

School-related injuries: a retrospective 5-year evaluation

R. Kraus · U. Horas · G. Szalay ·
V. Alt · M. Kaiser · R. Schnettler

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Abstract

Purpose Children and adolescents spend up to 50% of their time at school. The purpose of this study was to assess injury patterns of school accidents (along with their treatment) in the trauma center of a German university hospital, and to compare these data to those in the literature.

Methods All school accidents treated in a level 1 pediatric trauma center over a five-year period were statistically analyzed in a retrospective manner by chart review.

Results There were 1,399 school accidents that were treated in our department. Average age of the injured person was 11.8 years, with a boy:girl ratio of 3:2. Almost 40% of the injuries occurred during school sports. The most frequently injured region was the upper extremity, including the hand (36.8%). Distortion and contusion was the most frequent diagnosis among all injuries. Sixteen percent of the cases had to be treated surgically and/or under general anesthesia, and 16% of the patients had to be admitted to the hospital.

Conclusion It can be concluded that special attention must be paid during school sporting activities and breaks

because they account for most of the accidents. Traffic education may reduce severe injuries. Specific knowledge of the growing long bones of the upper extremity and the hand is important for the diagnosis and treatment of school accidents.

Keywords School · Accident · Injury · Fractures · Pediatric trauma

Introduction

Children and adolescents spend a significant part of the day at school: between 4 and 7 h, depending on the age of the child. Furthermore, the time spent traveling to and from school must also be factored in. With an average sleeping and resting time of 8–10 h, school attendance accounts for 25–50% of the child's daytime, which is the rationale behind the high risk of a school accident.

In certain countries there are specific legal social security regulations for school accidents; for example, in Germany a school accident is specifically covered—just like a work accident—by statutory accident insurance. This means that school and work accidents can only be treated by physicians with specific approval for these kind of injuries. Standardized documentation for these injuries is required that can facilitate their scientific evaluation and comparison.

The literature only began to show a specific interest in the term “school accident” in the 1990s. There are data on school systems with different cultures or organizations [1–4]. Many publications have provided age- and gender-related data [5–7], and the risk associated with school sporting accidents has been well assessed [8–10]. Only a few authors have focused on certain aspects, such as the

R. Kraus (✉) · G. Szalay · V. Alt · R. Schnettler
Department of Trauma Surgery,
University Hospital Giessen and Marburg,
Location Giessen, Rudolf Buchheim Strasse 7,
35385 Giessen, Germany
e-mail: Ralf.Kraus@chiru.med.uni-giessen.de

U. Horas
Department of Orthopedic and Trauma Surgery,
Main-Taunus-Kliniken, Bad Soden, Germany

M. Kaiser
Department of Pediatric Surgery,
University Hospital Luebeck, Luebeck, Germany

size of the school, injuries caused by classmates, or injury treatment efforts [4, 11, 12] and injury prevention [13–15].

The purpose of the current study was not only to collect statistical data on school accidents from a trauma service of a German university hospital, but also to assess specific risk and injury patterns that may differ between school accidents and general accidents in children and adolescents. The findings were critically compared to the literature.

Materials and methods

Data were collected from a level I trauma center of a German university hospital that provides medical services for 320,000 people. There are a further six hospitals and 25 surgeons in private practice that also have specific institutional approval for the treatment of school accidents.

From the emergency room data over a 5-year period, all patients who had sustained an accident in the course of regular school attendance, which is from class 1 to class 13 in Germany, were identified. Accidents related to vocational school and accidents suffered by adults in the course of second-chance education were excluded.

Accidents were subgrouped into the following categories: way to or from school, lessons, in-house break rooms, school yard, school sport, and “others.” Injured anatomic regions were categorized into head, trunk, upper extremity, hand, lower extremity, and foot. Injuries of the clavicle and scapula were considered upper extremity injuries due to their function. Injury types were differentiated into soft-tissue wounds, contusions, distortions, fractures, dislocations and “others,” which included closed head injuries, intraabdominal lesions, inhalation and burning injuries. Furthermore, whether the injury was caused by the injured party, by a classmate, or by other persons was assessed.

Only one injury per case was included in the assessment. In the case of multiple injuries, the most severe injury was identified and the injury pattern, the body region and treatment were noted in the following manner:

- A child that sustained a superficial soft tissue injury of the head and a distal radius fracture was registered as a “fracture” (type of injury) of the “upper extremity” (injured region) with “closed reduction under general anesthesia” (treatment)

However, there were special categories for multiple injuries or even polytraumatization. Diagnostic measurements were assessed using documented X-rays and ultrasound investigations.

Treatment was subdivided into four categories: (1) less invasive procedures such as saline draping, wound disinfection or vaccinations, (2) wound sutures in local

anesthesia, (3) plaster of Paris treatments, and (4) invasive procedures such as surgical and other interventions under general anesthesia.

Descriptive statistical figures such as the minimum, maximum and mean values were determined for each subcategory. The percentage distribution was calculated for each subcategory in relation to the overall collective and to defined subgroups.

Results

In the abovementioned period, 1,399 school accidents were treated, representing 14.5% of all 9,652 accidents that were handled under statutory accident regulations in our institution during that time. All of the injured were between 5 and 21 years old. The gender-independent average age of an injured person was 11.8 years. 61.1% of the injured were boys. The highest ratio of injured girls was found to occur between 9 and 12 years, and the lowest ratio between 13 to 16 years (Table 1). Most injuries occurred without external influence (72.6%); in 22.2% they were caused by classmates, and in 5.2% by other persons without any gender differences. In 213 cases (15.2%) there were multiple injuries, and in 26 cases the patient was polytraumatized (1.9%). There were no lethal injuries in this 5-year period.

Accident categories

School sport ($n = 554$, 39.6%) was by far the most frequent cause of the injuries. Accidents in the schoolyard accounted for 360 cases (25.7%), followed by accidents on the way to and from school ($n = 184$, 13.1%) and by those that occurred in in-house break rooms ($n = 163$, 11.7%). Accidents during lessons were rare ($n = 90$, 6.4%). The remaining 47 cases (3.5%) occurred during the course of other activities.

The proportion of school accidents was positively related to the age of the pupils, whereas the proportion of school break accidents, particularly those that happened in the schoolyard, showed a clear decline with increasing age.

Table 1 School accidents ($n = 1,399$) related to age and gender

Age groups	Number	Percentage	Male (%)	Female (%)
Total	1,399		61.1	38.9
17–21 years	140	10.0	59.9	40.1
13–16 years	429	30.7	63.6	36.4
9–12 years	585	41.8	59.3	40.7
5–8 years	245	17.5	61.2	38.8

The proportion of accidents that occurred on the way to school or traveling from it was twice as high for pupils aged 17–21 years than for all other age groups (Table 2).

Among the school sporting accidents, 40.3% occurred during ball sport activities, 18.6% during gymnastics, and 18.3% during athletics. Accidents during winter sports activities (3.3%) or swimming (3.1%) were rare. In 16.4%, some other cause of the school sporting accident was responsible, or the cause was unclear.

Pedestrians were most prone to accidents traveling to and from school (55.0%), whereas 11.4% were injured as cyclists or on scooters. Eleven percent sustained injuries on the school bus and 10.1% as a car passenger. 9.2% of the accidents concerned motorcyclists.

Injured body regions

The upper limb was the most frequently injured body region (36.8%); almost half of these cases concerned the

hand (17.4%). Injuries to the lower limb were found in 30.4%, with involvement of the foot in 4.6%. Head injuries occurred in 22.0%. Trunk injuries comprised only 10.8%, and occurred mainly in the spine (5.6%). Injuries to the abdomen (3.1%), to the thorax (1.2%) and to the pelvis (0.9%) were rare.

Injuries to the foot occurred in the same proportions for all age groups, whereas age was positively related to injuries of the lower limb and negatively related to head injuries. Trunk, arm and hand injuries were seen in the same proportions throughout all groups.

The hand was most frequently injured during school lessons. The injuries that happened during school sporting activities were mainly those to both the upper and the lower extremities. Head injuries were the most frequent diagnosis for accidents in the schoolyard. Injuries to the trunk and particularly to the spine were particularly common for accidents occurring while traveling to and from school (Table 3).

Table 2 Frequency distributions of different accident categories for various age groups

Accident category	Total (%)	5–8 years (%)	9–12 years (%)	13–16 years (%)	17–21 years (%)
Schoolway	13.1	14.7	10.8	11.2	26.4
Lessons	6.4	5.6	6.9	6.8	5.0
Breakroom	11.6	11.0	13.7	11.2	5.8
Schoolyard	25.8	43.7	32.5	13.8	2.8
Sports	39.6	23.4	32.8	53.4	54.3
Others	3.5	1.6	3.3	3.6	5.7

Percentages refer to the respective columns. Sports accidents increase with age, whereas break room and schoolyard accidents decrease. Schoolway accidents are double peaked, with higher risks for inexperienced young children as well as for adolescents and young adults with motorized vehicles

Table 3 Frequency distributions of injured body regions for different age groups (top) and for different accident categories (down)

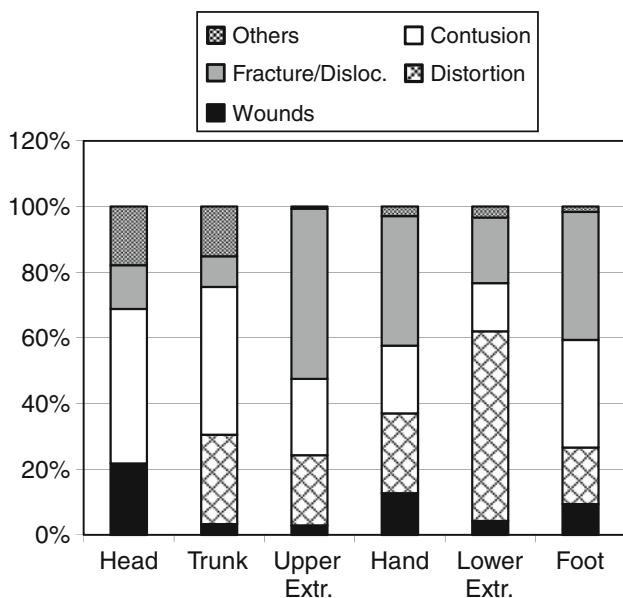
	Total (%)	5–8 years (%)	9–12 years (%)	13–16 years (%)	17–21 years (%)
Head	22.0	34.7	24.6	14.7	11.4
Trunk	10.8	7.5	11.6	9.8	14.2
Up. extr.	19.4	22.0	20.2	19.6	10.8
Hand	17.4	13.5	16.6	21.5	15.0
Low. extr.	25.8	17.2	21.5	30.4	44.3
Foot	4.6	4.1	5.5	4.0	4.3

	Total (%)	Schoolway (%)	Lessons (%)	Break room (%)	Schoolyard (%)	Sports (%)
Head	22.0	26.1	25.6	28.2	31.1	12.1
Trunk	10.8	22.7	15.5	10.4	6.1	9.8
Up. extr.	19.4	14.6	15.6	9.8	25.0	21.2
Hand	17.4	10.2	31.1	17.8	14.7	19.3
Low. extr.	25.8	22.7	8.9	26.4	21.7	31.7
Foot	4.6	3.7	3.3	7.4	1.4	5.9

Percentages refer to the respective columns. Head injuries decrease with age, while injuries to the lower extremity increase. Trunk injuries occur most frequently in schoolway accidents, whereas extremities are in danger in schoolyard and sporting injuries

Table 4 Relation between accident category and injury pattern

	Wounds (%)	Distortions (%)	Fractures/ dislocations (%)	Contusions (%)	Others (%)
Schoolway	8.2	21.2	27.7	28.3	13.0
Lessons	34.4	11.1	12.2	37.8	5.6
Break room	14.1	23.9	20.2	33.7	7.4
Schoolyard	9.4	16.1	30.2	36.4	7.8
Sports	3.4	41.7	28.7	21.3	4.9

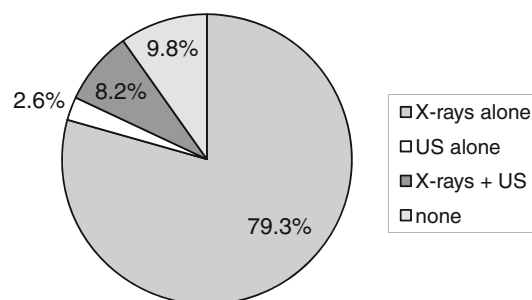
**Fig. 1** Prevalences of various types of injuries to different body regions ($n = 1,399$). The category “others” contains commotio cerebri, intracranial bleeding, pneumothorax, and blunt abdominal trauma with and without organic lesions for the trunk

Injury types

Superficial soft-tissue injuries like incisions, abrasions, and puncture wounds were diagnosed in 8.4%. Fractures or dislocations accounted for 27.4% of the cases. Contusions and distortions were found in 28.5 and in 27.5%, respectively. In 8.2% there were other diagnoses.

Similar proportions of soft-tissue injuries were found for all age groups (8.0–12.2%). There was a tendency for fewer contusions with increasing age, but there was a peak of 34.4% for 9–12-year-old patients. Distortions increased with age, from 12.7% (5–8 years) to 45.7% (17–21 years). The incidence of fractures was 34.7% in the youngest age group (5–8 years), which was one-third higher than for all other groups (25.7–25.9%).

There was a similar distribution of injury types for schoolyard and in-house break room accidents. Injuries during lessons were mainly soft-tissue injuries, particularly incision wounds. The incidence of “other” injury types for

**Fig. 2** Radiological measurements ($n = 1,399$). *US* ultrasound

schoolway accidents was double those seen for the other accident categories due to the higher proportions of head and abdominal injuries. Distortion was the typical diagnosis for school sporting accidents (Table 4).

Contusion was the most frequent diagnosis for the head (47.1%) and for the trunk (45.0%), whereas fractures and dislocations were the most frequent injury types for the upper extremity (51.8%), for the hand (39.5%), and for the foot (39.0%). The lower extremity was most commonly related to distortions (57.8%) (Fig. 1).

Diagnostic and treatment effort

Aside from standard procedures like case history and clinical examination, image-related diagnostic procedures were performed in 9 out of 10 cases. This was done in the vast majority of the cases by obtaining standard X-rays (79.4%), in 8.2% by ultrasound and X-rays, and in less than 3% by ultrasound alone (Fig. 2). Secondary diagnostic procedures such as CT scans and MRI investigations were not assessed.

15.8% of the patients were admitted to the hospital. The other 84.2% left the hospital after primary treatment in emergency room facilities. Proportionally more boys than girls had to be admitted for inpatient treatment. Inpatient treatment of injuries to the foot and hand was less common than the average, but it was more common than the average for all other body regions. There was a superproportional level of in-house treatment for schoolway accidents (Fig. 3).

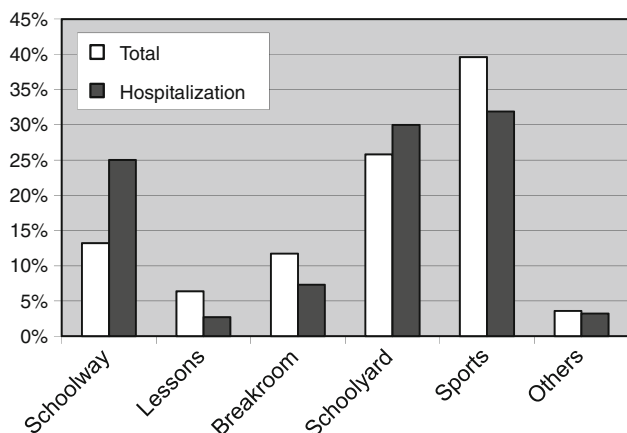


Fig. 3 Accident category versus total number of accidents (white columns, $n = 1,399$), and accident category versus the total number of accidents that required hospital admittance (black columns, $n = 221$)

Table 5 Treatments performed under general anesthesia ($n = 229$)

	<i>n</i>		<i>n</i>
Endoscopy	1	Suture of tendon	7
Trepanation	2	Wound debridement	14
Mandibular fixation	2	Reduction	38
Laparotomy	3	Arthroscopy (knee)	43
Suture of ligament	4	Osteosynthesis	115

63.4% of the patients could be treated by less invasive procedures or without any medical treatment. Plaster of Paris and other immobilizing drapings were used in 14.7%. Surgical treatment of wounds under local anesthesia was necessary in 5.5% of the cases. Treatment under general anesthesia was performed in 16.4% (Table 5).

Schoolway and school sporting accidents were over-represented among treatments performed under general anesthesia, whereas accidents occurring in the schoolyard or during lessons were rarely related to general anesthesia.

General anesthesia was most commonly used for fractures and dislocations. It was applied after distortion injuries for arthroscopy of the knee, except in two shoulder arthroscopy cases (Table 6).

Discussion

Kamel et al. found accidents to be the most frequent cause of morbidity and mortality for children and adolescents in Egypt, and investigated the perceptions of school personnel towards school injuries [3, 13]. In Switzerland each year, 45% of 12–15-year-old boys and girls have accidents that make a doctor’s visit necessary [16]. An investigation in the US of 17,110 children showed that, annually, 25% of all teenagers have accidents that need medical treatment [17]. An Austrian overview of injuries to adolescents, written by Jonasch and Berthel, showed that 25% of all medically documented injuries concerned children of school age [18]. School accidents were not assessed separately in this large study.

There are different data on the proportion of all injuries to adolescents that occur at school. In a study of Landin, only 4% of more than 8,000 fractures were related to school accidents, whereas Brudvik and Howe stated that of 30% of all fractures in children of school age were related to school accidents [19, 20]. However, there are only few specific data on school-related traffic and sporting accidents. Benamghar et al. [11] found 52 school accidents per 1,000 pupils per year among 4,751 adolescents that were documented by the social security system in France.

The current study showed that 14.5% of all accidents are school accidents that are covered by statutory accident insurance, and this underlines the importance of their specific assessment.

An excess of male patients (ratio 1.2:1–1.5:1) was found in studies of both general traumatology and school accidents in the literature [5, 9, 17]. Our data with a boy:girl ratio of 1.6:1 is in accordance with these findings. Furthermore, the excess of male patients in all different age

Table 6 Frequencies of various categories of accident and injury types, and proportions of the various categories of accident and injury types that were treated under general anesthesia

	Total percentage (%)	Percentage treated under anesthesia (%)		Total percentage (%)	Percentage treated under anesthesia (%)
Schoolway	13.1	17.3	Wounds	8.4	4.5
Lessons	6.4	4.5	Distortions	27.5	17.3
Break room	11.6	6.2	Contusions	28.5	–
Schoolyard	25.8	23.0	Fracture/dislocation	27.4	72.6
Sports	39.6	43.4	Others	8.2	5.8
Others	3.5	5.8			

groups, as previously published by Yang et al. [2], is in line with our results.

The average age of the injured party was approx. 12 years in the current study, with the highest proportion of injuries occurring in 9- to 12-year old pupils. Other studies confirm these observations, although there were different age subgroups in some studies. The peak mainly occurred at the beginning of puberty [6, 8, 10, 12, 20].

Limbos et al. [12] found that, among 11,674 accidents, 77.2% were real accidents and 16.8% of the injuries were done on purpose. In another study, fighting accounted for 4.1% [5]. Sixty-four percent of the 3,640 accidents that 13- to 15-year old patients were caused by the injured party him/herself [12]. In the current study, 75% of the accidents occurred without external factors, and more than 80% of the remaining accidents were caused by classmates. In opposite to Salminen and coworkers, we did not find more intentional injuries in boys [21].

The relationship of school accidents to the different activities of school attendance is mostly addressed in a similar manner in the literature. Sport injuries are separated from accidents during school breaks and from events that occur during the lessons.

Kelm et al. [10] found that annually 5% of all pupils sustained an injury during school sport. Hammarstrom et al. [1] also found sporting activities to be the most frequent cause among 547 school accidents. The ratio of school sport accidents in the literature is between 33 and 41% [4, 11]. It increases with the age of the pupil, possibly reaching a ratio of 34% at the age of 12 and 60% at the age of 15 [9]. We found a similar increase of 32.8% before the age of 12–53.4% after the age of 12 (Table 2).

This confirms the observations made by Schelp et al. [8], that there was a peak in the school break accidents among 7–12 year old pupils, whereas school sport accidents were the most frequent cause among 13–19-year-old patients.

We also found a decrease in school break accidents from over 50% at 5–8 years of age to 25% for pupils who are 13–16 years old, and to 8.6% for those aged >16 years old. Sosnowska et al. [4], in their study of 3,274 school accidents, found that 29.7% of them occurred in the schoolyard and 25.2% in school break rooms. In our data, we observed an excess of schoolyard accidents, in a 2:1 ratio. Yang and coworkers published similar results, with more accidents occurring in unsupervised areas [2].

Accidents on the way to and from school have rarely been assessed separately in school accident studies [22]. In Germany, traveling to and from school is considered to be part of school attendance, so accidents on the way to school are covered by statutory accident insurance regulations. The fact that the number of traffic accidents increases during school periods compared to during vacations shows that traveling to and from school represents a considerable

risk [23, 24]. We found no differences in the injuries incurred on the way to school and on the way back home.

We observed that 13.1% of all school accidents were schoolway accidents. The most striking part of this assessment is that the severity of injury, which was estimated according to the proportion treated under general anesthesia (Table 6) and admitted to hospital (Fig. 3), is superproportional compared to all accidents in general. Our data reveal that the risk of a schoolway accident increases with the use of a motor vehicle for older pupils, whereas other studies found significant risks of pedestrian accidents [22, 25].

Yang et al. [2] found that most injuries were suffered by the limbs. Similar observations were made in school-independent investigations of fractures in adolescents, which showed that 80–90% of all fractures occur in the extremities [18–20]. Predine et al. [26] revealed that the hand (27.4%), the head (20.6%), and the upper extremity (20.1%) were particularly prone to injuries.

We found that head injuries mainly occurred to younger pupils (5–8 years) and decreased in frequency over time, whereas injuries to the trunk and the lower limb were related to traffic accidents and sport injuries, respectively, and increased in frequency over time (Table 3).

Schelp et al. [8] found that 24% were fractures, 21% were superficial wounds, 15% were distortions, and there was also a high proportion of tooth injuries (14.5%). Our data reflect a rather similar distribution of about 25% distortions, contusions and fractures. Distortions were mainly seen for school sporting accidents, which is in line with the observations of Kelm et al. [10]. These proportions are similar to the findings of school accident-independent statistical data [18, 27].

Contusion was the most frequent diagnosis in the questionnaire-based assessment of Predine et al. [26], whereas 80% of all injuries did not require medical treatment.

The relative risk of a school accident compared to a non-school-related accident is 1.8 for boys and 2.6 for girls [1].

School breaks in unsupervised areas, gymnastic halls, and playgrounds are risk factors for school accidents [27, 28]. The size of the school and the number of pupils are also positively related to the risk of a school accident [4].

Gore et al. [28] found that the need for medical treatment after school accidents increased with the availability of school-specific accident prevention programs and local vicinity to a hospital. However, this was not related to an increase in the number of school accidents.

Predine et al. [26] studied 2,396 adolescents, and found that 2.7% of all school accidents incurred by this group and 13.8% of all medically treated school accidents required hospital admittance, whereas the general hospitalization rate after domestic injuries was reported to be 5.8% by

Majori and coworkers [7]. Benamghar et al. [11] found that interventions under general anesthesia were required in 14%. Compared to this data set, our data showed only slight increases to 15.8% in hospital admittance and to 16.4% in interventions performed under general anesthesia. However, we found that the proportion of X-ray and ultrasound investigations was more than 90%, compared to only 75% in the other study.

Conclusion

We conclude from our study that there are specific regions of interest in relation to school accidents. For younger pupils, school break accidents resulting in head injuries are most likely. For older pupils, accidents with distortions of the lower limb incurred during school sporting activities on the one hand and schoolway accidents involving their own motor vehicles on the other merit special attention.

In terms of hospital admittance and surgical treatment, fractures and injuries after traffic accidents require more intensive diagnostic and treatment-related measurements, regardless of the age of the child and the injured body region.

The high proportion of hand injuries means that specific knowledge and abilities in this field are prerequisites for the physician.

In many ways, our results confirm the observations of other investigations into school accidents. No major differences between school accidents and general accidents were found.

Based on our data, improving the education of teachers and pupils in relation to school accidents, as well as better surveillance of school break activities could help to prevent school accidents—although these have been stated as being necessary in many previous studies [5, 13, 15, 21, 29].

Conflict of interest None.

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