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Evaluation of intentional and unintentional injuries in children and adolescents with trauma scoring systems

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ABSTRACT

Aim: To evaluate the general characteristics of cases under the age of 18 years who presented at our forensic medicine clinic due to intentional or unintentional trauma and to evaluate the severity of injury using trauma scoring systems.

Methods: This study included all cases under the age of 18 years with a forensic report prepared due to trauma in the forensic medicine clinic between 2017-2021. The cases included in the study were evaluated in terms of the following parameters: "gender, age, forensic event, cause of accidental injury, intentional or unintentional injury, injury site, location of traffic accident victims, safety belt using, degree of forensic injury, trauma scores [Injury Severity Score (ISS) and New Injury Severity Score (NISS)]. The ISS and NISS were calculated using the Abbreviated Injury Scale (AIS) 2008 update. The results were statistically compared and evaluated.

Results: The majority of the cases were male (n=281, 75.13%), and the mean age was 12.03±4.83 years. More than half of the cases (n: 190, 50.80%) were unintentional injuries. The victims were injured most frequently due to battery (n=180, 48.10%). The most common injury sites were the head and neck (n=136, 36.40%). The majority of child and adolescent victims of traffic accidents under the age of 18 did not use helmets, seat belts, and protective equipment. The mean injury severity score (ISS) of the cases was 3.66±5.79, and the mean new-injury severity score (NISS) was 5.03±7.58. The ISS and NISS values were significantly higher in unintentional injuries than in intentional injuries.

Conclusion: More severe injuries were caused unintentionally in children and adolescents. Pedestrians, cyclists, and motorcyclists were at the greatest risk for serious injury. It is necessary to provide necessary training on the importance of protective equipment for this age group and to increase the controls.

Key words: Injury, intentional, unintentional, trauma scores, child, adolescent

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Introduction

Children and adolescents are populations at high risk of injury [1]. Every year, approximately 950,000 children under the age of 18 years die as a result of injuries and assaults, and many more suffer injuries that require treatment in hospitals and may even result in disability [2]. Pediatric injuries are a major public health problem in both low-income and high-income countries but are more prominent in countries with excessive urbanization and industrialization [3]. However, mortality from injuries in children is higher in low- and middle-income countries than in high-income countries [4]. In China, intentional injuries were closely related to age, male gender, living in rural areas, and being a student [5]. In a

study of including 3921 children aged 7-14 years in Turkey, it was claimed that the male gender and a low home population increased the risk of accidental injury to children [6].

Injuries of children and adolescents under the age of 18 years cause significant emotional, physical, and economic damage to society. The lifetime medical and job loss costs of injuries to individuals under the age of 18 years in the United States of America are estimated to be $94 billion [7]. Hospital costs for child injuries over a 10-year period in Australia were estimated to be $2.1 billion [8]. Analyzing this public health problem may help to identify the risk factors, which may then be reduced with preventative measures [7].

The Injury Severity Score (ISS) and New Injury Severity Score (NISS) are valuable trauma scoring systems in showing trauma severity (9). The NISS is one of the trauma scoring systems that best predict mortality [10]. Li and Ma reported that NISS was more valuable than ISS in predicting mortality in patients with severe blunt trauma [11]. Brown et al. demonstrated that an ISS of ≥25 is a critical indicator of mortality in the pediatric patient group [12]. A one-unit increase in ISS in pediatric injuries results in a 33% higher relative probability of hospitalization [13].

Evaluation of the severity of intentional and unintentional injuries in children with trauma scoring systems may provide a better understanding of the risk factors that cause severe trauma in children. Thus more accurate measures may be taken to reduce these risks. This study aimed to evaluate the general characteristics of cases under the age of 18 years who presented at our forensic medicine clinic due to intentional or unintentional trauma and to assess the severity of injury using trauma scoring systems.

Materials and methods

This retrospective study was conducted in Forensic Medicine Clinic of Bolu Abant Izzet Baysal Training and Research Hospital. Besides, although it is designed as a retrospective study with no identification data or human/animal subjects, and thus it is out of the scope of the informed consent doctrine. Ethics committee approval was obtained for the study from the Clinical Research Ethics Committee of Bolu Abant Izzet Baysal University (decision no: 2022/103, dated: 26.04.2022). The study was conducted by the principles of the Declaration of Helsinki of 1964, revised in 2013.

All cases under the age of 18 for whom the forensic report was requested as a result of intentional and unintentional injury between January 01, 2017, and December 31, 2021, were included in this retrospective study. Cases older than 18 years, without traumatic injury, or with incomplete data were excluded from the study. The data were collected retrospectively from the hospital's automated records system, forensic records, and patient files of the cases included in the study.

The cases included in the study were evaluated in terms of the following parameters: “gender, age, forensic event, cause of accidental injury, intentional or unintentional injury, injury site, location of traffic accident victims, safety belt using, degree of forensic injury, trauma scores (ISS – NISS). The ISS and NISS were calculated using the Abbreviated Injury Scale (AIS) 2008 update.

Statistical analysis: Data obtained in the study were analyzed statistically using Statistical Package for Social Science (SPSS), version 21.0 software (IBM Corpn., Armonk, NY, USA). The conformity of variables to normal distribution was investigated using visual (histogram plots) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk test). Descriptive

statistics were presented as frequency, percentage, mean, and median and standard deviation values. Categorical variables were compared with the Chi-Square Test. Non-parametric tests were conducted to compare non-normally distributed: Two groups were evaluated with the Mann–Whitney U Test, and more than two groups with the Kruskal–Wallis Test (Post-Hoc:Dunn-Bonferroni test). Descriptive analyses were given using median and interquartile range (IQR) for the non-normally distributed and ordinal variables and using frequency and percentage for the ordinal variables. A *p*-value of less than 0.05 was considered to show a statistically significant result.

Results

In this study, 374 cases were included: 75.13% (n=281) of the cases were male and 24.87% (n=93) were female. The mean age of the cases

Table 1. Characteristics of intentional and unintentional injuries.

Paramaters			**n**	**%**
Age (Years)	0-12 years		151	40.40
	13-15 years		91	24.30
	16-17 years		132	35.30
Forensic event	Battery		180	48.10
	Traffic accident		133	35.60
	Accident		45	12.00
	Suicide		4	1.10
	Occupational accidents		6	1.60
	Dog attack		6	1.60
Traffic accident	In-vehicle	Driver	4	3.01
		Front seat passenger	23	17.29
		Back seat passenger	30	22.56
	Off-vehicle	Pedestrian	35	26.32
		Rider	14	10.52
	Motorcycle	Driver	19	14.29
		Passenger	8	6.01
Injury site	Head–neck		136	36.40
	Extremity		109	29.10
	Chest		12	3.20
	Abdomen		6	1.60
	Multiple		111	29.70
In-vehicle traffic accident	Seat belt fastened		6	10.52
	Seat belt not fastened		51	89.48
Accident cause	Falling		19	42.22
	Falling off bike		5	11.11
	Pouring boiling water on		5	11.11
	Sharp object injury		4	8.88
	Gunshot injury		2	4.44
	Object falling on		2	4.44
	Others		8	17.80

was 12.03±4.83 (range 1-17 years), and the most common age group was 0-12 years (n=151, 40.40%) (Table 1). More than half of the cases (n: 190, 50.80%) were unintentional injuries. The cases were injured most frequently due to battery (n=180, 48.10%) and to traffic accidents (n=133, 35.60%) (Table 1). The most common injury sites were the head and neck (n=136, 36.40%) and extremities (n=109, 29.10%) (Table 1). The most common victims of traffic accident injuries were pedestrians (26.32%) in the vehicle (Table 1). Seat belts were not fastened in 89.48% of the victims of in-vehicle traffic accidents (Table 1). Helmets and protective equipment were not used in 74.10% (20/27) of the motorcycle accident victims. Of the 49 (36.84%) cases injured in off-vehicle traffic accidents, 21 (42.80%) were struck by a vehicle while crossing the road, 14 (28.60%) were thrown onto the road and 14 (28.60%) were riding a bicycle. None of the cases of bicycle accidents were wearing a helmet or protective equipment. The most common cause of accidental injury was falling (n=19, 42.22%) (Table 1).

Table 2. Distribution of ISS according to gender, age group, intentional - unintentional injury, forensic event, injury site, traffic accident, degree of forensic injuries.

Parameters		**Injury Severity Score (ISS)**					***p***
		Mean	S.D.	Median	25th per	75th per	
Gender	Male	3.91	±6.08	1.00	1.00	4.00	.041[1]
	Female	2.91	±4.77	1.00	1.00	2.00	
Age group	0-12 years	3.53	±5.06	1.00	1.00	4.00	.861 [2]
	13-15 years	3.32	±5.78	1.00	1.00	3.00	
	16-17 years	405	±6.56	1.00	1.00	4.00	
Intentional – unintentional injury	Intentional injury	2.25	±3.78	1.00	1.00	2.00	<.001[1]
	Unintentional injury	5.03	±6.97	2.00	1.00	5.25	
Forensic event	Battery	2.23	±3.78	1.00	1.00	2.00	<.001[2]
	Traffic accident	5.32	±7.57	2.00	1.00	5.00	
	Occupational accidents	4.16	±3.92	2.50	1.00	9.00	
	Suicide	3.00	±4.00	1.00	1.00	7.00	
	Accident	4.62	±5.75	1.00	1.00	9.00	
	Dog attack	2.66	±2.25	1.50	1.00	5.25	
Injury site	Head–neck	2.54	±4.62	1.00	1.00	1.00	<.001[2]
	Extremity	2.32	±3.13	1.00	1.00	2.00	
	Chest	2.41	±2.46	1.00	1.00	4.00	
	Abdomen	7.66	±9.35	5.00	1.00	13.00	
	Multiple	6.28	±7.88	2.00	2.00	8.00	
Traffic accident	In-vehicle	2.80	±4.16	1.00	1.00	4.00	<.001[2]
	Off-vehicle	6.48	±7.66	4.00	1.00	9.00	
	Motorcycle	8.51	±10.89	4.00	1.00	13.00	

[1] Mann-Whitney U test [2] Kruskal-wallis test

ISS and NISS

The mean ISS of the cases was 3.66±5.79, and the mean NISS was 5.03±7.58. No statistically significant relationship was found between age groups and injury severity (p>0.05) (Tables 2-3). The ISS and NISS values were significantly higher in males than in females (p<0.05) (Tables 2-3). The ISS and NISS values were significantly higher in cases of multiple trauma than in head and neck injury, extremity injury, and chest injury (Kruskal Wallis: p<0.001, Post-Hoc: p<0.001, p<0.001, p<0.05) (Tables 2-3). The ISS and NISS values were significantly higher in cases injured as a result of traffic accidents than in battery (Kruskal Wallis: p<0.001, Post-Hoc: p<0.001) (Tables 2-3). The ISS and NISS values were significantly higher in off-vehicle traffic and in motorcycle accidents (Kruskal Wallis: p<0.001, Post-Hoc: ISS: p<0.001, p<0.01; NISS: p<0.001, p<0.001) (Tables 2-3).

Table 3. Distribution of NISS according to gender, age group, intentional - unintentional injury, forensic event, injury site, traffic accident, degree of forensic injuries.

Parameters		**New– Injury Severity Score (NISS)**					***p***
		Mean	S.D.	Median	25th per	75th per	
Gender	Male	5.48	±8.17.	3.00	1.00	5.00	.029[1]
	Female	3.66	±5.24	2.00	1.00	3.00	
Age group	0-12 years	4.82	±7.08	1.00	1.00	4.00	.073[2]
	13-15 years	4.25	±6.29	2.00	1.00	3.00	
	16-17 years	5.81	±8.83	3.00	2.00	4.00	
Intentional – unintentional injury	Intentional injury	3.18	±5.38	2.00	1.00	3.00	<.001[1]
	Unintentional injury	6.82	±8.90	3.00	1.00	8.00	
Forensic event	Battery	3.11	±5.30	2.00	1.00	3.00	<.001[2]
	Traffic accident	7.24	±9.51	3.00	1.00	8.00	
	Occupational accidents	5.83	±6.40	3.50	1.00	11.00	
	Suicide	6.50	±7.00	3.00	3.00	13.50	
	Accident	6.13	±7.85	2.00	1.00	9.00	
	Dog attack	3.66	±1.96	3.00	2.50	6.00	
Injury site	Head–neck	3.96	±7.43	2.00	1.00	3.00	<.001[2]
	Extremity	3.47	±4.18	2.00	1.00	3.00	
	Chest	3.41	±4.79	1.00	1.00	4.00	
	Abdomen	9.33	±12.65	5.50	1.00	15.25	
	Multiple	7.81	±9.35	3.00	3.00	9.00	
Traffic accident	In-vehicle	4.01	±6.15	2.00	1.00	4.00	<.001[2]
	Off-vehicle	9.10	±10.46	5.00	2.00	11.50	
	Motorcycle	10.70	±11.55	4.00	3.00	17.00	

[1] Mann-Whitney U test [2] Kruskal-wallis test

Intentional – unintentional injuries

The ISS and NISS values were significantly higher in unintentional injuries than in intentional injuries (p<0.001) (Tables 2-3). Intentionally injured cases were observed to be older (13.79±3.59 vs. 10,48±5.25, p<0.001) (Table 4) Bone fractures seen in unintentional injuries were significantly more severe than in intentional injuries (p<0.001) (Table 4). Therewas no significant difference between intentional and unintentional injuries in terms of gender distribution (p>0.05) (Table 5). The incidence of fracture was significantly higher in the unintentional injury group (p<0.001) (Table 5). The rate of head and neck injuries was higher in intentional injuries (p<0.001), and extremity injuries were seen more in unintentional injuries (p<0.001) (Table 5).

Discussion

More than two-thirds (67.74%) of children and adolescents injured in China between 2006 and 2017 were males [1]. In low- and middle-income countries, 64.70% of injured children aged 0-12 years were boys [13]. It has also been reported that in Saudi Arabia, 69% of injured children aged 0-18 years were male [3], and the majority of childhood injuries were males in Tanzania [14]. In Turkey, mostly males were injured as a result of traffic accidents [15,16]. In this study, the majority of the cases (75.13%) were male, which could be related to the fact that boys are more active and engage in more risky behaviors than girls.

Children under the age of 12 years constituted 72.65% of children and adolescents injured intentionally and unintentionally in China

Table 4. Distribution of intentional - unintentional injuries according to age and fracture score.

Parameters		Mean	S.D.	Median	25th per	75th per	***p***
Age	Intentional injury	13.74	±3.62.	15.00	12.00	16.00	<.001
	Unintentional injury	10.71	±5.05	12.00	7.00	16.00	
Fracture score	Intentional injury	0.28	±1.04	0.00	0.00	0.00	<.001
	Unintentional injury	1.33	±2.07	0.00	0.00	3.00	

Mann-Whitney U test.

Table 5. Distribution of intentional - unintentional injuries according to gender, fracture, injury site.

Parameters		**Intentional injury**		**Unintentional injury**		***p***
		n	%	n	%	
Gender	Male	138	36.90	143	38.23	.953
	Female	46	12.30	47	12.57	
Fracture	Yes	17	4.55	64	17.11	<.001
	No	167	44.65	126	33.69	
Injury site	Head–neck	88	23.53	48	12.84	<.001
	Extremity	38	10.16	71	18.99	<.001
	Chest	6	1.60	6	1.60	.955
	Abdomen	2	0.53	4	1.06	.433
	Multiple	50	13.37	61	16.32	.297

Chi-square test

between 2006 and 2017 [1]. In Australia, 59.10% of cases under the age of 16 years who were hospitalized due to injury were aged < 10 years [8]. In the United States, 44.80% of non-fatal injuries to children and adolescents occurred in children under the age of 10 years, and 58.50% of fatal injuries occurred in children aged ≥15 years [7]. In this study the mean age of the cases was 12.03±4.83 (min:1, max: 17) and the most common age group was 0-12 years. Children under the age of 12 years seem to be at higher risk in terms of injury.

Falling (50.40%) and traffic accidents (16.40%) have been reported to be the most common causes of injury in children aged 0-12 years in low and middle-income countries [13]. Traffic accidents and falling have also shown to constitute the majority of child disabilities [2]. In the United States, the most common reason for presenting at the emergency department in children under the age of 15 years was falling, while the most common reason for referral in the 15-19 years age group was struck by/against [7]. Falling accounts for almost half (48.12%) of intentional and unintentional injuries under the age of 18 years in China [1]. Çetin et al. reported that among the forensic cases admitted to the emergency department, children aged 0-10 years were most frequently admitted due to traffic accidents, and cases aged 10-20 years were due to blunt trauma [17]. In this study, the cases were injured most frequently due to battery and traffic accidents. Children under the age of 16 years with a head or chest injury had a higher risk of death compared to children with other injuries [8]. Demirel and Akpınar reported that in children injured as a result of falling, the most common injuries were to the head and neck (49%) and extremities (39%) [18]. The extremities (45.10%) and head-neck area (34.80%) were the most prevalent injuries in children under the age of 15 years in traffic accidents, according to Serinken and Zen [16]. In this study, the most common injury sites were head and neck and extremities.

In an Australian study, vehicle collisions were linked to more severe injuries and death in children under the age of 16 years [8]. More than half (60.10%) of children and adolescents victims of traffic accident injuries in Singapore were motor vehicle passengers [19]. In this study, 42.86% of the victims injured due to traffic accidents were motor vehicle passengers.

In Saudi Arabia, more than half (53.80%) of children injured in automobile accidents were sitting in the back seat without a seat belt [3]. In Singapore, while 70% of motorcyclists aged 0-16 years who were injured as a result of a traffic accident were not wearing a helmet, 51% of the victims of in-vehicle accidents were not restrained by a seat belt [19]. In this study, 89.48% of the victims of in-vehicle traffic accidents were not wearing a seat belt. In addition, 74.10% (20/27) of the motorcycle accident victims were not wearing a helmet or protective equipment. Child passengers who are inappropriately restrained or not restrained at all have significantly higher ISS values than restrained children [20]. Brown et al. reported that none of the children who were optimally secured in vehicle traffic accidents were severely injured and that the use of restraints appropriate for their size should be encouraged [21]. Although it is obligatory to use special car seats and seat belts for children in the vehicle and to wear a helmet for motorcycle users in Turkey, the data obtained in this study clearly demonstrates that these rules are not implemented by society.

In a study of 50,579 children aged ≤16 years treated at a Pennsylvania trauma center, the median trauma score was 9 [12]. In a study conducted in a pediatric emergency department in Germany, the average ISS of injured child victims was 10 [22]. Atik et al. reported that the

mean ISS score of 453 cases aged 0-17 years, who were injured as a result of traffic accidents, was 3.32±3.76 [15]. In this study, the mean ISS was 3.66±5.79, and the mean NISS was 5.03±7.58.

Atik et al. found no statistically significant difference between genders in terms of ISS in child victims injured as a result of traffic accidents [15]. In this study, the ISS and NISS values were statistically higher in males than in females ($p<0.05$). This was thought to be due to the fact that boys are more likely to engage in more risky actions than girls.

The ISS values were seen to be considerably higher in cases of multiple trauma in child victims wounded as a consequence of a falling [18]. In this study, the ISS and NISS values were significantly higher in multiple traumas than in head and neck injury, extremity injury, and chest injury. In middle- and low-income countries, burns (mean: 7.6) had the highest ISS score in the 0-12 years age group, whereas traffic accidents (mean: 7.3) and falls (mean: 3.6) had the lowest [13]. In this study, the ISS and NISS values were significantly higher in cases injured as a result of traffic accidents compared to battery. In an Australian study, the majority (66%) of children injured in-vehicle traffic accidents suffered minor trauma such as minor external contusions, abrasions, and lacerations [21].

Morbidity and mortality were higher in off-vehicle traffic accidents in children [23]. In Singapore, the probability of serious injury was found to be higher in off-vehicle traffic and motorcycle accidents in the 0-16 years age group [19]. However, Atik et al. reported that there was no statistically significant difference between the type of traffic accident and the severity of injury according to the ISS in 443 patients aged < 18 years [15]. In this study, the ISS and NISS values were significantly higher in off-vehicle traffic and motorcycle accidents. In this study, none of the victims in motorcycle accidents had a driver's licence and 74.1% were not wearing a helmet or protective equipment. Of the 49 (36.84%) cases injured in off-vehicle traffic accidents, 21 (42.80%) were struck by a vehicle while crossing the road, 14 (28.60%) were thrown onto the road and 14 (28.60%) were riding a bicycle. None of those injured in a bicycle accident was wearing a helmet or protective equipment. It is necessary to increase training and controls for the use of helmets and protective equipment for children and adolescents who ride motorbikes and bicycles. It would be beneficial to establish social programs that inform both children and parents about the dangers of road accidents.

Intentional injuries are more likely to be milder injuries, such as soft tissue lesions [24]. A study in Tanzania reported mostly superficial injuries (14.4%) detected in pediatric emergency services [14]. Consistent with the literature, in this study, the ISS and NISS values were significantly lower in intentional injuries than in unintentional injuries.

In China, males had a higher risk of intentional injury than females [5], and in Israel, the intentional injury rate for males was 1.8-fold higher than for females [25]. In this study, there was no significant difference between intentional and unintentional injuries in terms of gender distribution.

The likelihood of presenting at the emergency room due to an intentional injury increases significantly with age [26]. Gallaher et al. showed that children intentionally injured had a higher mean age [24]. The risk of intentional injury increases as patients age [5]. In this study, cases with intentional injury were significantly older. This was thought to be related to the fact that adolescents are more prone to violence.

In China, fractures developed in 8.81% of unintentional injuries and 2.58% of intentional injuries in patients aged <18 years [1]. In this

study, the incidence of fracture was significantly higher in the unintentional injury group. Moreover, bone fractures seen in unintentional injuries were significantly more severe than in intentional injuries. This may be related to the fact that victims of unintentional injuries were exposed to more severe trauma, such as traffic accidents.

Nearly half of the intentional injuries occurred to the head and neck, while unintentional injuries generally occurred to the upper and lower extremities [24]. Half of the unintentional injuries (50.44%) in children and adolescents in China were to the extremities, while the head (39.7%) was the most frequent injury site in intentional injuries [1]. In this study, while the head and neck injury rate was higher in intentional injuries, extremity injuries were higher in unintentional injuries.

This study had some limitations. First, the study was prepared retrospectively, and only included cases that had survived the trauma and not the children who died after the trauma. Therefore, while the results provide information about the severity of trauma in intentional and unintentional injuries, they cannot provide information about mortality.

Conclusions

Unintentional injuries in children and adolescents caused more severe injuries. Pedestrians, cyclists, and motorcyclists were at the greatest risk of serious injury. The majority of children and adolescents aged <18 years who were involved in traffic accidents did not use helmets, seat belts, or protective equipment. There is a clear need to provide the necessary training and increase the inspections for this age group.

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