PATTERN OF LONG BONE FRACTURES IN A PAEDIATRIC POPULATION AT KENYATTA NATIONAL HOSPITAL

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ABSTRACT

Background: Paediatric injuries, both accidental and non-accidental are a global public health problem. In developed countries, injuries account for majority of the mortality in paediatric age group after one year of age. Musculoskeletal trauma is the most common form of injury in childhood. Locally, there is a paucity of data on the distribution, cause and severity of childhood fractures.
Objective: This study aimed to determine the pattern of long bone fractures, common mechanisms of injury, severity and location at time of injury in the paediatric age group.
Design: This was a cross-sectional study
setting: The study was conducted at the Accident and Emergency department, Paediatric Orthopaedic ward and Fracture Clinics in Kenyatta National Hospital.
Methodology: The study had 104 participants. All paediatric patients presenting with long bone fractures between October 2016 and December 2016 were registered, listed and assigned consecutive numbers. Sampling was done for those who met the inclusion criteria and they were recruited into the study. Data obtained was stratified and analyzed based on age of patient, anatomic site of fracture, fracture classification based on the AO PCCF classification system, mechanism of injury and location at the time of injury. Chi- square test was used to analyze categorical variables. The data was summarized in terms of means, medians and modes and categorical data was presented in form of tables, charts and graphs.
Results: One hundred and four participants who had sustained 119 fractures were recruited. Males were 61(59%) and females 43(41%) in number with a median age of 6 years and 5 months (2 – 14 years). Majority had single (84%) and closed (96%) fractures. Majority of the fractures were due to falls (56%) and commonly occurred at home or its surroundings (56%). Upper limb fractures predominated at 53% with majority involving the distal metaphysis of the humerus (70%).
Conclusion: Majority of the long bone fractures in children in our setting occur due to falls in the home or its surroundings and the distal metaphysis of the humerus is the most commonly fractured region. The fractures showed a bimodal type of distribution with peaks at 4 - 6 years and at 12 – 14 years of age. Fractures secondary to RTAs were higher than in other studies.

Key words: Children, Falls, Long bone fractures, Pattern, Mechanism of injury, Developing countries

INTRODUCTION

Childhood injuries are a global public health problem. It is estimated that in 2011, over 630, 000 children under the age of 15 were killed by an injury and that for every injured child who died, there were several thousand children who went on to live with varying degrees of disability (1). Up to one in four children sustain an injury annually (2,3). Out of all these injuries, it is estimated that fractures contribute 10 -25% with the majority of the injuries resulting from falls (4,5). The lifetime risk for sustaining a fracture in childhood is estimated to be up to 64% in boys and 40% in girls (6,7). Though some of these fractures occur in patients who already have conditions like skeletal dysplasia that significantly increase the risk of fractures, majority are in healthy children. Most fractures in children heal without loss of function, but still there are significant associated costs for the child and family that include time away from school, medical costs and reduced activity for prolonged periods of time due to pain (8).

Various studies have shown an increasing trend in the incidence of fractures in children (3,4). This is attributed to increased sporting activity, which cause up to 39% of the fractures (9,10). Different geographical regions demonstrate differences in the pattern and mechanism of injury of fractures sustained. This could

be due to the differences in the activities the children participate in different geographical regions e.g. in Scandinavian countries skiing is common while it is very rare in sub-Saharan countries. In a study carried out in Washington D. C., it was shown that neighbourhood characteristics affected fracture rate (11). In South Wales, U.K, Lyons *et al* (12) found that children from different electoral ward quarters had similar fracture rates but those from affluent quarters had more sport related fractures and those from deprived quarters had more assault related fractures.

Majority of childhood fractures are caused by falls, usually within the home environment (13). Most of these falls are preventable by institution of simple measures like supervision during play, use of soft landing surfaces in play areas and making play equipment safe. With the continuing urbanization and more people living in high-rise apartments, there is a likely increase in serious injuries resulting from falls above 3 meters. Another common mechanism of injury in childhood fractures is road traffic accidents.

The data on pattern of paediatric fractures and the mechanism of injury is essential in developing fracture prevention and intervention guidelines. The data currently available is mainly obtained from the western and developed world population. This data is not necessarily applicable in our region and cannot be reliably used in guiding preventive or interventional guidelines in our setting. This study aimed to determine the fracture pattern and the common mechanisms of injury amongst children as seen in a tertiary referral hospital.

MATERIALS AND METHODS

Study design: Cross-sectional study.

Study site: The study was carried out in the Accident and Emergency department, Paediatric Orthopaedic Ward and fracture clinics at Kenyatta National Hospital which is the largest tertiary hospital in Kenya.

Study population: All children and adolescents older than two years and younger than fourteen years of age presenting at Kenyatta National Hospital with a fracture/ fractures between October 2016 and December 2016 were included.

Exclusion criteria included:

1. Pathologic fractures
2. Patients on long term steroid treatment
3. Healed fractures
4. Patients/ guardians who declined to have radiographs of fractures taken

Sample size: A sample size of 104 participants was used. This was based on calculations done using the Cochrane formula.

Study procedures

Participant enrollment: The principal investigator or one of two research assistants did the enrollment using convenience sampling. Recruitment was done in the Accident and Emergency department on all days of the duration of the study between 8.00am and 8.00pm and any patient not captured during this period was captured within 72 hours in the orthopaedic paediatric ward in case of admission or the fracture clinic for those allowed home after treatment in Accident and Emergency department.

Consenting: The guardian/parent and the patient, if above 10 years of age, were explained to about the study. Consent was sought from the guardian and assent was obtained from patients who were above ten years of age. The participants were assigned a study number which was used in filling of the questionnaires and fracture coding forms.

Data collection: The principal investigator or the research assistants, using a questionnaire and a fracture coding form, collected data from the participants.

The following data was collected using the questionnaire: Age of patient, sex of patient, mechanism of injury, anatomic site of the fracture, whether open or closed fracture, if a fall, approximate height of fall, place of occurrence of accident, whether accompanied or not at time of injury, history of previous fractures, type of road accident and type of sport.

The fractures were classified according to the AO Paediatric Comprehensive Classification of Long-Bone Fractures guidelines. This was done using the AO PCCF charts and the AO Comprehensive Injury Automatic Classifier (AO COIAC) software by the principal investigator.

Data management and analysis: Collected data was stored in a secure database and at the end of the study exported to Microsoft Excel 2016 for analysis. The data was stratified and analyzed based on age of patient, anatomic site of fracture, fracture classification based on the AO PCCF classification system, mechanism of injury and place of injury. The data was summarized as means, medians and modes and was presented in form of tables and graphs.

RESULTS

The study was carried out between October 2016 and December 2016. One hundred and four patients with 119 fractures met the inclusion criteria. Of these, 17(16%) had sustained more than one fracture. The males formed a majority at 59% giving a male: female ratio of 1.4:1.
The mean age was 7 years and 2 months. Most of the fractures occurred in the 2 - 6 years age groups

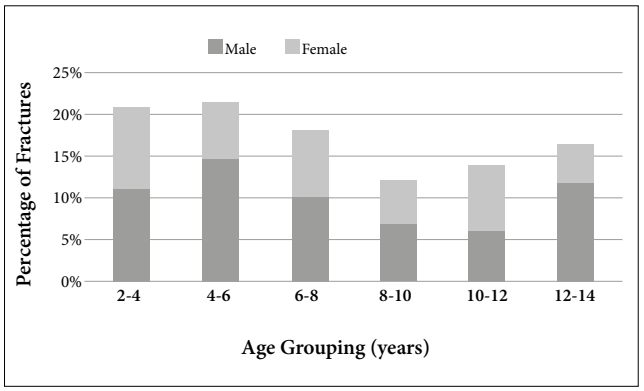
accounting for 45% of the patients. The 6 - 8 years age group had the least number of patients at 28%. Most of the fractures occurred at 'home or its surroundings' (56%) followed by fractures occurring on the 'road' (22%). The predominant mechanism of injury was falls at 56%. Only 13% of the patients sampled sustained fractures during sports. A majority of the patients (84%) sustained single fractures giving a single fracture: multiple fractures ratio of 21:4. A summary of these and other characteristics of the patients are as shown in Table 1.

Table 1
General characteristics

Characteristic		No. (n=104)	(%)
Gender	Male	61	59
	Female	43	41
Age	Mean	7yrs 3months	-
	Median	6yrs 5months	-
	IQR	6yrs 1month	-
Age groupings (years)	2 - 6	47	45
	6 - 10	28	27
	10 - 14	29	28
Place of injury	Home	58	56
	School	10	10
	Public playground	14	13
	Road	22	21
	Other	0	0
Mechanism of injury	Fall	58	56
	RTA	22	21
	Sport	13	13
	Assault	0	0
	Gunshot	0	0
	Other	11	0
Place of injury	Single	87	84
	Multiple	17	16
	Open	5	4
	Closed	114	96

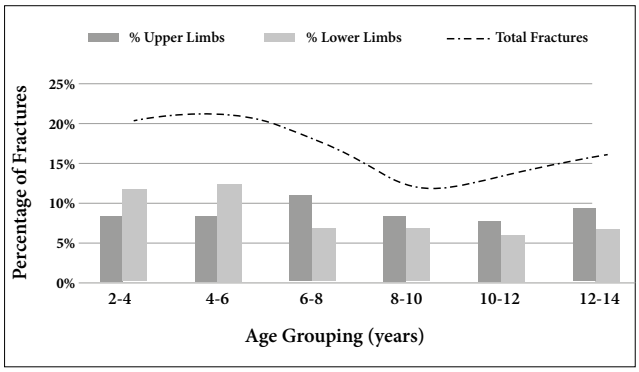
Fracture distribution: Fracture distribution by age demonstrated two peaks, one at 4 -6 years of age and another at 12 - 14 years of age. The 4 - 6 year olds accounted for 21% of all the fractures recorded while the 12 - 14 years age group accounted for 16%. Males accounted for most of the fractures in all age groups except in the 10 - 12 years age group where females dominated at 58% as shown in Figure 1.

Figure 1
Distribution of fractures by age and sex



Overall, the upper limb was involved in 53% of the fractures compared to 47% for the lower limb. This was significant having a p value of 0.007(A p value of ≤ 0.05 was taken as significant). Looking at the different age groups in Figure 2, it is noted that in the 2 - 4 years and 4 - 6 years age groups most of the fractures involved the lower limb, but, from the 6th year of age up to 14th year of age, the upper limb was predominantly fractured. There was no significant difference in involvement between the right and left sides (p=0.33) as shown in Figure 2.

Figure 2
Distribution of fractures by limb involved and age



Place of injury: Majority of the fractures occurred at the home and its surroundings (56%). Twenty one per cent of the fractures happened on the road, 13% in public playgrounds and only 10% in schools. Majority of the fractures occurring at home or its surroundings were in the 2 - 6 year old with a mean age of 6 years compared to the whole population mean of 7.3 years. Fractures occurring in the school environment peaked in the 8 - 14 years age groupings with a mean age of 9 years 6 months. Accidents on the road peaked in the four to eight year olds. Males were statistically more likely to sustain a

Table 2
Place of injury

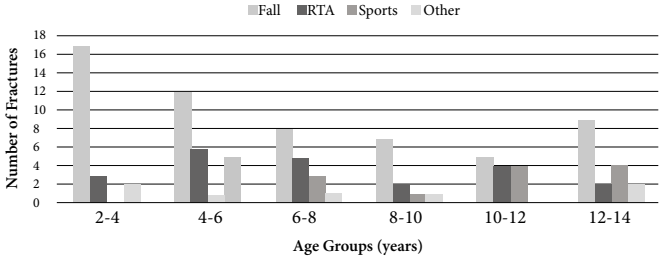
	Male	Female	Mean age	2-4 yrs	4-6 yrs	6-8 yrs	8-10 yrs	10-12 yrs	12-14 yrs	Total
Location	No.(%)	No.(%)	yrs	No.(%)	No.(%)	No.(%)	No.(%)	No.(%)	No.(%)	No.
Home	39(62)	19(46)	6	19(86)	17(71)	7(41)	3(27)	5(38)	7(41)	58
School	6(10)	4(10)	9.5	1(5)	1(4)	1(6)	2(18)	2(15)	3(18)	10
Road	11(17)	11(27)	7.8	2(9)	6(25)	5(29)	2(18)	4(31)	3(18)	22
Public playground	7(11)	7(17)	9.6	0(0)	0(0)	4(24)	4(36)	2(15)	4(24)	14
Total	63(100)	41(100)	7.3	22(100)	24(100)	17(100)	11(100)	13(100)	17(100)	104

fracture at home and its surroundings than the females. Table 2 shows the distribution of place of injury vs age.

Majority of the fractures happened while other children, at 49%, witnessed the event. An adult witnessed only 23% of the events leading to fractures in the sampled patients. Twenty eight per cent of fractures happened while the patient was alone.

Mechanism of injury: Four mechanisms of injury were identified. These were "falls" at 56%, "road traffic accidents" at 21%, "sport injuries" at 12% and "others" at 11% in that order. The distribution of mechanism of injury by age groups was as shown in Figure 3.

Figure 3
Mechanism of injury vs age



Males had significantly more fractures that resulted from falls than females. In the rest of the mechanisms of injury, there was no difference noted as shown in Table 3 (p value was taken to be significant at values ≤ 0.05).

Table 3
Mechanism of injury vs sex

Mechanism of injury	Male No.(%)	Female No.(%)	p value
Fall	37 (59)	21 (51)	0.035649
RTA	10 (15)	12 (29)	0.669815
Sports	8 (13)	5 (12)	0.405381
Other	8 (13)	3 (7)	0.131668

As shown in Table 4, falls from heights below 1 meter were the main cause of injury both in the "falls" subgroup and as a proportion of all fractures sustained. Majority of these falls were on hard surfaces adding up to 76% of all the falls.

Table 4
Fall vs height and landing surface

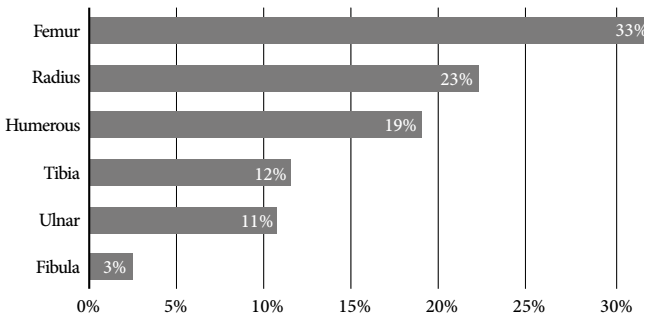
Height of fall	Hard landing surface	Soft landing surface	Total
0 - 1 meter	22	8	30
1 - 3 meter	17	2	19
> 3 meters	5	1	6
Totals	44	11	55

Road traffic accidents peaked at 4 - 8 years of age. In 68% of the road traffic accidents, the patient was a pedestrian, in 18% was a pillion passenger and in 14% was a passenger in a car. Of note is that all patients in the study who were car passengers at the time of accident were not restrained.

Sports injuries peaked at 10 - 14 years of age. Majority of the fractures, 62%, occurred in contact sports such as football. In the "Other" category of mechanism of injury, it was noted that another person falling on, or something heavy like a tire falling on the patient caused the fracture.

Anatomic distribution of fractures: The femur had the highest number of fractures at 33%. The radius followed at 23%. The fibula at 3% was the least fractured bone. Figure 4 illustrates the fracture burden by bone involved.

Figure 4
Fracture burden by bone involved



Majority of the fractures in all the bones surveyed involved the diaphysis at 71%. Fourteen (12%) of the fractures were epiphyseal with the radioulnar complex contributing 64% of these. None of these fractures involved a proximal epiphysis. A summary is presented in the Table 5.

Table 5
Fracture burden by bone segment involved

	Proximal Epiphysis	Proximal Metaphysis	Diaphysis	Distal Metaphysis	Distal Epiphysis
Humerus	0	3(13%)	3(13%)	16(70%)	1(4%)
Radio-ulnar	0	0	22(55%)	9(23%)	9(23%)
Femur	0	1(3%)	32(82%)	3(8%)	3(8%)
Tibio-fibular	0	0	15(88%)	1(6%)	1(6%)

Severity of injury: Twelve percent of the fractures were comminuted and all involved the lower limb (Femur – 6, 5%, Tibia – 5, 4% and Fibular – 3, 2.5%). Fourteen (12%) fractures involving the growth plates were observed. Four of these were equivalent to Salter Harris I and 10 were equivalent to Salter Harris II fractures.

DISCUSSION

One hundred and four patients were successfully recruited and as in other studies, results showed that males outnumbered females by nearly 1.5 times (14). The only time females predominated males in our study was in the 10 – 12 years age group. This age coincides with the pubertal peak height velocity in females, which causes a relative decrease in bone mineral density (15,16). Boys reach their pubertal peak height velocity about two years later and in this age group (12 -14 years) boys predominate at 76%. This generalized male predominance is probably due to the experimenting and risk taking behavior that is more common in males. The mean age of participants in our study was 7 years and 3 months, which falls within the ranges, found in other studies (9,14).

The fracture distribution was bimodal in nature with a peak at 4 – 6 years and another at 12 – 14 years. This is attributed to increased mobility in the younger age group and the relative decrease in bone mineral density and increased sporting activity in the older age group (17,18). Majority of the fractures were as a result of falls on hard surfaces and this could indicate a lack of proper and safe play areas for children. Rennie found a similar distribution with a peak at 6 – 7 years *et al* (19) and another at 13 – 14 years.

Overall, the lower limb was involved in 53% of the fractures. This is in contrast to other studies that have found that the upper limb is more involved (12). Up to 6 years of age, the lower limb predominated but after that, the upper limb was more likely to be fractured.The femur had the highest number of fractures at 33%. This is explained by the fact that KNH is a referral hospital hence likely to receive a disproportionate number of femur fractures, which are generally treated on an inpatient basis. The radius followed at 23%. Studies elsewhere have established the radius as the most fractured bone in childhood with rates of up to 40% of the fractures.

Rennie in Edinburg, Britain found fractures of the radius contributed 32.9% *et al* (19) while Tandon *et al* (20) in Mumbai, India came up with 22.4%. On further analysis of the radio-ulnar fractures, it was noted that majority of the fractures (55%) occurred in the shaft region in the study population. Distally the metaphysis and epiphysis contributed 23% each. The humerus was the third most fractured bone at 19% with majority involving the distal metaphysis (70%). The fibula was the least fractured bone at 3% and in all cases involved high-energy trauma. This could be due to the fact that the tibia carries most of the stress.The right side of the body was involved in 55% of the cases and this is comparable to what Randsborg *et al* (8) found.

Valerio *et al* (14) in Naples, Italy found that 68.3% of childhood fractures occurred in the home and its surroundings. In our study, 56% of the fractures occurred at the home or its surroundings. Provision of day cares at work places, public health interventions aimed at improved safety at home and training of nannies on safety could help reduce these fractures.

Only 10% of the fractures were sustained at school. These fractures showed a gradual increase from 5% in the 2 – 4 years age group to a high of 18% in the 12 – 14 years age group. The mean age was 9 years, 6 months with an equal preponderance of both male and females. This could be attributed to better supervision while at play or safer play facilities in schools.

Falls were the main mechanism of injury at 56%. Majority (55%) were from a level below 0.5 meters. These can be classified as slight trauma (21) and mainly resorted in distal humerus fractures and distal radial fractures. Thirty five percent were from a height of between 0.5 and 3 meters (moderate trauma) with more of shaft fractures both of the upper and lower limbs. Ten percent were from a height of > 3 meters, all from falls from balconies, equating to high-energy trauma. This is an indication that our balconies are not child proofed. Landing on a hard surface led to 80% of the fractures in this group, which was statistically significant. Simple *et al* (59) strategies like improving situational awareness amongst caregivers, closer parental attention, child friendly homes and playgrounds, padding of hard surfaces, child safe windows and covered balconies would go a long way in reducing these fractures. A good example where this has succeeded is the "Children can't fly" program in New York, U.S.A. (22).

Road traffic accidents contributed in 21% of the fractures which is higher than the figures (7% to 10%) from other studies in developed countries (4,10,23). Majority of this accidents involved pedestrians. An explanation for this could be the lack of properly designated pedestrian crossings and walking areas on our roads. Of all the fractures resulting from vehicular

accidents where the patient was a passenger, none was restrained. Several interventions have been used elsewhere to reduce road traffic accidents. These include speed controls, traffic restrictions in some areas, banning of traffic near where children play, providing transport to children to and from school and mandatory use of child car seats (24). The proportion of injuries from sports matched those found elsewhere at 12% (10,25). Sport injuries start to increase from around five years of age when children start participating in organized sports (9). Sport injuries peaked at 10 – 14 years of age. Majority, at 62% were secondary to contact sports like soccer and rugby.

We established a unique mechanism of injury in our study. This involved an object or person accidentally falling on the patient and causing a fracture. This mechanism of injury contributed 10% of the fractures, majority involving the upper limb (75%). These can be reduced by proper selection of toys and culturing safe play habits.

Open fractures constituted 4% of the fractures and involved mainly the tibia. The subcutaneous nature of the tibia can explain this. This is comparable to available data from other places (9,20). All these fractures were from high-energy events i.e. road traffic accidents. This low prevalence is in keeping with the patho- anatomy of paediatric fractures (26). Twelve percent of fractures were comminuted and involved the lower limb secondary to high-energy events.

Hedstromet *et al* (27) found 14.8% of fractures in children in Switzerland involved the physis. This is comparable to 12% that we established in our study. Of this, 64% involved the distal radial physis and 21% involved the distal femoral physis.

LIMITATIONS

Our study had several limitations. We had no single case of fractures secondary to child abuse. We relied on the information provided by guardians or parents and this could have made it difficult to identify such cases. The duration of the study also was not long enough to determine the effects of changes in climatic seasons and school/holiday seasons on fractures. In future, a study can be designed to overcome these limitations.

CONCLUSIONS

(i) The paediatric long bone fractures show a bimodal type of distribution (peaks at 4 – 6 years and 12 – 14 years).

(ii) Falls (56%) are the common mechanism of injury in paediatric long bone fractures. Fractures secondary to RTAs (21%) in the study sample are higher than those in other studies.

(iii) Majority of paediatric long bone fractures happen in the home and its surroundings (56%).

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