Original Article

Injuries to the lower limbs and associated injuries in children and adolescents resulting from road traffic incidents

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Abstract

Background: Fractures occurring in the lower extremities as a result of road traffic accidents (RTAs) can lead to considerable morbidity and constitute a large proportion of nonfatal injuries that necessitate hospitalization. The present study aimed to examine the epidemiology of lower extremity fractures linked with RTAs in pediatric patients. **Methods:** This is a descriptive retrospective research study carried out between 2015 and 2022 at St. Mary's Children's Hospital, Iasi, Romania, targeting the population below the age of 18 years who experienced trauma from RTAs and received treatment from the trauma department. Data pertaining to various aspects, including age distribution, the frequency of accidents, the types of injuries incurred, and surgical treatment, were gathered. **Results:** The findings revealed a total of 358 cases of RTAs, out of which 112 fit the required criteria, and a total of 22 patients, accounting for 19.64%, had open fractures. **Conclusion:** This research provides information on lower extremity fractures and associated injuries in the pediatric population living in urban and rural areas throughout the Moldova region in Romania, subsequent to RTAs. The objective is to deliver the most relevant information at the patient's bedside and provide proper healthcare services.

Keywords: Fracture treatment approach, orthopedic, pediatric trauma lower extremity, road traffic accidents

Introduction

Road traffic accidents (RTAs) involving children are a significant global concern, comprising approximately 22% of all RTA-related injuries.[1,2]

According to research conducted by the European Transport Safety Council, Romania stands out with the highest rate of fatalities among children under 14 years in road accidents compared to other European countries.[3,4] This underscores the urgent need to address road safety, especially concerning children, for public health and community well-being.[5,6] RTAs contribute substantially to global mortality and morbidity rates, with projections indicating a rise in road traffic injuries to the third position in disease burdens by 2025.[7,8] This study on lower extremity fractures in young populations due to RTAs offers

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valuable insights for practitioners and patients alike.[9] Healthcare professionals can benefit from comprehensive epidemiological data and evidence-based management strategies to enhance diagnosis and treatment outcomes.[10] In addition, patients can expect better recovery and quality of life through tailored treatment protocols and rehabilitation, alongside preventive measures to promote road safety in communities.[10]

Materials and Methods

This study is a retrospective analysis carried out from 2015 to 2022. The study employs patient medical information acquired from the Emergency Department (ED) of St. Mary's Emergency Clinical Hospital for Children, together with hospitalization data from the Pediatric Orthopedics Department. The study protocol was obtained with authorization from the administration of St. Mary's Clinical Emergency Hospital for Children, under the designated approval number 23177 dated July 10, 2020.

The hospital's ED functions as the main public facility for referring pediatric injuries, offering highly specialized medical treatment for the city and territory of Iași, as well as its surroundings, encompassing both rural and urban regions. Information from the hospital's computerized medical records was extracted to identify patients admitted to the ED for TAs. Our emphasis was primarily on patients with cause codes V00–V99. Furthermore, an electronic search by the keywords "road traffic accidents" and "traffic accidents" was conducted to uncover any potential occurrences of traffic accidents that may have been missed during the classification procedure, which relied on provided cause codes. This verification was carried out by meticulously scrutinizing their medical data.

In the study, a traffic accident was defined as an incident that takes place on a road and involves at least one vehicle in motion. The study identified a total of 358 instances of RTAs, of which 159 met the necessary criteria for injuries to the lower limbs. Out of those, 112 cases were found to have fractures. The data collection approach involved obtaining information on demographics, detailed data on the types of injuries sustained, and the treatment interventions provided. The location of the child at the time of the accident determined the classification of different accident types, whereas the precise anatomical region affected and the characteristics of the harm inflicted determined the classification of injury types.

To perform the statistical analyses, participants were divided into four age groups: 0–4 years, 5–9 years, 10–14 years, and 15–17 years. The study data were analyzed using IBM SPSS Statistics 25 and visualized using Microsoft Office Excel/Word 2013.

For quantitative variables, normal distribution was assessed using the Shapiro–Wilk test. Data were presented as means with standard deviations or medians with interquartile ranges. Non-parametric quantitative independent variables were compared between groups using the Mann–Whitney U test or Kruskal–Wallis H test. Qualitative variables were expressed as absolute or relative frequencies and compared using Fisher's exact tests.

Results

A cumulative number of 358 RTA cases were documented in the TR from 2015 to 2022. Out of these cases, 159 patients (44.41%) had injuries to the lower limbs, and 112 presented fractures. Out of the 112 cases of LEFs that were examined, 22 patients (19.64%) arrived at the ED with open fractures. The patients' mean age was 11.8 ± 4.01 years, representing a diverse sample of both male and female individuals. The male population accounted for 76.31% of the total sample [Figure 1]

The preschool age group and the pre-adolescent age group had a considerably greater likelihood of experiencing open fractures in pedestrian RTAs. The rates of open fractures were 27.27% and 25%, respectively ($P < 0.0001$), which is much higher compared to the average incidence of 9% seen in other categories of children.

Upon analysis of the extracted data, it was determined that 53% of the study participants, amounting to 85 individuals, exhibited injuries to the right limb, whereas 45% of instances manifested in the left lower limb. Merely 2% of cases were documented as demonstrating bilateral impairment [Figure 2].

Type of fracture

Patients aged 0–4 years were more frequently car passengers than pedestrians/wagon passengers/bicyclists (28.8% vs. 9.2%/7%/3.4%) while patients aged 15–17 years were more frequently wagon passengers or bicyclists than pedestrians or car passengers (46.5%/28.1% vs. 22.2%/8.2%) ($P < 0.001$) [Figure 3].

The distribution of open fractures, classified by fracture type, indicated that 50% of the open fractures involved the tibia, followed by 43% for fibula fractures, and a 7% incidence for femur fractures [Table 1].

Cause of the injury

Out of the 153 cases of LEFs that we examined, 64 (42.1%) occurred in pedestrians, 41 (27%) in bicycle riders, 27 (17.8%) in automobile occupants, and 21 (13.8%) in other road-related incidents.

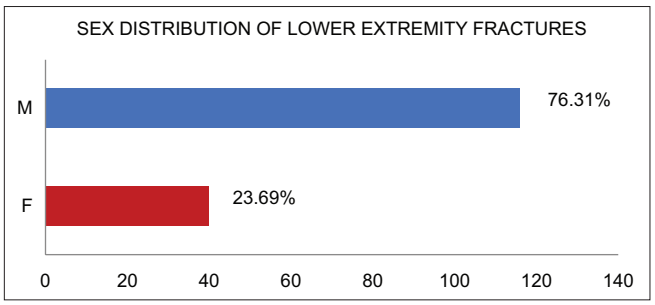

Figure 1: Sex distribution of lower extremity fractures (LEFs)

Table 1: Distribution of open lower extremity fractures (OLEFs) in different types of road traffic accidents (RTAs)

	Pedestrian			Bicycle			Car passenger			Other traffic-related accidents			Grand total
	0–6 y.o.	7–14 y.o.	15–18 y.o.	0–6 y.o.	7–14 y.o.	15–18 y.o.	0–6 y.o.	7–14 y.o.	15–18 y.o.	0–6 y.o.	7–14 y.o.	15–18 y.o.	
Femur	0	1	0	0	2	0	0	0	0	0	0	0	3
Tibia	6	6	2	1	3	0	1	1	0	0	0	2	22
Fibula	6	4	2	1	2	0	1	1	0	0	0	2	19
Total open fractures	12	11	4	2	7	0	2	2	0	0	0	4	44

y.o.=years old

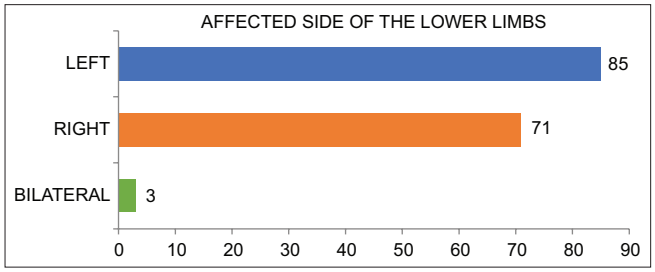

Figure 2: Distribution of lower limb injuries on each side resulting from road accidents

Table 2 presents the risk of each open fracture based on the kind of injury and age group. The group of patients with open fractures consisted of 25 individuals, who together had a total of 44 fractures. Out of these patients, 14 were pedestrians and had a total of 27 fractures, accounting for 63.36% of the total. In addition, four patients (18.18%) were bicycle riders and had nine fractures, while two patients (9.09%) were automobile passengers. The other two patients (9.09%) were engaged in other incidents linked to the road.

The preschool pedestrian group had a much greater likelihood of experiencing open lower extremity fractures (OLEFs) compared to the elder groups (64% vs. 36% cumulative, $P = 0.001$) [Table 2].

The most common types of open fractures in preschool pedestrians were tibia fractures, accounting for 45.45% of cases, followed by fibula fractures at 40.9%, metatarsal fractures at 9.09%, and femur fractures at 4.54%. In pre-adolescent patients, tibia fractures were the most prevalent, occurring in 57.14% of cases, followed by fibula fractures at 28.57%, and femur fractures at 14.28%. Within the adolescent group, there was a notable shift in the distribution of injuries. Specifically, the tibia and fibula exhibited an equivalent prevalence rate of 42.85%, whereas pelvic fractures accounted for 14.28% of cases.

Open fractures of the tibia and the fibula displayed a similar prevalence rate and were found to be the most prevalent forms of open fractures in preschoolers who enjoyed cycling. In contrast, tibia fractures were the most common among pre-adolescent patients, occurring in 43% of cases; this was followed by fibula fractures at a rate of 28.5%, and finally femur fractures at a rate of

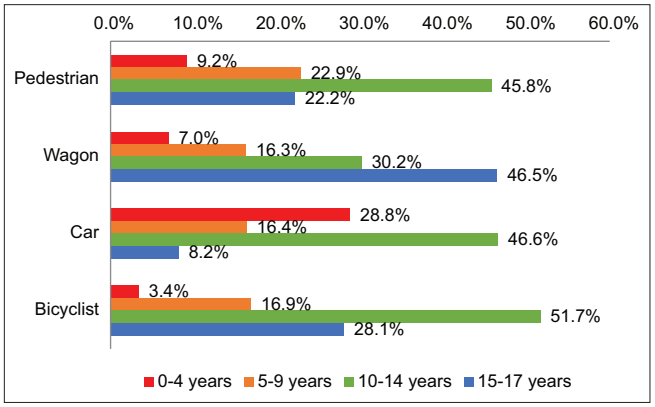

Figure 3: Distribution of the patients according to age and status

28.5%. There were no instances recorded among the adolescents who were affected.

For car passengers, open fractures of the tibia and the fibula were equally displayed in preschoolers and in pre-adolescent patients, occurring each for 25% of cases. No instances were recorded among the adolescent group. For other types of road traffic-related accidents, no cases could be found in the preschoolers and in the pre-adolescent group. No cases of road traffic-related accidents were observed in the preschoolers and pre-adolescent groups. Nevertheless, the group of adolescents exhibited superior outcomes, with an equal number of cases of tibia and fibula fractures, each accounting for 50% of the findings.

Type of treatment

From the point of view of the treatment, it was divided into two large categories: orthopedic treatment (which involves only cast immobilization or orthopedic reduction of the fracture and application of the cast) and surgical treatment (for closed or open fractures). Upon analyzing the relationship between the implementation of the orthopedic reduction procedure and the use of a cast to immobilize the affected limb, the following observations were made: for cases involving the femur, over half of them (62%) necessitated both orthopedic reduction and cast immobilization, while the remaining cases only required the application of a cast. At the tibia and fibula level, a comparable outcome was noted, with over 60% of patients necessitating both orthopedic reduction and immobilization with a cast. At the level of the metatarsal bones and phalanges, it was discovered that all patients needed orthopedic treatment involving the reduction of

fractures and immobilization using a plaster cast. Regarding the pelvic fracture, only 80% of the patients need the utilization of gypsum immobilization [Table 2].

After analyzing the data regarding the necessity of surgery for closed or open fractures, the following conclusions were drawn: out of 26 patients with femur fractures, three had open fractures and required immediate surgery, nine had significant fractures that were treated surgically as an emergency, four cases had additional injuries, resulting in the surgical treatment being performed 2 days after admission, and 10 cases did not require surgery and were treated conservatively with immobilization using a cast. After diagnosing tibia fractures, it was determined that half of the patients did not need surgery. Instead, they simply needed immobilization with a cast. Among the individuals requiring surgery, half presented with open fractures and underwent immediate surgical intervention, while the remaining half had displaced or comminuted fractures and also required urgent surgery. There were just two instances when injuries were severe enough to delay the intervention by two days following admission.

The tibia fracture and fibula fracture shared the same origin; 50% of the cases were managed non-surgically through immobilization with a cast, while the remaining 50% consisted of more than 60% of cases with displaced fractures that required emergency surgery. Out of these cases, two surgeries were delayed by 2 days after admission for realignment. The remaining cases were closed fractures with a risk of displacement and were operated on urgently.

On the other end of the spectrum are the fractures of metatarsals and phalanges, which were equally distributed between closed fractures and could be treated with immobilization using a cast. In 80% of instances, pelvic fractures were managed via plaster immobilization without the need for surgery. However, a minority of cases (20%) needed surgical stabilization [Table 3].

Associated injuries

Out of the 159 patients with LEFs, 129 (81.13%) experienced an extra injury. The highest probability of related injuries was seen in pedestrians (40.5%, $P < 0.0001$), followed by automobile occupants and cyclists (21.5%–23.5%) involved in RTAs ($P < 0.0001$).

The analysis of injuries connected with RTAs revealed that head and trunk injuries were the most prevalent (66.06%, $P < 0.0001$) in pedestrian-related RTAs. The most prevalent injuries among automobile occupants were to the head, trunk, and upper extremities, summing 67.81% ($P < 0.0001$). Head and chest injuries were the most prevalent in bicycle-related RTAs, followed by injuries to the upper and lower extremities ($P = 0.001$), in contrast with head and upper and lower extremities injuries being on the same level in other types of accidents [Table 4].

Patient follow-up outcomes

The follow-up of patients was conducted over a period ranging from 6 months to 5 years, based on data from observation sheets. Out of a total of 112 cases involving 154 fractures, 22 cases were represented by patients from other counties, accounting for 30 fractures. Consequently, follow-up for these cases was not possible as they did not return to our clinic for reassessment. Ninety cases, comprising 124 fractures, remained under observation.

Among these, 25 cases were identified as open fractures (2 were related to patients from other counties) classified according to the Gustilo Anderson classification. Specifically, there were 21 cases of type 1 fractures (18 located in the tibia and fibula, 2 in the femur, and 1 in the tibia), three type 2 fractures (located in the tibia and fibula), and one type 3 fracture (located in the tibia and fibula).

Female patients were significantly more likely to receive supervision as a therapeutic measure (44.8% vs. 17.5%/23.4%), while male patients were significantly more likely to receive orthopedic or surgical treatment (82.5%/76.6% vs. 55.2%) ($P = 0.007$) [Figure 4].

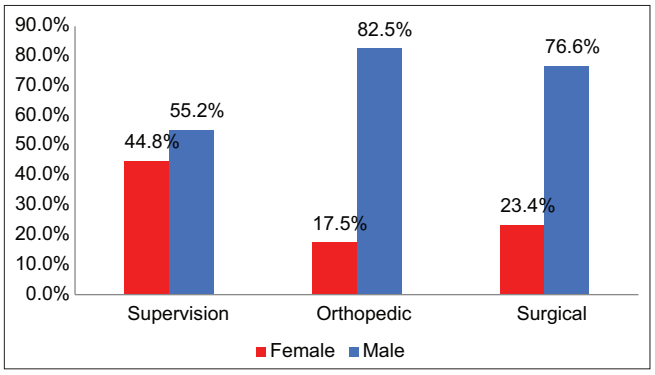

Figure 4: Distribution of the patients according to gender and therapeutic measures

Table 2: The distribution of the necessity for orthopedic reduction and the utilization of plaster immobilization

Cast	Orthopedic Reduction		Grand total
	Yes	No	
Femur	16	10	26
Yes	16	10	26
Tibia	45	27	72
Yes	45	24	69
No	0	3	3
Fibula	27	18	45
Yes	27	18	45
Metatarsal	2	0	2
Yes	2	0	2
Phalange	3	0	3
Yes	3	0	3
Pelvis	4	1	5
Yes	1	0	4
No	0	4	1
Total	97	56	153

Table 3: The link between the need for surgery for open or closed fractures

Open fracture	Operation					Grand total
	Yes			No		
	In emergency	2 Days	Total Yes	No surgery required	Total No	
Femur	12	4	16	10	10	26
Yes	3	0	3	0	0	3
No	9	4	13	10	10	23
Tibia	37	2	38	34	34	73
Yes	20	2	21	1	1	22
No	17	0	17	33	33	50
Fibula	25	2	27	18	18	45
Yes	16	2	18	1	1	19
No	9	0	9	17	17	26
Metatarsal	0	0	0	2	2	2
No	0	0	0	2	2	2
Phalange	0	0	0	3	3	3
No	0	0	0	3	3	3
Pelvis	1	0	1	4	4	5
Yes	1	0	1	0	0	1
No	0	0	0	4	4	4
Total	76	8	83	70	70	154

Table 4: Association between associated injuries and different groups of individuals involved in road traffic accidents

	Pedestrian	Bicycle	Car passenger	Other traffic-related accidents	Grand total
Head	19	9	8	2	38
Trunk	19	4	7	2	32
Chest	3	8	5	0	16
Upper extremities	8	4	6	4	22
Lower extremities	9	5	4	4	22
Total	58	30	29	12	129

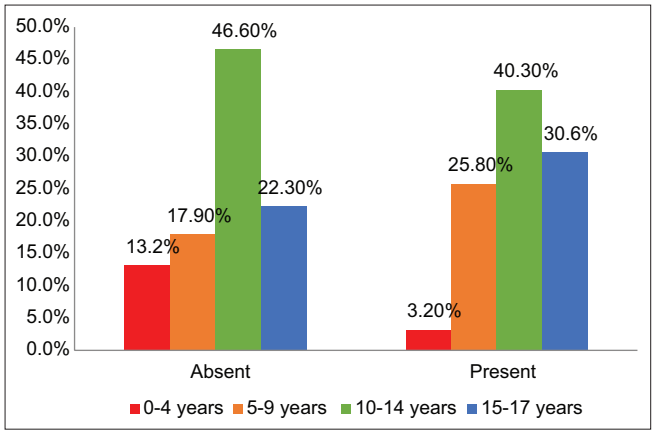

Figure 5: Distribution of the patients according to age and existence of complications

Patients aged 0–4 years were significantly less likely to experience complications (3.2% vs. 13.2%, $P = 0.034$) [Figure 5].

Discussion

Pediatric fractures differ significantly from adult fractures due to skeletal immaturity and distinct bone physiology.[11] Children benefit from the ability to remodel bone and avoid long-term deformities. However, prognostic factors such as age must be considered as younger children are more prone to significant deformities and dysmetria.[12]

In accordance with Romania's national demographic assessment for 2020, 51.6% of newborns were male, equating to a sex ratio of 107 boys for every 100 girls.[13] While the national gender distribution may appear balanced, a notable shift occurs in the context of traffic accidents, where a male predominance is observed. This aligns with findings from various studies.[14–16] Although some studies did not find significant gender differences,[17,18] a few reported a female predominance.[19] In addition, some research suggests that women, especially those over the age of 14 years, may experience more severe injuries compared to men.[20] In our research, male predominance was detected in a proportion of 3:1, consistent with other studies that indicate that men tend to sustain more severe injuries.[21]

There is a lack of comprehensive data on the epidemiology of injuries related to RTAs. Although previous studies have explored this topic, most are based on relatively small patient samples and show considerable methodological variability.[22] This highlights a significant gap in our understanding of orthopedic injuries

in the lower extremities, especially among children. Moreover, these studies mainly focus on RTA-related mortality rates and overall injury severity scores, providing insights into the affected body regions but lacking detailed information on the nature and patterns of injuries. This limitation hinders meaningful comparisons across the current research.[22]

A thorough analysis of the epidemiology of RTA injuries proves advantageous in gaining a profound understanding of the complexity of injuries, associated factors, and the likelihood of open fractures, which may vary depending on the patient's age and the mechanism of the RTA.[23]

Research shows that fractures are the most common injuries following RTAs, with lower extremity injuries being the leading cause of functional impairment 1 year after hospital discharge.[24] The present study revealed that approximately 42.45% of pediatric patients involved in RTAs experienced fractures of their lower limbs. This finding contrasts with earlier studies, which found a lower incidence of approximately 18% for such fractures.[25]

According to statistics from the Romanian Police covering the period from 2017 to 2022, the average annual number of children injured in road accidents nationwide was 342. Our study, therefore, represents 15% of the total cases reported nationally.[26]

Pedestrians and bicyclists are particularly vulnerable to lower extremity fractures, with approximately 20% of these patients experiencing open fractures. Among these injuries, tibia fractures are the most common. However, in RTAs involving bicycles, femur fractures are more frequently observed compared to other types of accidents.[27]

Serinken and Ozen analyzed the cases of 812 pediatric patients (under 15 years old) hospitalized at a medical center in Turkey over 5 years following RTAs, finding that 17.7% of these cases involved fractures in the lower extremities.[28] Similarly, a 10-year cohort study by Pan *et al*.[29] investigated the epidemiology of fractures and other injuries among 653,386 patients hospitalized due to RTAs in Taiwan. Only 7.04% of these patients were 17 years or younger, with 12.22% experiencing lower limb fractures. Both studies lacked detailed data on the RTA mechanisms, fracture types, and treatment methods. In contrast, our study revealed that 44.7% of all evaluated patients had injuries to the lower extremities.

Grivna *et al*.[30] conducted an 18-month study on patients aged 0–19 years admitted to major trauma centers in Al Ain, United Arab Emirates, due to RTA injuries. Among 245 participants, 69% were car occupants, 15% were pedestrians, 9% were motorcyclists, and 5% were bikers. In contrast, our study observed a different distribution, with the majority of injuries occurring while crossing roads as pedestrians or while cycling. In addition, 31% of injuries in our study involved the extremities. Specific details regarding the type of injury or the precise injury site were lacking in both studies. Grivna *et al*.[30] found no significant differences in injury severity, assessed by the Revised Trauma Score and Injury Severity Score, between car occupants and pedestrians, or between motorcyclists and bicyclists, groups typically considered at higher risk in traffic.

Lustenberger *et al*.[31] conducted a 5-year study using National Trauma Databank data, examining bikers injured by vehicles in the United States. The research included 12,429 patients, with limb fractures constituting 34.9% of cases. Among these, tibia-fibula fractures accounted for 23.6%, representing 58% of all lower extremity fractures. The study highlighted a significant association between lower extremity fractures and individuals under 15 years (approximately one-third, or 4095 individuals), emphasizing a higher likelihood of lower extremity fractures in this age group compared to upper extremity fractures. In contrast, our study found that only 27% of bicycle-related RTA injuries resulted in lower extremity fractures, with tibia fractures being the most prevalent at 43.9%.

As observed in our study, in the 4–10 and 10–14 age groups, both tibia and fibula fractures were equally observed, contrasting with the findings of Demetriades *et al*.[32] Their 10-year analysis of 5838 admissions to a level I trauma center involving pedestrians injured by vehicles, with 19.4% (1136 patients) being children aged 14 years or younger, showed a higher prevalence of pelvic and tibial fractures in adults.

It is important to highlight that nearly half of the patients, three-quarters in our study, who experienced lower extremity fractures (LEFs) also sustained additional injuries, with RTAs involving cars posing the highest risk. Interestingly, recent research, including our own, indicates that regardless of the mechanism of the RTA, injuries to the head and trunk are most commonly observed. This represents a notable departure from previous studies, where limb injuries were more prevalent than injuries to the head and neck.[33]

Furthermore, it is important for healthcare providers to recognize that nearly 20% of patients suffered from multiple lower extremity fractures (LEFs), underscoring the importance of minimizing the risk of missing fractures. Therefore, treatment must be tailored to each individual case following standard protocols or guidelines due to the diverse nature of the cases. In addition, procedures and therapies should be adapted based on the number, size, location, symptoms, and progression of the fracture.[34] Pediatric orthopedic surgeons have a significant responsibility in treating children with multiple injuries, given that 76% of these cases involve severe bone trauma, necessitating specialized care and leading to prolonged hospital stays.[35]

Limitations in the study and future directions

Primarily, as this investigation adopted a retrospective approach, specifically drawing from a regional registry, we must anticipate potential inaccuracies in coding and gaps in data. However, we employed logical validation tools to ensure the consistency of our database variables.

Secondarily, our study faces limitations due to the relatively modest representation of pediatric cases. Our sample encompasses cases from across the Moldova region, situated in the eastern sector of Romania, which ranks as the third-largest region in the nation in terms of both geographical expanse and population density. Furthermore, our dataset comprises solely hospitalized patients, predominantly those with severe conditions.

Expanding the scope of our investigation to encompass multiple centers could substantially augment the utility of our existing dataset. While this endeavor would entail a significant amount of effort and data coordination, we are contemplating pursuing multicenter research in the future.

Conclusions

Fifty-six percent of the patients with lower extremity injuries were followed up. Of those, 38% did not require surgery, and only one had complications. Out of the surgically treated patients, only 28% experienced complications that prolonged their healing and required additional surgery.

To the best of the authors' knowledge, this is the first study to date dealing exclusively with pediatric RTAs in Romania. Although there are several articles on the topic of RTAs in this geographical area, they are addressed to the adult population or have a general view encompassing all ages, lacking a specific focus on the pediatric population.

The study's novelty lies in its comprehensive analysis of pediatric LEFs resulting from RTAs, the focus on specific age groups, fracture types, and associated injuries contributing to a nuanced understanding of the impact of accidents, offering potential avenues for targeted future preventive measures and treatment strategies.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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