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ORIGINAL ARTICLE

EPIDEMIOLOGY AND AETIOLOGY OF HAND INJURIES IN PAEDIATRIC POPULATION

EPIDEMIOLOGIA I ETIOLOGIA URAZÓW RĘKI W POPULACJI PEDIATRYCZNEJ

Katarzyna Kwas[1], Marcin Mostowy[2], Krzysztof Małecki[3], Kryspin Niedzielski[4]
[1]Clinic of Orthopaedics, Traumatology and Hand Surgery for Children Department, Polish Mother's Memorial Hospital Research Institute, Poland
[2]Orthopedic and Trauma Department, Veteran's Memorial Teaching Hospital in Lodz, Medical University of Lodz, Lodz, Poland
[3]Clinic of Orthopaedics, Traumatology and Hand Surgery for Children Department, Polish Mother's Memorial Hospital Research Institute, Poland
[4]Clinic of Orthopaedics, Traumatology and Hand Surgery for Children Department, Polish Mother's Memorial Hospital Research Institute, Lodz, Poland

ABSTRACT

Introduction
Understanding the incidence and causality of paediatric hand injuries may be vital in injury prevention, training and treatment priority. However, few papers have addressed this subject.

Aim
The aim of the study was to identify the epidemiology and cause of hand injuries in the paediatric population.

Material and methods
The study group in the retrospective study included 291 patients (74 female, 271 male) aged 1–18 years old (mean age = 12.2; SD = 4.5). The cause of injury and diagnosis were taken from the hospital database. Institutional Review Board (IRB) approval was obtained.

Results
Data on the type of injury was collected and divided into nine groups, seven of which were used in the analysis: 5.2% were dislocations, 8.9% open fractures, 42.6% closed fractures, 12.7% isolated tendon injuries, 18.3% multiple tendon injuries, 4.8% subamputations and 15.4% amputations. Also, 54.5% of all injuries concerned the right upper limb, 45.4% the left, and 0.01% both upper limbs. Sex did not influence the injury incidence. However, age influenced the occurrence of closed fractures (mean age = 9.8; SD = 5.6; $p < 0.02$), isolated tendon injuries (mean age = 13.3; SD = 4.5; $p < 0.04$) and amputations (mean age = 10.5; SD = 4.9; $p < 0.007$). The main causes were sport training (29.8%), agricultural machine accidents (15.3%) and contact with sharp objects (14.5%).

Conclusions
Our current results show clear age-based trends in the epidemiology and causation of certain hand injuries in the paediatric population. These should be taken into account in special prevention programs.

Author responsible for correspondence:
Katarzyna Kwas
Clinic of Orthopaedics, Traumatology and Hand Surgery for Children Department
Polish Mother's Memorial Hospital Research Institute, Poland
E-mail: kwaskasia@gmail.com
https://orcid.org/ 0000-0002-2055-5914

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STRESZCZENIE

Wstęp

Częstość występowania i przyczynowość urazów rąk u dzieci może mieć kluczowe znaczenie w zapobieganiu urazom, szkoleniu i leczeniu. Niewiele jest w literaturze artykułów poruszających ten temat.

Cel

Celem pracy była ocena epidemiologii i przyczyn urazów rąk w populacji pediatrycznej.

Materiał i metody

Grupa badana w badaniu retrospektywnym obejmowała 291 pacjentów, 74 kobiety i 271 mężczyzn w wieku 1–18 lat (średnia wieku = 12,2; SD = 4,52). Przyczyna urazu i diagnoza została zaczerpnięta ze szpitalnej bazy danych. Uzyskano zgodę Komisji Bioetycznej. Przeprowadzono analizę statystyczną.

Wyniki

291 pacjentów zakwalifikowano do badania, zebrane dane podzielono na 9 grup urazowych. Stwierdzono: 5,2% zwichnięć, 8,9 złamań otwartych, 42,6% złamań zamkniętych, 12,7% izolowanych urazów ścięgien, 18,3% mnogich urazów ścięgien, 4,8% subamputacji i 15,4% amputacji. 54,5% wszystkich obrażeń dotyczyło prawej kończyny górnej, a 45,4% lewej, 0,01% obu kończyn górnych. Nie wykazano związku między płcią a wystąpieniem urazu ręki. Wykazano jednak związek między wiekiem a występowaniem złamań zamkniętych (średnia wieku = 9,8; SD = 5,6; $p < 0,02$), izolowanych urazów ścięgien (średnia wieku = 13,3; SD = 4,5; $p < 0,04$) i amputacji (średni wiek = 10,5; SD = 4,9; $p < 0,007$). Główne przyczyny urazów ręki to: trening sportowy (29,8%), wypadki podczas użytkowania maszyn rolniczych (15,3%) oraz kontakt z ostrymi przedmiotami (14,5%).

Wnioski

Aktualne wyniki jednoznacznie wskazują na epidemiologię i przyczyny urazów rąk w populacji pediatrycznej, które należy uwzględnić w specjalnych programach profilaktycznych.

Słowa kluczowe: urazy ręki, ortopedia, epidemiologia, etiologia, chirurgia ręki

Introduction

The presence of children with hand injuries is a common sight in the Emergency, Traumatology and Orthopaedics department. While the hand plays an essential role in their everyday life, helping in skills development and exploring the world, it is also one of the most commonly-injured anatomic regions in this population (van Onselen *et al.* 2006, Liu *et al.* 2014, Naranje *et al.* 2016, Lempesis *et al.* 2019). It has been reported that approximately 29% of all paediatrics injuries admitted to the orthopaedics department concern the structures of the hand (Chew *et al.* 2012, Mirzaie *et al.* 2014); this not only causes impairment to the child but also represents a substantial economic problem (Johnson *et al.* 2017).

Previous studies have examined the management of hand injuries and their socio-economic outcomes, and have discussed preventive strategies. Interestingly, despite the differences in geographical localization (Rosberg and Dahlin 2004; Shah *et al.* 2012, Liao and

Chong 2019), some universal trends regarding the epidemiology and aetiology of hand injury in children and teenagers have been identified. Most importantly, key roles have been identified for sex and age (Mayranpaa *et al.* 2010; Liu *et al.* 2015), with the incidence of hand injury being highest in those aged 12–15 years old (Cebula *et al.* 2020, Liao and Chong 2019). Johnson *et al.* and Vadivelu *et al.* report that the most common aetiology of hand injuries is sport. Worryingly, Chew *et al.* (2012) indicate a misdiagnosis rate of 8%.

Current literature concerning the epidemiology and aetiology of hand injuries in eastern and central Europe is limited. Relatively few papers have assessed the characteristics of paediatric hand injuries in particular regions, and none have been comparative studies. Furthermore, none clearly show the prevailing aetiology or propose any effective preventive measures (Nauta *et al.* 2017, Lempesis *et al.* 2019, Cebula *et al.* 2020).

Since paediatric hand injuries present a substantial medical and socio-economic problem, it is vital to understand the epidemiological and aetiological aspects of paediatric hand injuries. This understanding will ensure proper treatment, lower healthcare costs, timely diagnosis, and the use of effective preventive strategies (Sozbilen *et al.* 2021).

Aim

The aim of this paper is to identify trends in the epidemiology and aetiology of paediatric hand injury in paediatric patients of the Polish Mother's Memorial Hospital Research Institute (ICZMP).

Material and methods

This retrospective and the descriptive study included 291 patients aged 1–18 years old admitted to the Polish Mother's Memorial Hospital Research Institute (ICZMP). All participants had been admitted to the Clinic of Orthopaedics, Traumatology, and Hand Surgery for Children between January 1st, 2015, and January 1st, 2020 and treated surgically with the use of general anaesthesia, with the exclusion of patients provided by the emergency department.

Data regarding the injuries were taken from the hospital database with the approval of the Institutional Review Board (IRB). The following data was also taken from the medical histories: sex, age, type of injury, side of the injury, structure affected by the injury, cause of the injury, including the type of provocative factor. Eight subgroups were differentiated regarding the type of injury: closed fractures, open fractures, amputation, dislocation, subamputation, isolated tendon injury, multiple tendon injury, and other soft tissue injuries, including injuries with difficulties in skin-cover reconstructions.

In some cases, the aetiology of the injury was also noted in the medical history. This data was divided into seven subgroups: sports, daily activities, fall from own height, sharp objects, hand trapping, agricultural or carpenter's machinery, and assaults. This data is collected in Table 1.

The obtained data were analyzed using the Chi-Square test or two-tailed Fisher's exact test according to the number of patients in the analyzed group. Odds ratios were also calculated. The Student's t-test was used for analyses associated with age group. All relationships between the epidemiology groups and aetiology subgroups were tested. In addition, the incidence of traumatic injuries in the seven subgroups was also determined.

Results

Over the five years, 291 patients were qualified for the study. The participants were aged between one and 18 years, with a mean age of 12.2 years (SD = 4.5). Of these, 25.4% (74 patients) were female, and 74.6% (217 patients) were male (Figure 1). A significant proportion of the injuries were observed among children aged 17 years, with a visible increase in injuries in the 16- to 17-year-old group. The frequencies of injuries according to the eight defined types are presented in Figure 2. However, as most patients had suffered more than one type of injury, it was

Table 1. Causes of injury divided into seven subgroups.

Daily activities	Agricultural machinery	Sharp objects	Trapping	Sports	Fall from own height	Assaults
playground fun	agricultural machine use	broken cup	car door	volleyball	loss of consciousness	Party
dog bite	mower use	vegetable knife	gate	spokes	car accident	Fight
juicer use	circular saw use	broken bottle	door frame	gym		
hit in face	silo use	kitchen knife	window frame	basketball		
fireworks	agricultural tractor use	glass door	drawer	football		
skidding	carbon machine use	axe	hammer	riding a bike		
table saw	board peeler use	broken glass	brick	rollerskating		
farm care		broken window	car boot flap	ice-skating		
carrying furniture		broken jar		PE lessons		
alcohol				rugby		

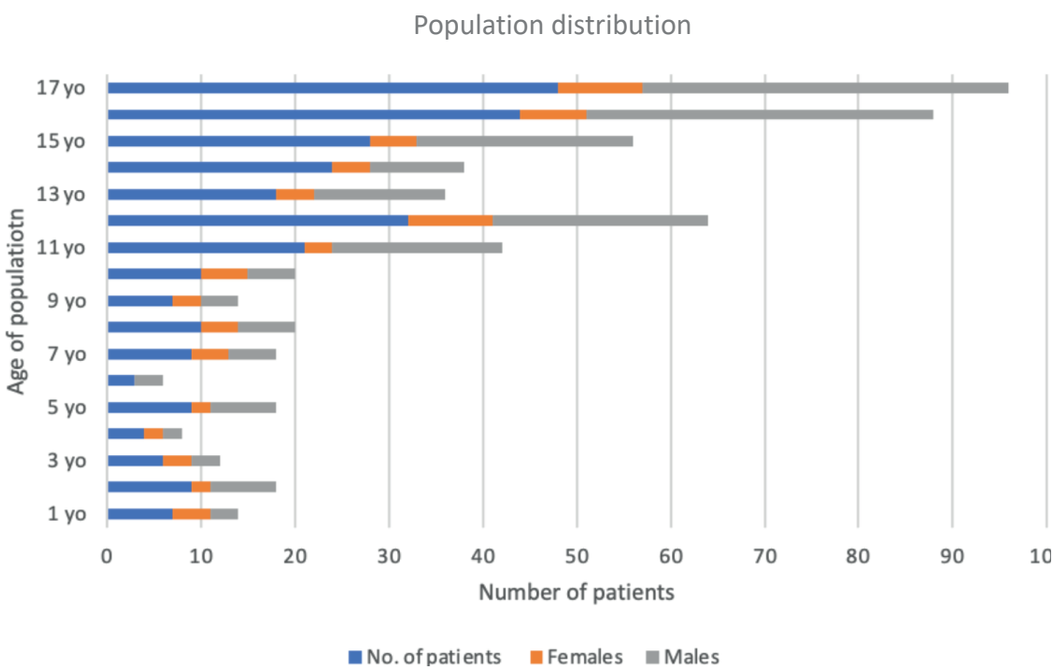

Figure 1. Population distribution

impossible to assess the percentage occurrence of each injury group.

Analysis of sex influence on injury incidence shown following results: for closed and open fractures (p = 0.064, p = 0.69), dislocations (p = 1.00), isolated tendon injuries and multiple tendon injuries (p = 0.22, p = 0.28), amputations and subamputations (p = 0.57, p = 0.97).

Of the injuries, 54.5% (n = 158) concerned the right upper limb, 45.4 % (n = 132) the left, and 0.01% (n = 3) both. In 129 patients (44.5%), the aetiology of the injuries was stated. The frequencies of each defined injury aetiology subtype are presented in Figure 3.

The effect of age on particular injuries was assessed with the T-test for dependent pairs. As the group of patients with soft tissue injuries was excluded from the risk analysis due to insufficient size, only seven injury subgroups were included: closed fractures, open fractures, dislocations, isolated tendon

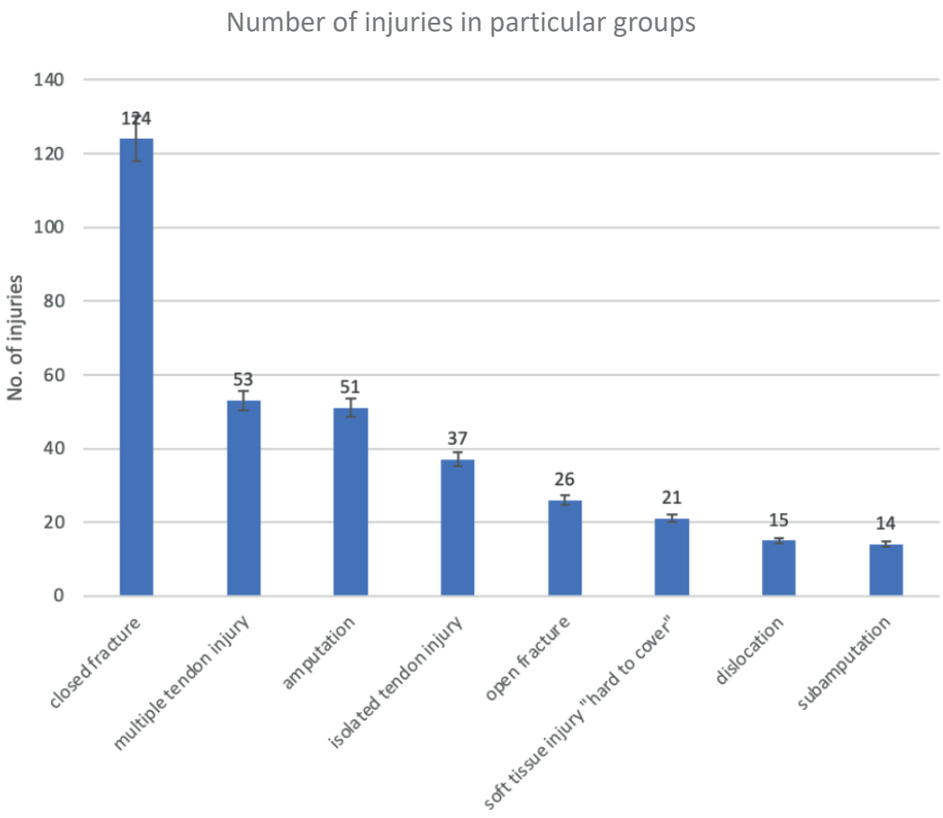

Figure 2. Number of injuries in particular groups

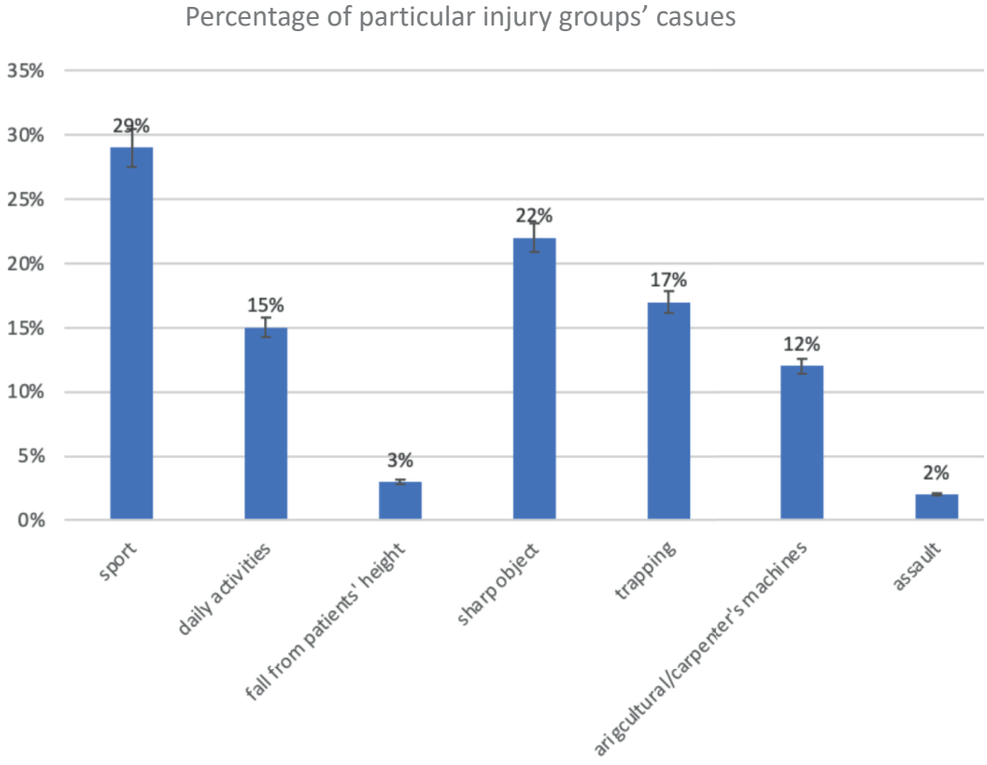

Figure 3. Percentage of particular injury groups' causes

injury, multiple tendons injury, subamputation and amputation. The statistical analysis was performed with the Mann-Whitney U-test and T-test for dependent pairs.

Age had a significant influence on the chance of isolated tendon injury (mean 13.3 years; SD = 4.5; p = 0.04), open fracture (mean 9.8 years; SD = 5.6; p = 0.02) and amputation (mean 10.5 years; SD = 4.9; p = 0.007). In contrast, age had no significant influence on the risk of closed fractures (mean age 13.2 years; SD = 3.3), dislocation (mean age 13.2 years; SD = 3.7; p = 0.4), multiple tendon injury (mean age 13.2 years; SD = 4.0; p = 0.07) or subamputation (mean age 10.5; SD = 5.1; p = 0.1). Above stated data versus values in patients who have not sustained a particular type of injury, is presented in Table 2.

sport increases the risk of closed fracture injury (p < 0.0001) and agricultural machine use increases the risk of subamputation (p = 0.01). Sharp object use increases the chance of both multiple (p < 0.0001) and isolated tendon injuries (p < 0.00001), whereas trapping increases the risk of open fracture (p = 0.05) and amputation (p = 0.0003). Daily activities and assaults did not appear to influence any injury subtype. No analysis could be performed on the fall from own height group due to the small group size (n = 3).

Discussion

Our findings are in line with those of previous studies regarding trends in paediatric hand injuries (Mirzaie *et al.* 2014; Lempesis *et al.* 2017, Cebula *et al.* 2020). Hand injuries

Table 2. Impact of age on the prevalence of particular injury.

Analysed subgroup	Mean age in injury group (years); SD	Mean age in group without particular injury (years); SD	p-value
Closed fractures	13.2; SD = 3.3	11.5; SD = 5.1	0.061
Dislocations	13.2; SD = 3.7	12.2; SD = 4.5	0.453
Open fractures	9.8; SD = 5.6	12,5; SD = 4.3	**0.021**
Isolated tendon injury	13.3; SD = 4.5	12.1; SD = 4.5	**0.045**
Multiple tendon injury	13.2; SD = 4.0	12.0; SD = 4.6	0.071
Subamputation	10.5; SD = 5.1	12.3; SD = 4.4	0.142
Amputation	10.5; SD = 4.9	12.5; SD = 4.3	**0.007**

Table 3. Impact of aetiology on the type of injury.

	Increased risk OR (95% CI)	p value	Decreased risk OR (95% CI)	p value
Trapping	**Open fracture** 4.3 (1.1–16.9)	p = 0.04821		
	Amputation 6.6 (2.4–18.4)	p = 0.00028		
Sport	**Closed fracture** 9.8 (3.9–24.1)	p < 0.0001	**Multiple tendon injury** 0.1 (0.01–0.6)	p = 0.00114
			Amputation 0.1 (0.01–0.5)	p = 0.00031
Sharp object	**Isolated tendon injury** 8.1 (2.5–26.5)	p < 0.00001	**Closed fracture** 0.1 (0.01–0.3)	p < 0.00001
	Multiple tendon injury 8.9 (3.4–23.5)	p < 0.00001		
Agricultural/ Carpenters' machines	**Subamputations** 12.8 (2.0–83.9)	p = 0.01364		

The prevalence of each particular hand injury was also calculated according to the injury mechanism. All the obtained results are presented in Table 3. As it was stated, appear to be generally more common among boys and older children, with a mean age of 12.2 years (Al-Jasser *et al.* 2015; Johnson *et al.* 2017; Lempesis *et al.* 2017). The two most

common injury types identified in the present population were closed fractures and injuries performed during sports training. Such results correspond with previous studies including populations from other countries, e.g., America or Sweden (Johnson *et al.* 2017, Lempesis *et al.* 2019, Zhi *et al.* 2021).

An interesting finding may be that the frequency of hand injury peaks around 15–17 years, and that their incidence increases from around 11 years. This may be related to an increase in sports activity and the children having greater independence in their daily activities. However, these results do not correspond to all literature values; for example, Naranje *et al.* (2016) and Cebula *et al.* (2020) report a peak incidence at around 11–12 years of age. However, other studies suggest a rise in incidence at around 10–11 years and a peak at around 14–15 years (Chew *et al.,* 2012).

Our findings clearly show that hand injuries were more common for boys than for girls and that most injuries concerned the right hand, although a high number of left-hand injuries were also recorded. However, it is impossible to describe which side resulted in greater disablement due to the lack of hand dominance assessment; such information should be included in a further study since it may influence the quality of life and functionality (Sanal-Toprak *et al.,* 2021).

Like previous studies, our findings clearly indicate that closed fractures were common among younger children (mean age 9.8 years), while isolated tendon injuries were more common among older ones (mean age 13.3 years), (Mirzaie *et al.* 2014; Lempesis *et al.* 2017). The most common injury type was a closed fracture, and the least common was subamputation. Age was found to be related to the incidence of closed fractures (mean age = 9.8; SD = 5.6; $p < 0.021$), isolated tendon injuries (mean age = 13.3; SD = 4.5; $p < 0.04$) and amputations (mean age = 10.5; SD = 4.9; $p < 0.007$). A similar study in an Iranian paediatric population found tendon laceration to be the most common hand injury, and amputations the least (Mirzaie *et al.* 2014). These differences may be due to differences in aetiology. However, no relationship was observed between age and aetiology in the present study.

In the present study, most injuries were experienced during sports activities (29.8%). This finding agrees with those of Lempesis *et al.* (2017), who note a prevalence of 42.4% for sports injuries. However, a study in Saudi Arabia found door trapping and home activities to be the leading causes of hand injury in children (Al-Jasser *et al.* 2015), while Mirzaie *et al.* reported a significant proportion of injuries to be caused by road traffic accidents. In the present study, the incidence of accidents due to home activities or road traffic was too small to be included in the analysis.

Although most studies have focussed on single populations, which presents multiple discrepancies between study groups (cf. Shah et at. 2012; Johnson *et al.* 2017; Nauta *et al.* 2017), all their findings indicate that hand injuries lead to severe disability and impaired child development. Our present findings clearly show that sports activities, sharp objects, or the use of agricultural or woodworking machinery increase the incidence of specific injury types. Such information may be vital in designing educational and healthcare programs aimed at reducing the incidence of hand injury in the paediatric population (Lempesis *et al.,* Sozbilen *et al.,* 2021).

Still, there is a need for more studies on the occurrence of hand injuries in the paediatric population, as this represents a substantial socioeconomic problem. Although our present study research did not assess the economic burden of paediatric hand injuries, this has been addressed previously. Therefore, it is vital to introduce focused preventive strategies, educational programs and health care instructions aimed at influencing parent attitudes toward child hand injury.

This study has some limitations, the first of which is its retrospective nature. In addition, the study group is relatively small; although this is only a pilot study intended as an introduction to more advanced research, analyses

of epidemiology and aetiology nevertheless demand larger groups with more precise data regarding injury causation. Furthermore, the patients included in this study were treated in only one medical unit. Finally, further research should include data regarding the dominant hand of each patient, more specific data regarding the exact injured structure, as well as the financial aspects of hand injuries management.

Conclusion

Paediatric hand injury remains a significant problem in emergency and orthopaedic departments worldwide. Our findings confirm previous data indicating that hand injury is more likely to be experienced by boys, and the prevalence of such trauma increases with age. In addition, the likelihood of amputation, isolated tendon injury and open fracture is also associated with age. The occurrence of hand injury peaks at around 16 to 17 years old. The most common injuries were fractures and subamputations the least. The most frequent causes of injury were sports, trapping, sharp object, and agricultural machine.

There is a clear need for effective preventive strategies and educational programs to limit the number of accidents leading to severe hand injury and disability in the paediatric population.

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