UDC 616.717-001-036.2-053.2-053.8

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Epidemiology of upper extremity musculoskeletal injuries in children

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Paediatric Surgery (Ukraine). 2025. 1(86): 59-64. doi: 10.15574/PS.2025.1(86).5964

For citation: Kiepura S, Dutka J. (2025). Epidemiology of upper extremity musculoskeletal injuries in children. Paediatric Surgery (Ukraine). 1(86): 59-64. doi: 10.15574/PS.2025.1(86).5964.

This study **aimed** to determine the epidemiology of upper extremity musculoskeletal injuries that require hospitalization in children and adolescents as a starting point for forming preventive recommendations and introduce measures to reduce morbidity and mortality.

Materials and methods. This was a retrospective analysis of epidemiological data collected from 602 children treated at the Paediatric Surgery Department from 2019–2023 with upper extremity fractures or dislocations. Age, sex, incident circumstances, fracture type, and associated damage were evaluated.

Results. Upper limb musculoskeletal injuries accounted for 16% of all hospital admissions due to injuries to different body parts. The median age of the participants was 9.6 years, ranging from 2 months to 17 years. The main causes of injuries were one-story falls (27%), second-story falls (21%), and traffic accidents (9%). The most common fractures involved the distal epiphysis of the radius and ulna (38.5%), the shafts of the bones of the forearm (26%), and the distal epiphysis of the humerus (15.6%). In the analyzed material, 38% of the children experienced fractures/dislocations at home and 31% experienced fractures/dislocations at school. 21% of fractures were sustained during sports activities.

Conclusion. Upper limb fractures and dislocations are the leading causes of hospitalization in children and adolescents in the surgical department. Upper extremity fractures and dislocations predominantly occur at home, at school, and in their surroundings, especially during sports activities. A one-story fall is the most common cause of these injuries. In traffic accidents, pedestrians usually suffer more complex injuries.

The research was carried out in accordance with the principles of the Declaration of Helsinki. The informed consent of the patients was obtained for the study.

The authors declare no conflict of interest.

Keywords: epidemiology, fractures, upper extremity, adolescent, children.

Епідеміологія травм опорно-рухового апарату верхніх кінцівок у дітей

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Метою дослідження було визначення епідеміології травм опорно-рухового апарату верхніх кінцівок, які потребують госпіталізації в дітей та підлітків.

Матеріали та методи. Здійснено ретроспективний аналіз епідеміологічних даних, зібраних від 602 дітей, які лікувалися у відділенні дитячої хірургії з 2019 по 2023 рік із переломами або вивихами верхніх кінцівок. Було оцінено вік, стать, обставини інциденту, тип перелому та пов'язані з ним пошкодження.

Результати. Травми опорно-рухового апарату верхніх кінцівок становили 16% усіх госпіталізацій через травми різних частин тіла. Медіанний вік учасників становив 9,6 років, коливаючись від 2 місяців до 17 років. Основними причинами травм були падіння з першого поверху (27%), з другого поверху (21%) та дорожньо-транспортні пригоди (9%). Найчастіше траплялися переломи дистального епіфіза променевої та ліктьової кісток (38,5%), діафізів кісток передпліччя (26%) та дистального епіфіза плечової кістки (15,6%). 38% дітей отримали переломи/вивихи вдома, а 31% – у школі. 21% переломів було отримано під час занять спортом.

Висновок. Переломи та вивихи верхніх кінцівок є основними причинами госпіталізації дітей та підлітків до хірургічного відділення. Вони переважно трапляються вдома, у школі та в їхньому оточенні, особливо під час занять спортом. Падіння з першого поверху є найпоширенішою причиною цих травм. У дорожньо-транспортних пригодах пішоходи зазвичай отримують складніші травми.
Дослідження виконано відповідно до принципів Гельсінської декларації. На проведення дослідження отримано інформовану згоду пацієнтів.
Автори заявляють про відсутність конфлікту інтересів.

Ключові слова: епідеміологія, переломи, верхня кінцівка, підліток, діти.

Introduction

The epidemiology of upper extremity injuries is the subject of very few studies in the professional literature. Socioeconomic changes have altered the pattern of fractures and dislocations over the last few years. However, it remains the main cause of emergency intervention, hospitalization, and treatment of children and adolescents. A detailed analysis of musculoskeletal injuries is directly linked with age-related risk factors that promote traumatic events. It is the starting point for forming recommendations for preventive measures to reduce morbidity and mortality. This analysis is also necessary to develop educational programs advocated for guardians and children. This study aimed to determine the epidemiology of fractures and dislocations of the hand, forearm, arm, and shoulder that require hospitalization in a population of children.

Materials and methods of the study

The Department of Paediatric Surgery is one of two departments covering a population of over 350,000 children from the urban area and the surroundings of Krakow. From 2019–2023, 3589 children were hospitalized in the ward, including 1363 (38%) due to injuries. Upper limb fractures and dislocations were the cause of 602 (16%) hospitalizations, which were included in the retrospective epidemiological analysis. The study was based on an analysis of available medical records and assessed age, sex, incident circumstances, type of injury, and associated injuries. Patients from the study group were assigned to individual age groups: 0–2, 3–6, 7–12, and 13–17 years.

The results were analyzed via the STATISTICA 13.3 program. The Chi-square correlation test was used separately for each age group to determine relationships between the age of the children and the fracture site.

The patients' parents were informed that data from the research would be submitted for publication and would provide their consent.

Results of the study

The study group of 602 patients with upper extremity fractures or dislocations included 371 (62%) males and 231 (38%) females. In the analyzed group, fractures/dislocations most commonly occurred in children aged 3–6 – 33% of the patients. Injuries were less common in children aged 0–2 years, accounting for 12% of all injuries. The most typical fractures involved the forearm bones and distal epiphysis of the radius and ulna, including the growth plate, and occurred in 232 (38.5%) children. Fractures of both forearm bone shafts were diagnosed in 156 (26%) children, whereas supracondylar fracture of the humerus was recognized in 94 (15.6%) patients. We also noted fracture and dislocation of the metacarpal bones and phalanges in 44 (7.3%) children. The data revealed that in the 3–6 year group, fractures around the elbow joint were the most common, including supracondylar fractures of the humerus. The 7–17-year-old age group was dominated by fractures of the metaphysis and distal epiphysis of the radius and ulna (see Tables 1, 2). There was a statistically significant correlation between age and upper extremity fractures in age group 7–12 (p=0,01).

Table 1
Upper extremity fractures distribution in selected age-groups

Age years	Values M:F	Fracture of								p-value
		hand	distal epiphysis of radius	proximal epiphysis of radius and ulna	diaphysis of radius or ulna	supracondylar fracture of humerus	humerus	clavicula	multiple fractures	
0–2	41:21	5	28	4	19	15	1	2	0	0.02
3–6	126:71	7	91	1	43	43	6	5	0	0.5
7–12	94:69	13	63	4	51	21	5	6	1	0.01
13–17	94:52	19	50	1	43	15	8	5	2	0.06
SUM	-	44	232	10	156	94	20	13	3	-
%	-	7.3	38.5	1.6	25.9	15.6	3.3	2.1	0.5	-

Notes: M – male, F – female.

Table 2
Upper extremity dislocation distribution in selected age-groups

Age years	Values M:F	Dislocation of				SUM
		shoulder	acromioclavicular joint	elbow	interphalangeal joints	
0–2	0:0	0	0	0	0	0
3–6	2:2	0	0	1	2	3
7–12	5:3	0	1	1	6	8
13–17	9:5	3	2	4	5	14
SUM	16:10	3	3	6	13	25
%	-	0.5	0.5	1%	2.1%	-

Notes: M – male, F – female.

Table 3
Distribution of mechanism and location of traumatic injuries

Age years	Quantity	Road traffic accident		Sport activities		Home	School	Others
		pedestrian	passenger	athletics	contact sports			
0–2	74	3	6	0	0	62	0	3
3–6	199	11	7	2	0	114	56	9
7–12	172	8	9	21	27	26	73	7
13–17	157	5	6	29	32	18	50	18
SUM	602	27	28	52	59	220	179	37
%	-	4.6%	4.8%	8.9%	10%	38%	31%	6.3%

Table 4
Circumstances directly leading to musculoskeletal upper extremity injuries

Circumstances	Age (years)			
	0-2	3-6	7-12	13-17
One-level fall	25	58	55	28
Fall from one level to another	17	39	37	36
Fall down the stairs	7	14	14	7
Fall from the furniture	5	7	3	2
Fall on skating, skiing, roller skates	0	21	9	24
Fall from bicycle	0	25	7	14
Road traffic accident with bicyclist	3	4	18	15
Road traffic accident – passenger	6	7	9	5
Road traffic accident – pedestrian	3	11	8	5
Crushing by objects	2	4	5	3
Others	3	9	7	18
SUM	73	199	172	162

In the analyzed material, 220 (38%) children experienced upper extremity injuries at home, and 179 (31%) experienced upper extremity injuries at school. In 111 (18.4%) cases, fractures were sustained during sports activities, and in 55 (9%) cases, they were sustained as a result of traffic accidents (Table 3).

The most common cause of fracture was a one-story fall (on the same plane) (166 (27%) cases), a second-story fall (between planes) (129 (21%) cases), and a fall from a bicycle (46 (7.6%) cases). Children from the age groups 0–2 years and 3–6 years most often had injuries at home, including falls from the changing table, bed, and furniture. In the groups of 7–12- and 13–17-year-olds, injuries more frequently occurred at home and at school, where fractures were sustained during sports activities or school fights. Sports-related injuries are equally common in contact sports and athletics. Among the analyzed groups, traffic accidents were the third most common cause of fractures/dislocations (Table 4).

Table 5
Associated injuries

Associated injuries	Number of patients (%)
Head contusion	24 (42.0)
Brain concussion	2 (3.5)
Chest wall contusion	5 (8.8)
Abdominal wall contusion	6 (10.5)
Cervical spine distorsion	2 (3.5)
Lumbar spine distorsion	3 (5.3)
Thoracic spine distorsion	1 (1.8)
Ankle distorsion	4 (7.0)
Hip contusion	2 (3.5)
Thigh and calf contusion	4 (7.0)
Tibial fracture	3 (5.3)
Femoral neck fracture	1 (1.8)
SUM	57 (100.0)

In our study, 57 (9.5%) patients had concomitant injuries, mostly head trauma 24 (42%), and abdominal wall contusion 6 (10.5%) (Table 5).

Upper limb injuries were most common in children in the 3–6-year-old and 7–12-year-old groups. Typically, the incidence of fractures gradually decreases with age. However, in the 3–6-year-old age group, the fracture location was similar to that in the 7–12-year-old age group. With respect to age, the analyzed injuries took place under specific circumstances. In the 7–12-year-old and 13–17-year-old age groups, injuries were most often sustained during sports activities as a part of PE (physical education). In the younger age groups, they constituted a small percentage. The distribution of injuries in traffic accidents was similar across all age groups. A one-story fall (on the same plane) leading to fracture was equally common in all age groups.

Discussion

The high incidence of upper extremity injuries in children and adolescents and their consequences such as growth limb disorders and angular or rotation deformities which can lead to disability are the primary causes of actions aimed at reducing injury rates. Although, fractures and dislocations of the upper extremity are the most common causes of morbidity in children, reports on their epidemiology are rare. This study presents a retrospective analysis of upper extremity musculoskeletal injuries that significantly contributes to the process of gathering epidemiological data. In our study, in all age groups, fractures mainly affected forearm bones (66%), followed by supracondylar fractures of the humerus (15.6%) whereas dislocations generally involve small joints of the hand. L.V. Barr et al. investigated the epidemiology of supracondylar humeral fractures in paediatric patients and showed that the majority of patients were in their school years [1]. A greater number of fractures in the 7–12 year age group which was demonstrated in this material is also consistent with reports of E.M. Clark and E.M. Hedström et al. [3,6]. The evaluation of incidence and characteristics of fractures among children by G. Zacay et al. shows the same pattern and predominantly affected the upper limb followed by injuries of the lower limb with seasonal bimodal distribution [18].

In contrast, S.M. Naranje et al. found that the annual occurrence of fractures increased from ages 0 to 14 with a peak at the age of 10 to 14, and the most common fractures among the entire study population were the forearm injuries [14]. In the analyzed material, upper extremity fractures/dislocations were predominant in boys, which can be explained by their increased activity and more frequent practice of sports. Differently, other researches such as A. Issin et al. showed that ankle, elbow, and shoulder fractures were more common in girls, whereas wrist and forearm fractures were more common in boys [7]. C.E. de Putter et al. also showed an increase in upper extremity fractures among young male soccer players [4]. Worth mentioning is a review of published literature on paediatric snowboard injuries by K. Rusell et al. shows that most injuries occurred to an upper extremity or the head and falls and collisions were the most common mechanisms with overall injury rates ranged from 0.5 per 1,000 runs to 420 per 1,000 snowboarders. The author also highlighted the importance of injury prevention efforts in terms of use of protective equipment [17]. Generally, deaths among children (0–19 years) due to injury have reduced over the last 30 years. In 1980 the average mortality rate in the European Union was 23/100,000, by 2012 this had reduced to 6.6/100,000 [9].

Our study revealed a slightly greater rate of injuries to the left upper limb but there was no correlation between the side of fracture/dislocation and age, sex, or circumstances of the incident. The slightly greater exposure of the left upper limb to injuries can be explained by the smaller dominance of the left limb and therefore its poorer neuromuscular coordination. In addition, when the right upper limb performs the main action, the left limb is used as a protective extremity in the study conducted by Hedstrom et al. the distribution of injuries was similar [6]. Fractures/dislocations usually occur in preschool-aged and school-aged children, in those aged 3–12 years (62%), and less frequently in those younger than 2 years (10%). Similarly, E. Jespersen et al. in a 2–5 year prospective cohort study established the highest rate of musculoskeletal extremity injuries in schoolchildren aged 6–12 [8]. The article by S. Merckaert et al. that inves-

tigates the epidemiology and fracture pattern of the upper extremity within a paediatric population in Switzerland also confirmed that upper extremity fractures represent 76% of injuries with boys had a higher risk of having a traumatic injury and fall from height or football represented the main injury mechanisms [12].

It was unambiguously demonstrated that injuries were most often caused by one-story falls (27%) and second-story falls (21%), with a similar frequency in all age groups. According to the findings of other authors, one-story falls and traffic accidents are the prevailing circumstances of injuries [6,8,12,10].

In our study, five percent of upper limb injuries were accompanied by other types of trauma, such as superficial head injury in 21 (29%) patients, brain concussion in 2 (0.3%) patients, and soft tissue contusion of the thigh and lower leg in 4 (0.6%) patients. This finding is consistent with currently available reports from other authors [8,10]. Notably, the house (38%), school (31%), and their surroundings are the locations of most musculoskeletal injuries. Fractures caused by traffic accidents account for 9% of all these types of injuries. Injuries in the youngest age group took place mainly at home (87%) or were a result of traffic accidents – the remaining 13%. Pedestrians are likely to sustain an injury similar to passengers, and this observation applies to all age groups. In the 7–12-year-old and 13–17-year-old groups, sports-related activities were the third most common cause of injuries. There was a comparable number of fractures/dislocations in contact sports and athletics. In the 0–2 year age group, injuries are rarely accidental and result from a lack of due care or child maltreatment. R.H. Pan et al. on the other hand estimate in a 10-year nationwide survey estimate this number at 2%; however, in traffic accidents, associated injuries are more common [15].

On the basis of our data, we can conclude that 10% of children aged 0–2 years were hospitalized because of fractures/dislocations. E.M. Hedström et al. analyzed injuries in children and adolescents who visited the emergency department and showed that the most common cause of visits were minor injuries such as contusions without significant increase in the rate of injuries resulting in hospitalization [6]. On the other hand, C. Farell et al. in epidemiological study of fracture care in US emergency departments from 2010 to 2015 for children 0 to 18 years old found that the national incidence rate of paediatric fractures decreased slightly with emergency department resource utilization increased over time [5].

Taking into account the general overview other authors have evaluated the effectiveness of preventive measures, such as the recommendation to wear helmets and protective gear while cycling, skating, and skateboarding [17]. The need to change habits and awareness among parents, educators, and children to reduce the incidence of injuries and their consequences is also crucial. Satisfactory indicators were not identified for all areas and very few local area data were available. These data indicate the necessity of implementing preventive measures and legislative changes aimed at improving safety on roads and children's environment. The exemplary actions in this area include mandatory use of helmets by those who go by bicycles, mopeds, or scooters and their passengers and regulations imposing the use of seat belts in children and adolescents in cars and the transport of children and adolescents up to the age of 13 years in the rear seats of motor vehicles [9,13]. D.J. Mathison et al. in a recent review article outlines the developing epidemiology of paediatric fractures that depends on many demographic factors, the various contributors to bone health, and an individual's risk-taking behaviour. Although traditional play activities continue to be the prevalent causes of fractures, there is an evolving array of new sport and recreation activities that carry significant fracture risk. The following review article outlines the developing epidemiology of paediatric fractures by analyzing some of the individual risk factors that influence fracture incidence as well as the variety of activities that are associated with these fractures [11]. Similarly, to highlight the importance of effective preventive measures to reduce the incidence of pediatric fractures X. Qiu et al. retrospectively analyzed the epidemiological characteristics of 10.486 fractures in pediatric patients aged ≤18 years old according to the distribution characteristics of age, gender, cause of injury, and fracture site [16]. The growing scale of the problem also forces changes in health care and adaptation to the growing needs. B.P. Cassidy et al. in their article concluded that there is a need to increase surgical capacity, optimize referral patterns, and standardize fracture management in Malawi [2].

Conclusions

1. Upper extremity fractures and dislocations in children and adolescents are major medical and socioeconomic problems that require in-depth epidemiological studies.

2. Fractures of the bones of the forearm and supracondylar fractures of the humerus are the most common. Dislocations are less common and involve mainly the joints of the hand.

3. Upper extremity musculoskeletal injuries occur at home and its surroundings and in school, especially during sports activities.

4. A one-story fall is the most common cause of the discussed injuries. In traffic accidents, pedestrians more often suffer from injuries.

5. There is a need to develop and implement programs for prevention and education for parents, carers, teachers, and children to prevent injuries.

The authors have no financial, consultative, institutional, or other relationships that might lead to bias or conflicts of interest.

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Стаття надійшла до редакції 27.01.2025 р., прийнята до друку 18.03.2025 р.