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Original article

Firearm injuries among children due to the Kivu conflict from 2017 to 2020: A hospital-based retrospective descriptive cohort study

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ABSTRACT

Introduction: Firearm-related injuries are deadly but avoidable. The case of Kivu, a region in the Eastern Democratic Republic of Congo (DRC), is alarming. Decades of unresolved regional conflicts birthed armed groups that have massacred inhabitants and injured several children. This regional instability has also created barriers to seeking and obtaining timely care, decreasing the survival rate. This region's lack of data on paediatric fatal and nonfatal firearm injuries (F&NFFIs) needs studying. Thus, we aim to determine the prevalence and evaluate the outcomes of paediatric F&NFFIs in Kivu.

Methods: We included all F&NFFI paediatric patients (≤18 years), admitted at our institution between 2017 and 2020. We extracted data from patient records. Next, we assessed the relationship between determinants of paediatric outcomes using the Chi-square test and the student's *t*-test. Confounders were identified using cox regression.

Results: This study included 101 paediatric patients, mostly male (63.4%), with an average age of 15.9 years residing 164.4 km on average from the hospital. On average, they were admitted 2.9 days post-injury, with the most affected anatomical regions being lower limbs (53.5%) and upper limbs (18.8%). The mean length of stay was 52.9 days, and the mortality rate was 4.0%. Also, injury complications increased the mean length of stay and mortality rate. In addition, mortality was correlated with circulatory failure and anaemia.

Discussion: Paediatric F&NFFIs in Eastern DRC is a preventable tragedy. Mortality is increased by injury complications and correlates with some biological factors. Prevention strategies should be developed to protect children and appropriate measures should be established to improve rates of prehospital care and early hospital presentation to lower mortality and improve paediatric outcomes.

African relevance

- The twenty year old Kivu conflict opposes the Congolese government to rebel forces.
- Children have suffered disproportionately from the war as child soldiers and civilians.
- We found the burden of firearm injuries among children during the Kivu conflict is unacceptably high.

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Introduction

The Eastern Democratic Republic of Congo (DRC) has been plagued by armed conflict for more than two decades. This conflict, dubbed the Kivu conflict because it involves the North and South Kivu regions, is fuelled by avarice for precious minerals, including coltan and gold [1,2]. The Kivu conflict's toll keeps rising despite interventions by the international community. As of June 2021, the conflict has led to the death of around 12,000 people and is estimated to have caused hundreds of thousands of excess deaths indirectly [1]. The excess indirect deaths result from internal migration, Ebola viral disease epidemics, and destruction of the social fabric that increases barriers to safe, timely, and affordable healthcare [1,3,4]. The DRC's emergency medicine system remains underdeveloped and unable to handle the enormous burden of emergency medicine diseases it is faced with. For example, emergency medicine has not yet been established as a specialty, and there is no organised national or provincial emergency medical service [5].

Like most conflicts, the weapon of choice in the Kivu conflict is firearms [1,6]. Firearm injuries cause significant morbidity and mortality worldwide. In some high-income countries, firearms kill as many people as cancer does, are five times as deadly as cardiovascular diseases, and are responsible for 15 times more deaths than infectious diseases [7]. Low- and middle-income countries (LMICs) have higher incidences of firearm injury fatalities, and armed conflicts are responsible for increasing rates of fatal and nonfatal firearm injuries (F&NFFIs) in these regions [8,9]. In Africa, almost three-quarters of combat-related injuries are firearm-related, and civilians' and children's involvement further complicates the situation [6,8,10]. F&NFFIs are the second leading cause of children's death in the United States, accounting for 15% of deaths [7]. Up to 59% are homicides, 35% are suicides, and 4% are unintentional injuries [7]. Children have suffered significantly in the DRC's armed conflicts both as civilians and as combatants. It is estimated that children aged 8 to 16 make up more than 60% of combatants in the Eastern DRC, some as young as six years old [11]. This situation is a violation of human rights and a public health, social, and economic emergency.

A preliminary literature search revealed no one had studied the epidemiology and outcomes of conflict-related firearm injuries in the Kivu regions. This study aimed to quantify the burden of F&NFFIs in the Eastern DRC and identify predictors of mortality. Understanding the nature, characteristics, and survival patterns of firearm injuries among children is important to guide the management of F&NFFIs among children, provide data for the protection of children in conflict areas, and advocate for a peaceful resolution of the conflict.

Methods

This retrospective descriptive cohort study is reported per the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE Statement) guidelines [12].

The ethics committee of the first author's institution authorised this study. Consent was obtained from the children's parents or legal guardians. In addition, the children's assent was sought when appropriate. All de-identified patient data were stored in a password-protected Excel spreadsheet to which no one but the authors had access.

All patients ≤18 years presenting at the authors' institution with F&NFFI between January 2017 and December 2020 were included in the study. All patients whose injuries were not linked to the Kivu conflict were excluded. For example, gang assault and robbery-related F&NFFIs were excluded.

Sociodemographic, clinical, and therapeutic data were extracted from patient records.

Summary descriptive statistics were computed, the Chi-square test and Student's *t*-test were used to assess the relationship between outcome variables (i.e., mortality and complication rates) and sociodemographic and clinical data. Also, the Cox regression was used to identify confounders, and a cumulative hazard curve was plotted to illustrate the risk faced by the patients during their hospitalization.

Results

101 patients aged 15.9 (95% CI [15.0, 16.8]) years on average were admitted at our institution from 2017 to 2020, and 36 (35.6%) were admitted in 2019. Almost two-thirds were male (63.4%), and the lower limbs were the most injured body part. At admission, the children had a mean heart rate (HR) of 89.5 (95% CI [84.2, 94.7]) bpm, respiratory rate (RR) of 21.5 (95% CI [20.4, 22.6]) cpm, systolic blood pressure (SBP) of 115.5 (95% CI [111.7, 119.4]) mmHg, diastolic blood pressure (DBP) of 70.3 (95% CI [66.1, 74.5]) mmHg, and body temperature of 36.7 (95% CI [36.5, 36.9]) ^{o}C. The mean oxygen saturation (SaO_2) was 96.3 (95% CI [95.0, 97.6]) % and haemoglobin (Hb) concentration was 11.2 (95% CI [10.6, 11.9]) g/dl. The mean shock index (SI) was 0.83 (95% CI [0.77, 0.88]).

47 children (46.5%) sustained open fractures (Table 1). The most commonly fractured bones were the femur (12.9%, 95% CI [3.3%, 22.5%]), tibia (7.9%, 95% [0.2%, 15.6%]), and ulna (5.0%, 95% CI [−1.3%, 11.2%]) (Fig. 1). Most patients had vascular injuries (n = 65, 64.4%) and 17 (16.8%) had Gustillo IIIb fractures. Vascular (OR = 2.33, 95% CI [1.00, 5.45], P = 0.48) and nerve (OR = 3.50, 95% CI [1.53, 7.99], P = 0.02) injuries were more common among patients with fractured bones. Also, 27 (23.8%) had lesions to more than one system (Table 1). The mean composite Revised Trauma Score (RTS) was 11.8 (95% CI [11.7, 12.0]).

On average, the children lived 164.4 (95% CI [114.8, 214.0]) km away from the hospital, and they were admitted 2.9 (95% CI [1.2, 4.6]) days post-injury.

Twenty-five patients (24.8%) presented a complication during their hospital stay including infection (n = 23, 22.8%), malunion (n = 4, 4.0%), anaemia (n = 2, 2.0%), haemothorax (n = 2, 2.0%), hemoperitoneum (n = 1, 1.0%), and pneumothorax (n = 1, 1.0%). Of note, the patients with malunion presented late at our facility and had received care from traditional healers. Also, twelve patients (11.9%) with infections had an open fracture. The mean length of stay was 52.9 (95% CI [39.8, 66.0]) days and patients who had sustained complications stayed

Table 1
Sociodemographic characteristics of Congolese children who sustained gunshot injuries.

Characteristics	Frequency (percentage)
Sex	
Male	64 (63.4)
Female	37 (36.6)
Year	
2017	24 (23.8)
2018	21 (20.8)
2019	36 (35.6)
2020	20 (19.8)
Injured body part	
Lower limb	54 (53.5)
Upper limb	19 (18.8)
Abdomen	10 (9.9)
Thorax	9 (8.9)
Central nervous system	6 (5.9)
Maxillo-facial	2 (2.0)
Pelvis	1 (1.0)
Open fracture	47 (46.5)
Gustillo I	3 (3.0)
Gustillo II	9 (8.9)
Gustillo IIIa	10 (9.9)
Gustillo IIIb	17 (16.8)
Gustillo IIIc	8 (7.9)
Vascular lesion	65 (64.4)
Nerve lesion	44 (43.6)
Lesions to other systems	27 (23.8)

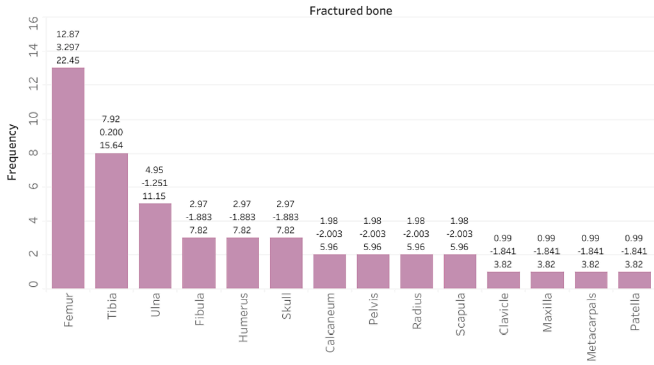

Fig. 1. Most common fractured bones in Congolese children suffering gunshot injuries. The top number is the percentage, the middle number is the lower limit of the 95% confidence interval, and the bottom number is the upper limit of the 95% confidence interval.

longer in the hospital (73.2 days vs. 46.3 days, P = 0.01).

Four patients (4.0%) died: three among the children who had experienced complications and one among those who had not experienced complications (OR = 9.1, 95% CI [0.91, 91.9], P = 0.06). The children who died had longer lengths of stay (P = 0.02), lower HR (P = 0.01), and lower haemoglobin values (P = 0.02). HR (β = −0.02, SE = 0.01, P = 0.003) and haemoglobin (β = 0.13, SE = 0.05, P = 0.01) were statistically significant explanatory variables in the Cox regression. In Fig. 2, we can see that the hazard experienced by Congolese paediatric F&NFFI patients increased over time.

Discussion

In this study, we evaluated the outcomes of paediatric F&NFFIs in the Eastern DRC, an area plagued by armed conflict. Most patients were male teenagers, and they often sustained F&NFFIs to their limbs. The children travelled about 160 km to reach our facility, and they presented almost three days after the injury. They had sustained mild trauma, most had a shock index suggestive of haemorrhagic shock at admission, and one-in-four experienced an infectious complication. Patients were hospitalised for more than two months on average, and complications often prolonged the hospitalisation. Also, these complications increased the mortality risk considerably. The mortality rate was low; however, it was correlated with circulatory failure and anaemia.

Most children sustained injuries to their limbs, and the mortality rate was relatively low. Hussain et al. [8] found similar results in North-East Nigeria, where 77.5% of injuries were sustained on upper and lower extremities. In their study, the mortality rate was 0.3%, and the mean length of stay was ten days [8]. On the other hand, our patients were hospitalised for 52.9 days, and the mortality rate was 4.0%.

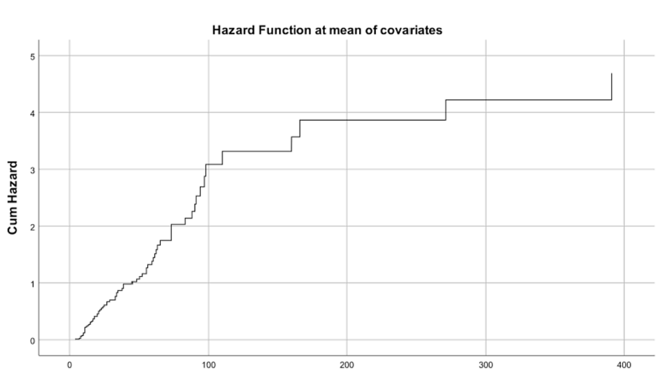

Fig. 2. Cumulative hazard plot of Congolese children who sustained gunshot injuries.

Almost all complications were infections. The high infection rate in our cohort can be explained by the high proportion of open fractures and the long injury-to-admission delay. Almost half of the children had open fractures, and the majority arrived more than 24 h after their injury. The diagnosis of fracture-related infections is made based on two sets of criteria: confirmatory and suggestive [13]. The confirmatory criteria of fracture-related infections include wound breakdown, presence of pus, or creation of a sinus tract. In contrast, the suggestive criteria include local and systemic signs, imaging signs, new-onset joint effusion, biological signs, and persistent wound drainage [13]. Fracture-related infections cause excess morbidity and mortality in trauma patients [14]. As such, preventive measures should be taken to reduce their prevalence. Early surgical management of open fractures reduces the infection rate. Surgical debridement within six hours of the injury is the widely accepted standard [15]. However, treatment by an experienced surgical team within 24 h and in the absence of aggravating injuries (ex: gross contamination, vascular injury, compartment syndrome, and concomitant injuries to multiple systems) equally yields satisfactory results [16]. Prophylactic antibiotic therapy reduces infection rates [16]. Broad-spectrum antibiotics are sufficient in Gustilo-Anderson type I and II; however, antibiotics covering gram-negative bacteria are recommended in Gustilo-Anderson type III fractures [16]. Other factors regularly cited as determinants of infection are the length (i.e., <72 h vs. >72 h) and mode of administration (i.e., intravenous vs. oral). However, recent research suggests that they do not impact the infection rates [17]. In this study, the patients were referred to our facility from the field with limited data on their prehospital management. As such, it is not possible to comment on the quality of prehospital care. For this reason, all F&NFFI patients admitted to our facility received broad-spectrum antibiotics and debridement as soon as possible.

Despite this protocol, twelve children with open fractures developed an infection. When a fracture-related infection develops, the surgical team must debride the wound, administer antibiotics, and propose surgical treatment [18]. The primary aims of surgery in fracture-related infections are “consolidation, eradication of the infection, healing of the soft tissue envelope, restoration of function, and prevention of chronic infection.” [19] The surgical team must decide whether to keep, exchange, or remove the surgical implant. The implant can be removed if the fracture has healed; however, if the fracture has not healed, the team must consider changing the implant, especially if “the implant and fracture are unstable, reduction is not acceptable, or in severely compromised cases with poor host physiology.” [18]

The majority of our patients were aged 15–17 years, and most were male. These sociodemographic characteristics are similar to those described in the United States [20–22]. The incidence remained relatively stable from 2017 to 2020, and the mortality rate was 4.0%. Thus, the mortality rate was lower than previously published mortality rates [20,21,23]. The lower mortality rate in our patient cohort can be explained by the higher RTS.

The increase in cumulative hazard over time might be due to the difference in the risk between patients who experienced complications (high-risk) and those who did not (low-risk). High-risk individuals were more likely to die and stayed almost four weeks longer at the hospital. As a result, the cumulative hazard plot reflects that low-risk individuals were discharged earlier than high-risk individuals.

More than 251,000 people die each year from F&NFFIs worldwide, and most deaths are recorded in LMICs [10]. F&NFFI research remains sparse, especially in the civilian population and in LMICs [24,25]. F&NFFI researchers face more barriers than their counterparts in other injury-related specialties. For example, F&NFFI researchers often face personal threats and barriers to career advancement related to the political sensitivity of their work [25]. In addition, African researchers face multiple barriers related to a lack of funding and institutional support [26]. For the most part, African countries face competing priorities and focus on communicable diseases that affect pregnant women and children. Of note, the COVID-19 pandemic has exacerbated this prioritization [26–28].

We recognise multiple limitations to our study. The major limitation of this study is that we lack data on the injury patterns of patients who did not make it to our facility. It is plausible that patients with more severe injuries died on the injury site or on their way to our facility. Next, many prehospital factors could explain the unacceptably high complication rates. For example, it is unclear what proportion of patients with open fractures received prophylactic antibiotics and debridement before their referral. Also, it is unclear how soon they got this treatment. This limitation highlights the need for research on the landscape of prehospital F&NFFIs in Eastern DRC, patient pathways, and barriers to seeking and reaching specialised emergency care. In addition, our study was retrospective and inherently prone to certain biases. We are currently designing a prospective study and data collection system to study the predictors of mortality further.

Notwithstanding the limitations mentioned above, this study expands the literature by providing novel data on the nature and characteristics of F&NFFIs among children of the Eastern DRC, an underrepresented group in emergency medicine and trauma research.

In this study, we quantified the prevalence of paediatric F&NFFIs in Eastern DRC and identified the determinants of paediatric outcomes. The management of F&NFFI was delayed, and a significant proportion of patients had a complication. Additionally, complications increased the length of stay and increased the mortality rate. These findings highlight the nefarious impact of the conflict on children in the Eastern DRC. The United Nations Organization Stabilization Mission in the Democratic Republic of the Congo and belligerent parties should protect children from injury. Also, these stakeholders should develop strategies to reduce the burden of paediatric F&NFFIs by investing in health systems to reduce the barriers to timely and safe trauma care.

Dissemination of results

Results from this study were shared with staff members at the data collection site during an internal conference.

Authorship contribution statement

Authors contributed as follow to the conception or design of the work; the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content: RBM, PMB, and USK contributed 20% each; and TNT, GKT, FCG, PMS, LEMM, GMB, DCB, and AM contributed 5% each. All authors approved the version to be published and agreed to be accountable for all aspects of the work.

Declaration of competing interest

The authors declare no conflicts of interest.

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