Turkoglu A et al: Comparison of the severity of traumatic brain injuries in pedestrians and occupants of motor vehicles admitted to First health center: A five-year series in an Eastern Turkish city. *Med Sci Monit*, 2009; 15(1): P11–4
14. Brazinova A, Rehorcikova V, Taylor MS et al: Epidemiology of traumatic brain injury in Europe: A living systematic review. *J Neurotrauma*, 2016; 25 [Epub ahead of print]
15. Samad SV, Rouzbeh RG, Sajjad R et al: Bicycle-related injuries presenting to Tabriz Imam Reza Hospital, Iran. *Trauma Mon*, 2016; 21(2): e20856
16. Bener A, Abdul Rahman YS, Abdel Aleem EY et al: Trends and characteristics of head and neck injury from falls: A hospital based study, Qatar. *Sultan Qaboos Univ Med J*, 2011; 11(2): 244–51
17. Elmenyar A, Mekkodathil A, Althani H et al: Incidence, demographics and outcome of traumatic brain injury in the Middle East: A systematic review. *World Neurosurgery*, 2017; 107: 6–21
18. Kuppermann N, Holmes JF, Dayan PS et al: Identification of children at very low risk of clinically-important brain injuries after head trauma: A prospective cohort study. *Lancet*, 2009; 374: 1160–70
19. Amy EF, Sumera K, Sue M: The epidemiology of severe traumatic brain injury among persons 65 years of age and older in Oklahoma, 1992–2003. *Brain Injury*, 2007; 21(7): 691–99
20. Home Safety Council. National nonprofit urges caregivers to protect older adults and children – the age groups at most risk. 2008. Available at: [http://homesafetycouncil.org/media/media\\_w\\_142.aspx](http://homesafetycouncil.org/media/media_w_142.aspx)
21. Runyan CW, Kotch JB, Margolies LH et al: Childhood injuries in North Carolina: A statewide analysis of hospitalizations and deaths. *Am J Public Health*, 1985; 75: 1429–32
22. Maureen SD, Danielle Laraque, Ilona Lubman et al: Epidemiology and prevention of traffic injuries to urban children and adolescents. *Pediatrics*, 1999; 103(6): e74
23. Thompson RS, Rivara FP, Thompson DC: A case-control study of the effectiveness of bicycle safety helmets. *N Engl J Med*, 1989; 320(21): 1361–67
24. Lotfi Sadigh S, Gholipour C, Vahdati SS et al: Clinical predictors of abnormal computed tomography scan in minor head trauma in children under 2 years old. *Anal Res Clin Med*, 2015; 3(1): 57–63
25. Susan DS: Detecting violence in the archaeological record: Clarifying the timing of trauma and manner of death in cases of cranial blunt force trauma among pre-Columbian Amerindians of West-Central Illinois. *Int J Paleopathol*, 2012; 2: 112–22
26. Makhlouf, Rambaud C: Child homicide and neglect in France: 1991–2008. *Child Abuse Negl*, 2014; 38: 37–41
27. Hyejin P, Bongwoo L, Connie Y: Suicide by blunt head trauma – Two cases with striking similarities. *Forensic Sci Int*, 2015; 255: 102–5
28. Muñoz-Sánchez MÁ, Murillo-Cabezas F, Cayuela A et al: The significance of skull fracture in mild head trauma differs between children and adults. *Childs Nerv Syst*, 2005; 21(2): 128–32
29. Thurman D, Guerrero J: Trends in hospitalization associated with traumatic brain injury. *JAMA*, 1999; 282: 954–57
30. Irie F, Brocque RL, Kenardy J et al: Epidemiology of traumatic epidural hematoma in young age. *J Trauma*, 2011; 71(4): 847–53

## Conclusions

This was the first population-based study assessing clinicopathological characteristics of traumatic HI among juvenile, middle-aged, and elderly subjects. The current findings might provide novel insights into the clinicopathological and epidemiological characteristics of traumatic brain injury in different age groups and help improve the clinical diagnosis and treatment of HI. Further studies are required to identify the specific causes of differences in clinical and pathological features of traumatic HI in different age groups as well as the relationships among HI types.

## Conflicts of interest

None.



31. Harvey LA, Close JC: Traumatic brain injury in older adults: Characteristics, causes and consequences. *Injury*, 2012; 43(11): 1821–26
32. Cusimano MD, Chipman ML, Volpe R, Donnelly P: Canadian minor hockey participants' knowledge about concussion. *Can J Neurol Sci*, 2009; 36: 315–20
33. Menon A, Pai VK, Rajeev A: Pattern of fatal head injuries due to vehicular accidents in Mangalore. *J Forensic Leg Med*, 2008; 15: 75e7
34. Aghakhani K, Heidari M, Yousefinejad V et al: Frequency of intracranial injury in cadavers with head trauma with and without scalp injury in Tehran. *J Forensic Leg Med*, 2014, 28: 36–38