PATTERNS AND EARLY OUTCOMES OF FIREARM-RELATED MUSCULOSKELETAL INJURIES IN PATIENTS PRESENTING AT KENYATTA NATIONAL HOSPITAL

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A Dissertation Submitted for Examination in Partial Fulfilment of the Requirements for Award of the Degree of Master of Medicine (M.Med) in Orthopaedic Surgery of the University of Nairobi.

2018

DECLARATION

I hereby declare that this dissertation is my original work and has not been presented elsewhere for examination or award of a degree. Where other people's work or my own work has been used, this has properly been acknowledged and referenced in accordance with the University of Nairobi's requirements.

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DECLARATION OF ORIGINALITY FORM

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Title of the work: PATTERNS AND EARLY OUTCOMES OF FIREARM-RELATED MUSCULOSKETETAL INJURIES IN PATIENTS PRESENTING AT KENYATTA NATIONAL HOSPITAL

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1. I understand what Plagiarism is and I am aware of the University's policy in this regard

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DEDICATION

This study is dedicated to my wife Asha and my children Abdallah and Humeyyraa for their unconditional love and support during this study period. My sister Hadijah and my mother for being available during my long absence in pursue of academic excellence. Lastly to Dr. Gakuya for his mentorship and introducing me to the practise of Orthopaedic surgery.

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LIST OF ABBREVIATIONS

AO-	Arbeitsgemeinschaft für Osteosynthesefragen
ERC-	Ethics and Research Committee
Exo-fix -	External fixator
FA-	Fire Arm
FAI-	Fire Arm Injuries
Fps-	Feet per second
G-A-	Gustilo-Anderson
IM-	Intramedullary
J-	Joules
KNH-	Kenyatta National Hospital
KE-	Kinetic Energy
K-wires-	Kirschner wires
M/s-	Meters per second
NPWT-	Negative Pressure Wound Therapy
ORIF-	Open Reduction and Internal Fixation
SPSS-	Statistical Package for the Social Sciences
UON-	University of Nairobi
UN-	United Nations

ABSTRACT

Background: The incidence of firearm injuries is increasing throughout the world and Kenya is no exception. Circumstances of firearm injuries include armed robbery, police encounter, political violence and cattle rustling. Patients are usually managed with antibiotics, debridement, and external fixation acutely and definitively by open reduction and internal fixation. The most common complications of such injuries are infections and delayed union.

Objectives: To determine the patterns and early outcomes of firearm-related musculoskeletal injuries in patients presenting at Kenyatta National Hospital.

Study design: Cross-sectional study.

Study setting: This study was carried out in Kenyatta National Hospital Accident and Emergency department, operating theatres, Orthopaedic wards, Orthopaedic clinic and the General Surgical wards.

Methodology: This was a cross-sectional study done for a period of six months between April and September, 2018. Fifty six patients of all age groups with firearm injuries were recruited after obtaining informed consent. Patients' bio-data information was obtained, history taken and physical examination performed. The injuries were examined and classified using the Gustilo-Anderson classification. Patients were started on tetanus prophylaxis and antibiotics then managed either non-operatively or operatively with debridement and or external fixation in operating theatre. After initial management on the second day and the second week, patients' wounds were re-examined to asses for the presence or absence of infection. On the third month plain radiographs were obtained from patients with fractures to asses for delayed union. All information obtained was recorded in the questionnaire.

Data analysis: Qualitative and quantitative data were collected from respondents using a questionairre. The raw data were recorded in excel sheet then transferred for analysis using SPSS version 23. For categorical factors, comparisons were done using Chi square tests. Conversely, for continuous independent variables comparison of means was conducted using Student's t-test between the group experiencing early outcomes and those not experiencing the outcomes. Data was presented in form of tables, charts and graphs for better understanding and inferences deduced.

Results: In this study, armed robbery was the most common circumstance leading to firearm injury (52%) followed by police encounter (25%). Young people aged between 21 and 30 years (48.2%) and particularly males (89.3%) were injured due to firearms. Most of the injuries occurred in Nairobi County (69.4%), mainly in low socioeconomic regions such as Embakasi and Dagoretti. This study also found that most patients sustained firearm injuries between 6 p.m and midnight (60.7%). The common fractured bones were femur (33.3%) and ulna (23.3%). Most patients were managed operatively (92.9%). Infection rates were 12.5 % and 32.2% on the second day and second week respectively. At three months follow-up 16.7% of patients with fractures had delayed union.

Conclusions: Young males are mostly affected and the most common circumstances leading to firearm injuries were armed robbery and police encounter. Patients were mostly managed operatively. Infections and delayed union are some of the complications due to firearm injuries.

Recommendations: Kenyatta national hospital should have protocols for management of firearm injured patients in order to reduce morbidity and mortality.

1.0 CHAPTER ONE: INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

The incidence of firearm injuries (FAI) among civilian population is increasing worldwide and Kenya in particular (1,2). Due to political instability and long history of conflicts amongst Kenya's neighbouring countries, illegal trade of firearms have proliferated on its borders leading to increased availability of firearms in the country (2). The circumstances of FAI in developed countries are mainly due to suicide and homicide, whereas the causes of FAI in Kenya and most developing countries include armed robbery, political violence, police encounter, cattle rustling, insurgent groups, intimate partner violence, accidental discharge and rarely suicidal attempts (2,3). Firearm injuries affects mainly males in the age group of 21-30 years (46.5%) followed by those 31-40 years (30.3%) and are mostly caused by low-velocity weapons (4).

Unlike high velocity gunshot wounds which are extremely contaminated, most low velocity bullet wounds are less contaminated and thus can be managed by local wound care and prophylactic antibiotics (5). Most firearm injuries affect the extremities and Orthopaedic surgeons are amongst the first clinicians to encounter and manage these patients in casualty department (6). Orthopaedic surgeons and other healthcare providers should have basic knowledge of wound ballistics in order to adequately manage FAI.

1.2 Wound Ballistics

Wound ballistics is the science of study of the wounding mechanisms of bullets penetrating tissues and its effects on the body (7). Generally, bullet wounds are categorized as either low or high velocity. Low velocity wounds have projectiles with muzzle velocities of less than 350m/s and are caused mainly by handguns and shotguns, whereas high velocity wounds have projectiles with muzzle velocities above 350m/s and are due to hunting and military weapons. High velocity wounds cause extensive tissue damage and are more contaminated compared to low velocity wounds (5).

Although, bullet wounds are commonly classified as "Low velocity" and "High velocity", the most appropriate classification is based on the energy causing them: High energy (>1000J), Medium energy (250-1000J) and Low energy (<250J). This classification based on energy is comparable to Gustilo-Anderson Classification (G-A) of open fractures whereby low and medium energy wounds are equivalent to G-A type I and II ,whereas high energy are comparable to G-A type III injuries (5,8).

Tissue damage is directly proportional to the kinetic energy as per the formula below;

$$\mathbf{KE = KE = \frac{MV2}{2}}$$

KE = Kinetic Energy, **M**= Mass, **V**= Velocity

Tissue injuries occur by the following mechanisms; i) **Crushing-**main mechanism of tissue injury in low velocity weapons. As the bullet advances it crushes tissues on its path forming a permanent cavity. A bullet hitting a target at 0 degrees yaw crushes tissues equal to the diameter of the bullet, unlike a bullet hitting a target at 90 degrees yaw which can cause damage up to 3 times its diameter and thus cause severe tissue damage (7). ii) **Shock waves-** mechanism of tissue damage in high velocity weapons. Tissues away from the path of the bullet are compressed and damaged in a shock wave pattern. Due to this mechanism nerve injury can occur without necessarily being transected by the bullet (1). iii) **Temporary cavitation-** primary mechanism in high velocity weapons causing extensive tissue damage. After hitting a target a bullet deforms and yaws to 90 degrees, crushing tissues maximally and creating a cavity. This cavity has a negative pressure and thus sucks in debris, bacteria and air leading to wound contamination. If the bullets path is short, it will exit at a point of temporary cavity formation thus forming a large exit wound (1,6).

1.3 Epidemiology

Hugenberg *et al.,* (2006) in a retrospective study of 120 patients with FAI admitted at KNH between January and June 2006, reported that the circumstances that led to the injuries were; armed robbery 94 patients (85.5%), police encounter 6 patients (5.5%), stray bullets 5 patients (4.5%), and shot under unclear circumstances 4 patients (3.6%). Male to female ratio was 10:1(2).

Saidi *et al.*, (2002) in his study of 107 patients with gunshot injuries at Aga Khan Hospital between 1993 and 1998 found male to female ratio was also 10:1 and the causes were armed robbery (74.7%), police encounter (9.4%) and stray bullets (3.8%) (1).

The United States reported 32,288 firearm related deaths in 2012, 69.6% of all homicides and 50.9% of all suicides were caused by firearms. It was also reported that between 2002 and 2012, 82.2 deaths occurred daily due to firearm injuries (9).

1.4 Classification

For many years there had been a challenge due to lack of a good classification system for open fractures. Several classification systems have been developed including: i) Ganga hospital open injury severity score-this is an important classification system as it gives guidance towards limb salvage, its shortcoming is that it is limited to type IIIB fractures(10). (10).ii) Muller-AO classification system-is a comprehensive classification system though its memorability, intra-obsever and inter-observer reliability has been questioned. iii) Hannover fracture scale-is a reliable classification system in regards to limb salvage-its main shortcomings is that it has poor inter-observer correlation (11). iv) The Red Cross Wound Classification-mainly developed for wounds sustained during armed conflicts due to mainly high velocity weapons (12).

v) Gustilo-Anderson classification-in 1976, Gustilo and Anderson eventually developed a classification system that became universally accepted to Orthopaedic surgeons. They divided open fractures into types I, II and III (13).

Gustilo *et al.,* (1984) sub-classified group III fractures into III_A, III_B,III_C due to increasing intensity of soft tissue injury and presence of vascular injury (14).

Type I are due to low velocity injuries, size of the wound is less than 1cm; it is usually caused by inside-out mechanism with minimal soft tissue comminution.

Type II the wound size is more than 1cm, there is moderate soft tissue damage; it is also due to low velocity injuries.

Type III injuries are mainly due to high velocity injuries with extensive soft tissue damage and wound size more than 10cm.

Type IIIA there is extensive soft tissue damage but bone coverage can be achieved primarily.

Type IIIB injuries there is extensive soft tissue damage with exposed bone and periosteal stripping. Bone coverage cannot be achieved primarily and thus the need of coverage using either a graft or a flap.

Type IIIC injuries there is extensive soft tissue damage associated with a vascular injury (8,13,14).

1.5 Injury patterns/ regions of the body injured

Saidi *et al.,* (2002) noted that the most commonly affected body region was the upper limbs in 31 patients (26.3%), lower limbs in 29 patients (24.6%) and spine 3 patients (2.5%). Police officers and armed robbers primarily targeted the upper half of the body in the majority of the cases reported (1).

Oboirien *et al*., (2016) reported that the lower extremity was most commonly involved representing 37.2%, followed by the upper extremity in 25.6%, head and neck in 9.3% and pelvis in 2.3% of the cases (4).

1.6 Time of injury

Omoke *et al*., (2017) noted that the peak period when most FAI occurred on the roads were between 6:00 p.m to 11:59 p.m. and in the homes were between midnight to 05:59 a.m. and they attributed this to peoples lifestyles as most people are heading and retiring to their homes (3).

1.7 Retained bullet and bullet fragments

Retained bullets and bullet fragments to the spine can be managed conservatively, due to high complication rates associated with operative management. Indications for removal of bullets in the spine includes; worsening neurologic deficit, presence of cerebrospinal fluid fistula, spinal instability and bullet lodged within the spinal canal with risk of migration and toxicity (15).

Indications for removal of bullets in the extremities includes; bullets within the articular surface, associated neurovascular injury and bullets in the hands and feet (16).

1.8 Use of Antibiotics

Cochrane review in 2004 analysed data of 1106 patients with limb fractures and concluded that prophylactic antibiotics reduced infection rates by 59%. The authors recommended that antibiotics should be used in addition to the standard principles of surgical wound management (17).

1.9 Management

The principles of management of open fractures includes wound irrigation, tetanus prophylaxis, early debridement, prophylactic antibiotics and stabilization of fractures (casting, Kirschner wires, external fixation, plating and intramedullary nailing). External fixators provides adequate stabilization of fractures while providing optimum infection control (18).

Bach *et al*., (1989) in their study comparing plates to external fixators concluded that though both methods provided good results, external fixators should be considered primarily for stabilization of G-A type II and III fractures (19).

Marinovic *et al*., (2013) reported on the role of negative pressure wound therapy (NPWT) in the management of open fractures due to firearms. In their study after 1 month of NPWT changed every 4 days, adequate granulation tissue had formed and split thickness skin grafting was done (20).

Penn-Barwell *et al*., (2015) reported that soft tissue reconstruction following firearm injuries is by delayed primary closure, healing by secondary intention, skin grafting and flaps (free or local muscle flaps). Regardless of how uncontaminated the wounds appear primary closure should not be attempted in the first encounter (6).

Swiontkowsky *et al*., (2008) noted that wound coverage can safely be achieved by primary closure within 48-72 hours (21).

1.10 Early outcome

Determining the presence of wound infection has been a challenge to surgeons for a long time. Several definitions of wound infections have been described including:

i) United States Centers for Disease Control and Prevention (CDC).

ii) The English Nosocomial Infection National Surveillance Scheme (NINSS).

iii) Asepsis Wound Scoring System (AWSS).

The CDC definitions for surgical site infection surveillance will be adopted for this study to ascertain the presence or absence of infection on the second day and on the second week after surgical debridement. The parameters to check include; 1) Purulent discharge. 2) At least one of the following signs and symptoms of infection; pain or tenderness, localized swelling and redness. 3) Diagnosis of infection made by the surgeon (22).

Riehl *et al*., (2015) reported that the presence of bullets and bullet fragments more than 20% of the cortical width had increased rates of delayed union probably due to the local effect of lead toxicity on fracture healing. Patients with fractures will be reviewed on the third month with plain radiographs to assess for delayed union (23).

1.11 Study Justification

Firearm injuries among civilian population are increasing in Kenya. There are few studies done on injuries sustained as a result of firearms, but there are no studies done on patterns and early outcomes of firearm related musculoskeletal injuries. Patients usually present late to hospital after sustaining firearm injuries leading to increased complications, this could be partially due to inadequate transport system. The information obtained will hopefully help focus on the management and establishment of protocols in the management of firearm injuries.

1.12 Objectives of the study:

1.12.1 Main objective

To determine the patterns and early outcomes of firearm-related musculoskeletal injuries in patients presenting at KNH.

1.12.2 Specific objectives

a To determine the patterns of musculoskeletal injuries (place, time, circumstance, and region of the body injured).

b To determine the management (Operative versus Non-operative).

c To determine the early outcomes (Infection and Delayed union).

2.0 CHAPTER TWO: MATERIALS AND METHODS

2.1 Study Design

A cross-sectional study.

2.2 Study Setting

Kenyatta National Hospital, located in Nairobi, the capital and the largest city in Kenya. It is a public, tertiary and the largest referral and teaching hospital in Kenya. It is the teaching hospital for the University of Nairobi, College of Health Sciences.

2.3 Study Population

All age groups patients with firearm injuries to the extremities, pelvis and the spine who presented at Accident and Emergency department and admitted to the Orthopaedic and General Surgical wards were recruited to the study.

2.3.1 Inclusion Criteria

All patients with FAI to the extremities (upper and lower limbs), spine and spine and pelvis with either bone and or soft tissue involvement.

2.3.2 Exclusion Criteria

Patients with FAI to the abdomen, thorax and the skull and not extending to the pelvis, extremities and spine. Eligible patients who didn't give consent for the study, were not to be included.

2.4 Study Period

April to September 2018.

2.5 Sample Size

Sample size calculation for proportions (Woolson, 1987)

$$n = \frac{Z^2 a/2[P(1-P)]}{d^2}$$

Where: Z^2a/2 is critical value for 95% confidence interval = 1.96

P is the estimated proportion of patients with gunshot wound undergoing orthopaedic operation = 50% (estimated proportion is unknown thus 50% proportion is recommended)

d is the level of precision = 10%

n is the number of patients required

$$n = \frac{1.96^2[0.5\ (1 - 0.5)]}{0.10^2}$$

n = 96 patients

The final sample size was calculated by applying Finite Population Correction (FPC) to

N = 90 (estimated minimal number of target population seen is approximately 10 patients per month (90 patients for 9 months) according to Kenyatta National Hospitals registry book)

$$n = \frac{n}{1 + n/N}$$

n = **56 patients**

3.0 CHAPTER THREE: DATA COLLECTION AND ANALYSIS

The questionnaire provided was used to collect data. The data was verified by the principal investigator by cross checking with the hard copy to ensure completeness, consistency and accuracy. The operating surgeon provided information on intra-operative findings related to the study e.g. presence of neurovascular and visceral injury. The parameters in CDC definitions of surgical site infection were used to assess the presence or absence of infection. Radiographs were obtained on the third month to assess for delayed union. Data such as age, sex, time of injury and circumstances of injury were presented using mean, median and standard deviation. Obtained data were presented using pie-charts, tables and graphs after analysis using SPSS.

3.1 Ethical Considerations

Approval to carry out the study was sought and granted from Kenyatta National Hospital as well as the Department of Orthopaedic Surgery University of Nairobi, Ethics and Research committee (KNH/UON-ERC). All information obtained from the participant or the guardian were used with utmost confidentiality. Participants' names were not used in the study, they were allocated a serial number linking them to their bio-data. Patients phone number was used solely for follow-up of outcomes, all these information was accessible to the principle investigator alone.

Patients' participation to the study was voluntary and they were at will to withdraw at any stage of the study. This didn't prejudice the medical care they received from KNH.

3.2 Study limitations

It was not possible to assess the type of weapon causing the firearm injuries. Inability to include patients who died before arrival to the hospital. Unconscious patients with FAI admitted to intensive care unit. Inability to trace some patients at three months follow-up due to incorrect contacts given.

3.3 Data Analysis

The data was analyzed using SPSS, version 23. Descriptive analysis was conducted to summarize the patterns, management, and early outcomes of musculoskeletal injuries. Univariable analysis involving calculating means and standard deviation for continuous variables was done at this stage. To correlate for example, the socio demographic factors and early outcomes of musculoskeletal injuries cross tabulations was conducted. For categorical factors, comparison was done using Chi square tests. Conversely, for continuous independent

variables comparison of means was conducted using Student's t-test between the group experiencing early outcomes and those not experiencing the outcomes. In addition, the outcomes were correlated with management correlating relative risk with 95% confidence interval and Chi-squared values. Significant differences and associations were determined by P values of less than 0.05.

4.0 CHAPTER FOUR: RESULTS

Table 4.1: Age of injured patients

	Frequency	Percent
<10	1	1.8
10-19	6	10.7
20-29	27	48.2
30-39	13	23.2
≥40	9	16.1
Total	**56**	**100**

Mean Age (SD) = 29.04 (9.16)

Table 4.2: Gender of injured patients

	Frequency	Percent
Male	50	89.3
Female	6	10.7
Total	**56**	**100**

Table 4.3: Response by counties

Counties	Frequency	Percent
Nairobi	39	69.4
Samburu	3	5.4
Kajiado	2	3.6
Mandera	3	5.4
Machakos	2	3.6
Kiambu	2	3.6
Isiolo	2	3.6
Marsabit	1	1.8
Garissa	1	1.8
Nyeri	1	1.8
Total	**56**	**100**

Figure 4.1: Response by constituency of injured patients in Nairobi

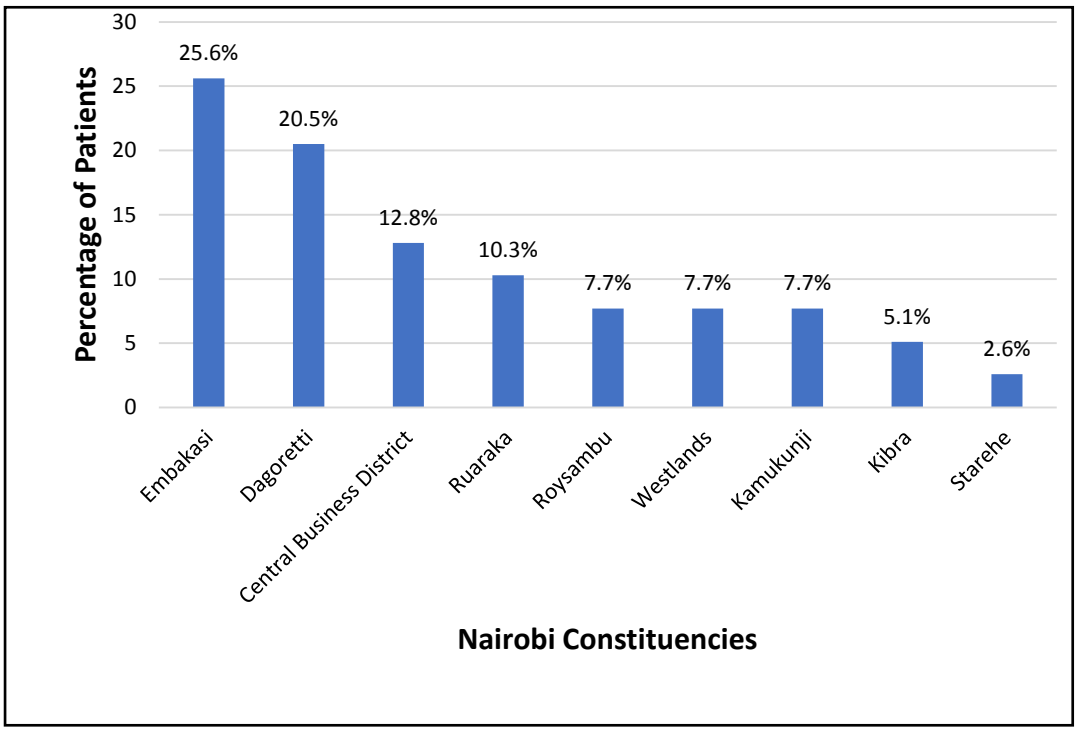

Table 4.4: Time of the Injury

	Frequency	Percent
06:00-11:59 hours	8	14.3
12:00-17:59 hours	8	14.3
18:00-23:59 hours	34	60.7
00:00-5:59 hours	6	10.7
Total	**56**	**100**

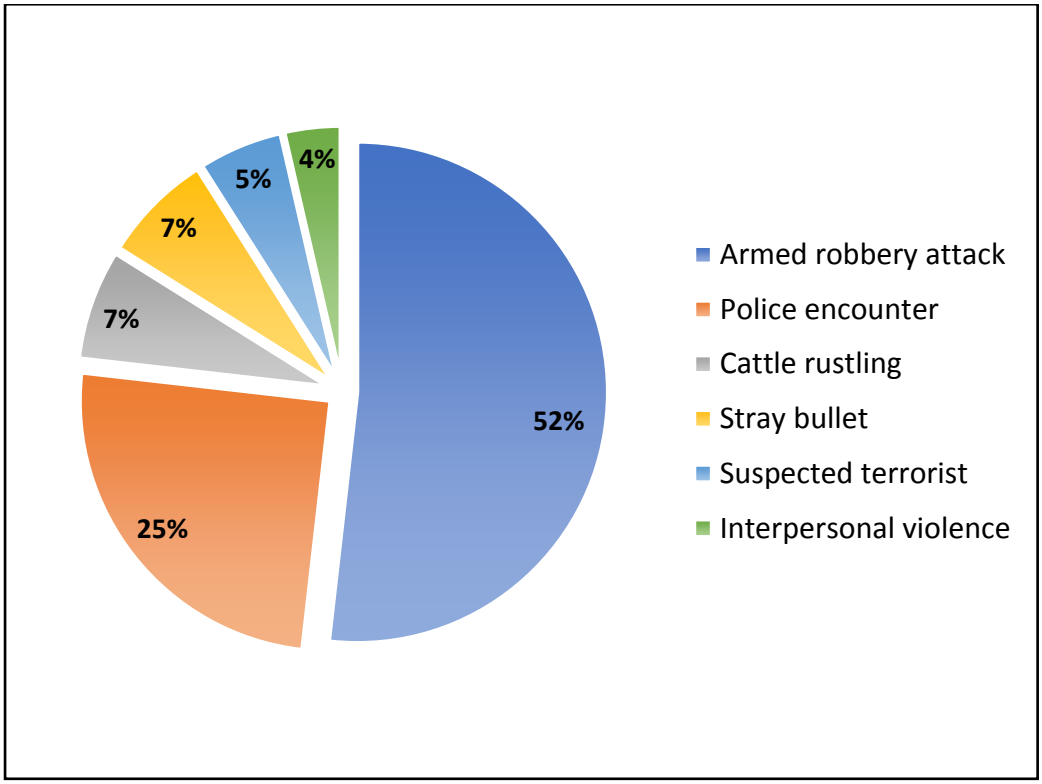

Figure 4.2: Circumstances of Firearm Injury

Table 4.5: Region of the lower limb injured

	Frequency	Percent
Thigh	26	84.0
Leg	3	9.6
Hip & Pelvis	2	6.4
Total	**31**	**100**

Table 4.6: Region of the upper limb injured

	Frequency	Percent
Shoulder	9	36.0
Arm	8	32.0
Forearm	7	28.0
Hand	1	4.0
Total	**25**	**100**

Table 4.7: Region of the spine injured

	Frequency	Percent
Cervical	5	50.0
Lumbar	2	20.0
Cord Injury	2	20.0
Thoracic	1	10.0
Total	**10**	**100**

Table 4.8: Bone fractured

	Frequency	Percent
Femur	10	33.3
Ulna	7	23.3
Humerus	4	13.3
Tibia	4	13.3
Radius	3	10
Lumbar Spine V. Body	2	6.8
Total	**30***	**100.0**

*Two patients had fractures in more than one bone

Table 4.9: Association between circumstances of firearm injury and bone fractured

Circumstances of Firearm Injury	Bone Fractured		P value
	No	Yes	
Armed robbery attack	17 (60.7%)	12 (42.9%)	**0.132**
Police encounter	6 (21.4%)	8 (28.6%)	
Cattle rustling	3 (10.7%)	1 (3.6%)	
Interpersonal violence	0 (0.0%)	2 (7.1%)	
Suspected terrorist	2 (7.1%)	1 (3.6%)	
Stray bullet	0 (0.0%)	4 (14.3%)	
Total	**28 (100.0%)**	**28 (100.0%)**	

Table 4.10: Blood pressure of injured patients

Blood Pressure Category	Systolic mmHg (upper number)	Diastolic mmHg (lower number)
<120 and <80	20 (35.7)	37 (66.1)
120-129 and <80	11 (19.6)	-
130-139 and 80-89	13 (23.2)	12 (21.4)
≥140 and≥90	12 (21.4)	7 (12.5)

Table 4.11: Pulse rate (beats per minute) of the injured patients

	Frequency	Percent
60-100	39	69.6
>100	17	30.4
Total	**56**	**100.0**

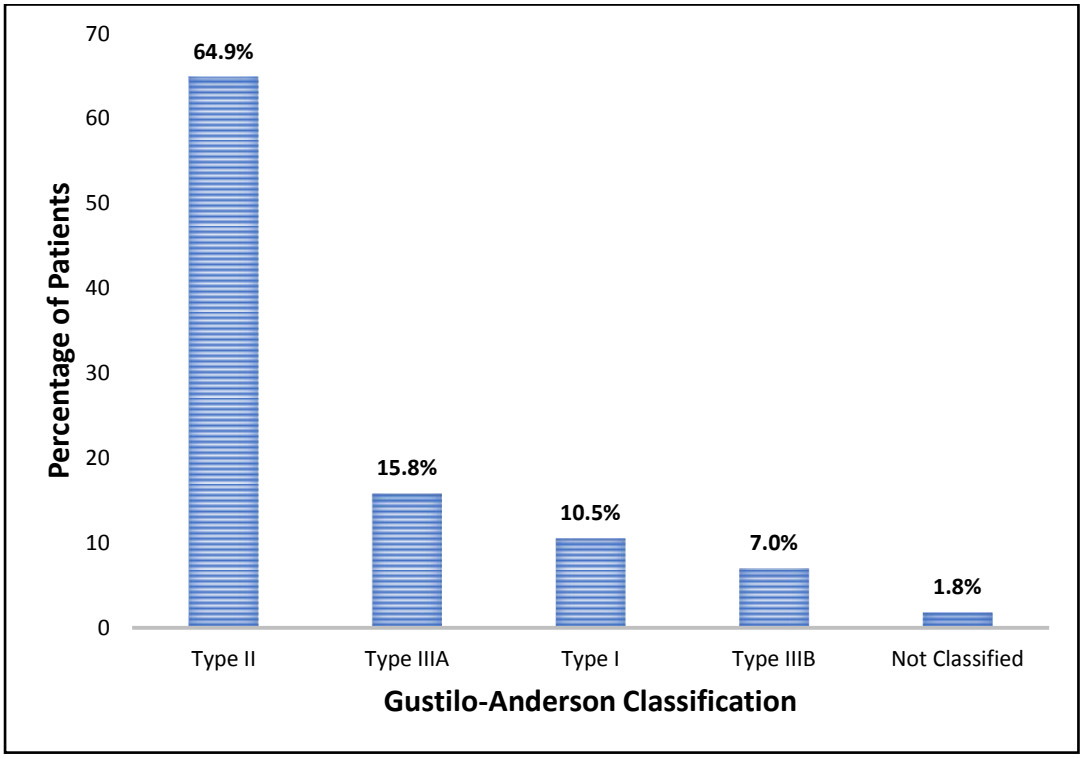

Figure 4.3: Gustilo-Anderson Classification

Table 4.12: Association between gustilo-anderson classification and soft tissue injury

Gustilo-anderson classification	Soft tissue injury		P value
	No	Yes	
Type I	1 (4.3%)	5 (15.2%)	**0.001**
Type II	11 (47.8%)	26 (78.8%)	
Type III A	9 (39.1%)	0 (0.0%)	
Type III B	1 (4.3%)	2 (6.1%)	
Not classified	1 (4.3%)	0 (0.0%)	
Total	**23 (100.0%)**	**33 (100.0%)**	

Table 4.13: Management

	Frequency	Percent
Operative	52	92.9
Non-Operative	4	7.1
Total	**56**	**100.0**

Table 4.14: Operative

	Frequency	Percent
Debridement	45	86.7
Debridement and External Fixation	4	7.6
Debridement and ORIF	3	5.7
Total	**52**	**100.0**

Table 4.15: Operator

	Frequency	Percent
Registrar	42	75.0
Consultant	10	17.9
Not Indicated	4	7.1
Total	**56**	**100.0**

Table 4.16: Antibiotics used

	Frequency	Percent
Ceftriaxone and Metronidazole	24	42.9
Ceftriaxone	13	23.2
Floxapen	3	5.4
Augmentin and Metronidazole	3	5.4
Meropenem	2	3.6
Augmentin	2	3.6
Ceftriaxone and Gentamicin	2	3.6
Metronidazole and Floxapen	2	3.6
Meronem and Flagyl	1	1.8
Floxapen and Augmentin	1	1.8
Floxapen + Metronidazole + Gentamicin	1	1.8
Flucloxacillin	1	1.8
Ciprofloxacin and Metronidazole	1	1.8
Total	**56**	**100.0**

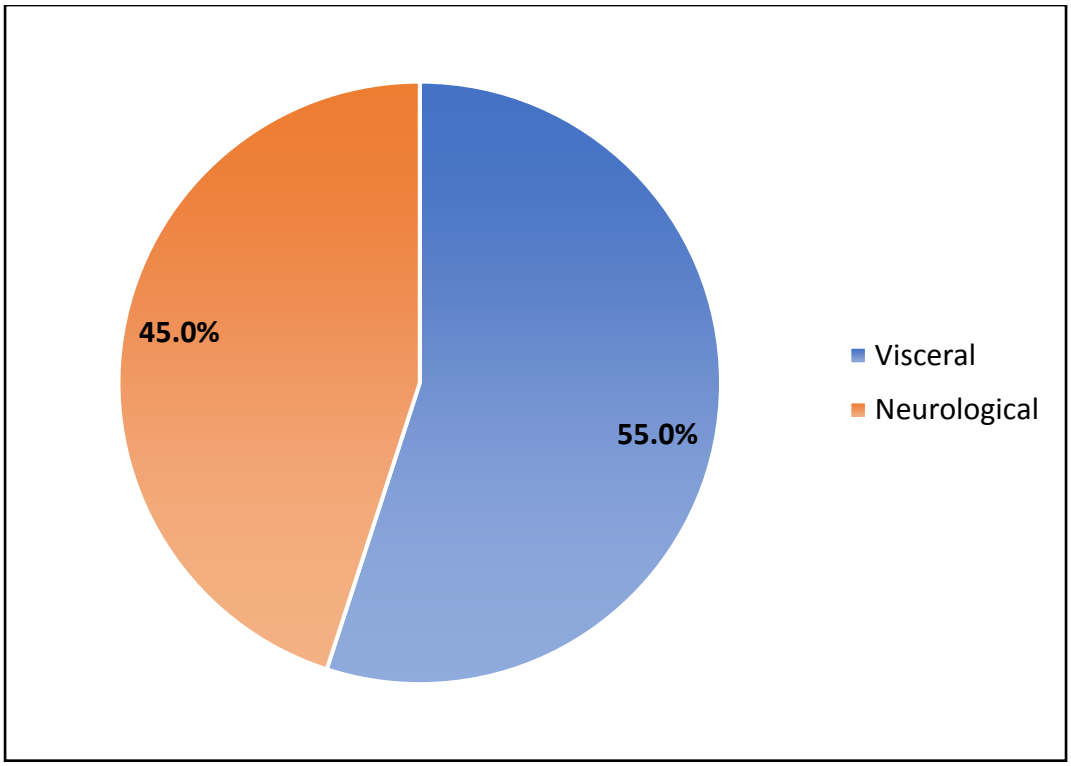

Figure 4.4: Associated Injury

Table 4.17: Specific Associated Injury

	Frequency	Percent
Ulnar Nerve Palsy	6	30.0
Lung	3	15.0
Liver	2	10.0
Large Intestine	2	10.0
Spinal Cord	2	10.0
Obturator Nerve	1	5.0
Spleen	1	5.0
Brachial Plexus Injury	1	5.0
Tongue	1	5.0
Tendon Injury	1	5.0
Total	**20**	**100.0**

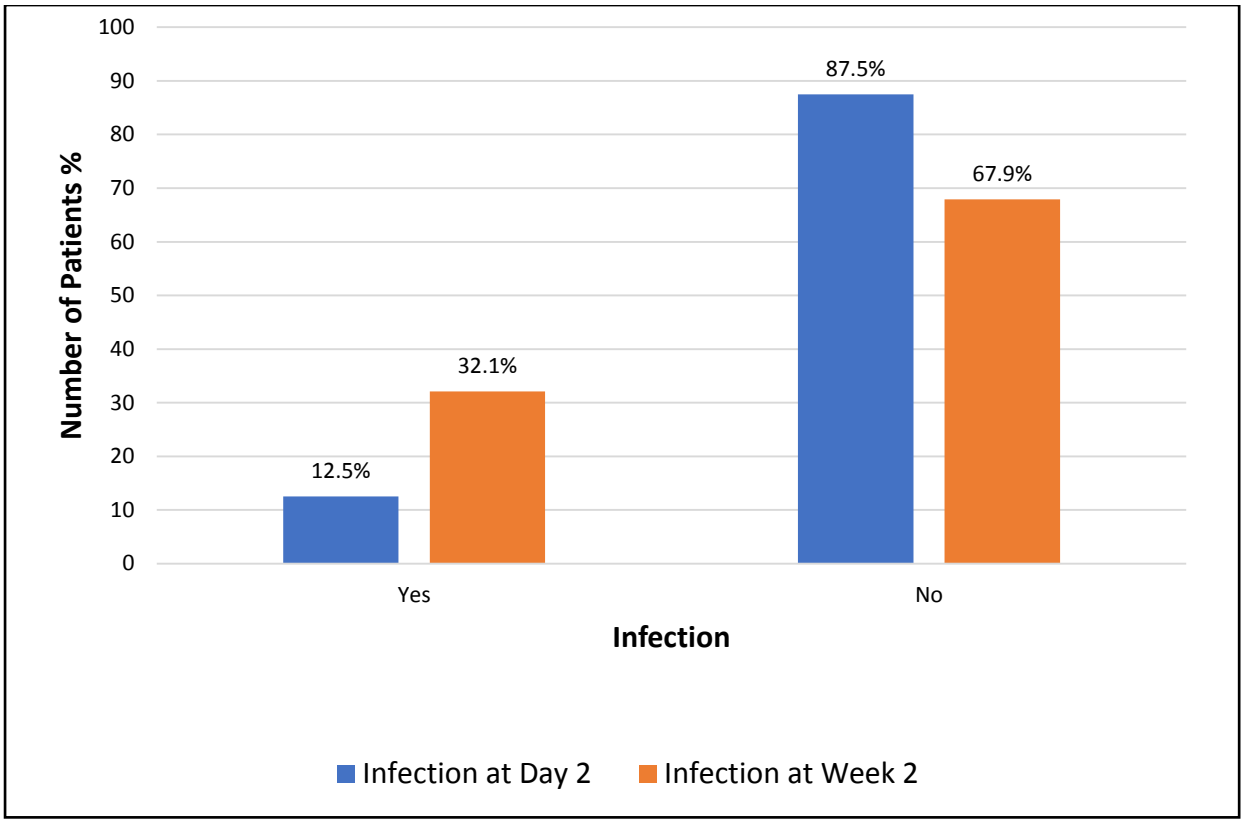

Figure 4.5: Infection on Day 2 versus Infection at Week 2

Table 4.18: Outcome of fractures at 3 months

	Frequency	**Percent (%)**
Healed normally	20	66.6
Delayed union	5	16.7
Lost to follow-up	5	16.7
Total	**30**	**100.0**

Table 4.19: Association between delayed union at 3 months and associated injury

Delayed union at 3 months	Associated injury		P value
	Neural	Visceral	
No	2 (40.0%)	7 (100.0%)	**0.061**
Yes	2 (40.0%)	0 (0.0%)	
Loss to follow-up	1 (20.0%)	0 (0.0%)	
Total	**5 (100.0%)**	**7 (100.0%)**	

Table 4.20: Overall outcome

	Frequency	Percent
Survived	52	92.9
Died	4	7.1
Total	**56**	**100.0**

5.0 CHAPTER FIVE: DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

This study aimed to determine the patterns and early outcomes of firearm-related musculoskeletal injuries in patients presenting at Kenyatta National Hospital. The study population included all patients with firearm injuries to the extremities (upper and lower limbs), spine and pelvis with either bone and or soft tissue involvement. The minimum sample size required for this study to have adequate power of 80% was 56 patients, and we managed to get a total of 56 patients.

Majority of the patients in this study were young people (48.2%) of age (21-30 years) **(Table 4.1)** and particularly males (89.3%), with a ratio of male to female approximately 10:1 **(Table 4.2).** This finding is not different from other previous studies which found that firearm injuries affected mainly males in the age group of 21-30 years (4). This finding is similar to a study done by Hugenberg *et al.*,(2007) in KNH, which found male to female ratio of 10:1 (2).

Most of the injuries occurred in Nairobi County (69.4%), and others were referred from other counties thus increasing the number of admissions to KNH **(Table 4.3).** In Nairobi county most of the injuries occurred in low socioeconomic regions such as Embakasi, Dagoretti, Roysambu, Ruaraka, Kamukunji, Starehe and Kibra constituencies **(Figure 4.1).**

This study found that most patients sustained firearm injuries between 6 p.m and midnight (60.7%) **(Table 4.4).** This result is similar to a study done by Omoke *et al.,* (2017) (3) where they found that most firearm injuries occurred between 6 p.m and midnight, which was largely attributed to the duration of time whereby most people are outside their homes or returning from their daily chores.

In this study armed robbery was the most common circumstance causing firearm injuries (52%) followed by police encounter (25%), cattle rustling (7%), stray bullet (7%), suspected terrorists attack (5%), and interpersonal violence (4%) **(Figure 4.2).** Previous study by Hugenberg *et al.*,(2007) (2) in KNH stated similar findings with high prevalence of firearm injuries due to armed robbery (85.5%) and police encounter (5.5%). Another study by Saidi *et al.*,(2002) at Aga Khan Hospital also showed similar results with armed robbery (74.7%) as the commonest cause followed by police encounter (9.4%) (1).

The most commonly affected body region was the lower limb (55%), followed by upper limb (45%) and spine 17% (some patients had combined injuries). The thigh, shoulder and cervical region were commonly affected regions in the lower limbs, upper limbs and the spine respectively **(Tables 4.5, 4.6 and 4.7).** A study by Oboirien *et al.,* (2016) found that the lower extremity (37.2%) and upper extremity (25.6%) were the common body regions affected. This study attributed to the fact that the assailants' intention was to maim rather than to kill as the injuries were mainly in the extremities (4).

The most common fractured bone as a result of firearm was the femur (33.3%), followed by ulna (23.3%), humerus (13.3%) tibia (13.3%) radius (10.0%) and lumbar spine vertebral body (6.8%) **(Table 4.8).** Riehl *et al.,* (2013) found that femur (35.2%) was commonly fractured due to fire arm, followed by humerus and tibia (17.6%) (16). **Table 4.9** shows that there was no statistical significant difference between circumstances of firearm injury and the bone fractured.

Thirty five percent (35.7%) of the patients had a low systolic blood pressure less than 120mmHg at presentation and 66.1% of patients had a low diastolic blood presure less 80 mmHg **(Table 4.10).** Thirty percent (30.4%) of the patients had a high pulse rate of more than 100 beats per minute **(Table 4.11).** The blood pressure and pulse rate were measured using digital blood pressure machine.

Gustilo-Anderson Type II injuries (64.9%) were the most common followed by Type IIIA (15.8%), then Type I (10.5%) and Type IIIB (7.0%), there were no Type IIIC injuries **(Figure 4.3).** G-A type II injuries were common possibly due to the low velocity nature of the weapons, although it was not possible to determine the type of weapons causing firearm injuries. **Table 4.12** shows there was a statistical significant difference between gustilo-anderson classification and soft tissue injury (p value= 0.001). Patients with Type II gustilo-anderson classification were more likely to have a soft tissue injury.

In this study 92.9% of the patients were managed operatively and 7.1% were managed non-operatively with antibiotics and wound care only **(Table 4.13).** Due to the complexity of fire arm injuries surgical management was required to ensure adequate exposure of the wounds and debridement of necrotic tissues, this accounted to the higher number of patients undergoing operative management (6). Majority of patients underwent debridement (86.7%), debridement and external fixations (7.6%) and debridement and ORIF (Plating and Nailing)

(5.4%) **(Table 4.14).** Registrars performed (75%) of the operations while consultants (17.9%) of the procedures **(Table 4.15).**

In this study antibiotic coverage varied according to the surgeon's preference and were administered empirically. Overally, ceftriaxone and metronidazole (66.1%) were the most commonly used antiobiotics **(Table 4.16).** Gosselin *et al.,* (2004) in Cochrane review showed that antibiotic use in open fractures reduced the incidence of infections (17). Penn-Barwell *et al.,* (2015) recommended earlier administration of antibiotics against gram positive bacteria, as delay lead to increased incidence of infections (6). Almost all patients (96.4%) received tetanus prophylaxis.

Some of the patients had visceral injuries (55%) and the rest had neurological injuries (45%) **(Figure 4.4).** Twenty patients had specific associated injuries including ulnar nerve palsy (30%), lung (15%), liver (10%), large intestines (10%), spinal cord (10%) and others (spleen, obturator nerve, brachial plexus injury, tongue, tendon injury-flexor pollicis longus) accounting to (5%) **(Table 4.17).** Some patients with thoracic and lumbar spine injuries had a bullet passing through the abdomen and chest thus the associated abdominal and chest visceral injuries. Saidi *et al.,* (2002) found neurovascular lesions of 13% and visceral injuries (bowel and liver) of 33% (1). The higher associated injuries found in his study were probably due to a larger sample size.

Also this study has shown that 12.5% patients had infection on the second day and 32.1% had infection on the second week **(Figure 4.5).** The infection rates increased from the second day to second week probably due to lack of access to negative pressure wound therapy (NPWT). Marinovic *et al.,* (2013) found that by using NPWT infections were controlled and by fourth week the wounds were ready for skin grafting (20).

Patients with fractures were followed up for a period of 3 months after the injury. In this study majority of the patients 66.7% healed normally, 16.7% had delayed union and the rest 16.7% were lost to follow-up **(Table 4.18).** Riehl *et al.,* (2013) found a higher incidence of patients with delayed union (47%) contrary to our study. This was attributed to retained bullet fragments near the fracture site (16). **Table 4.19** shows that the difference between delayed union at 3 months and associated injury was borderline statistically significant with a p value of 0.061. Patients with no delayed union at 3 months were more likely to be associated with visceral injury.

There was a favourable outcome as 92.9% of the patients survived whereas 7.1% of the patients succumbed to the injuries **(Table 4.20).** The mortality rate were mainly due to head and visceral injuries. Similar mortality rates were reported by Omoke *at el.,* (2017) and Onuminya *at el.,* (2005) (3) (24).

5.2 Conclusion

Armed robbery was the most common circumstance causing firearm injuries followed by police encounter. Most of the patients were aged between 21-30 years with male to female of 10:1. In Nairobi county most of the injuries occurred in low socioeconomic regions such as Embakasi followed by Dagoretti constituencies. Most of the firearm injuries occurred between 6 p.m and midnight. Commonly affected body region was the lower limb followed by the upper limb and the spine. The thigh was the most common affected region in the lower limb and the shoulder in the upper limb. The femur was the commonest fractured bone followed by ulna and radius. Most patients were managed operatively. Infections and delayed union are some of the complications of firearm injuries.

5.3 Recommendations

Kenyatta national hospital (KNH) should have protocols for management of firearm injured patients in order to reduce morbidity and mortality.

DISCLAIMER

I, Dr. Mustafa Ngeiywe Masai, have not received any financial benefits or incentives from any party or individual that may benefit from this study.

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WORK PLAN

JAN – FEB 2018	Background reading , writing and submitting proposal
FEB 2018	Study Proposal Presentation
MAR – APR 2018	Submission for Ethical Approval
APR. – SEPT 2018	Data Collection and Analysis
SEPT. – NOV 2018	Thesis writing and presentation
20TH FEB 2019	Thesis defence

BUDGET

Unit	Quantity	Cost Per Unit	Total Cost (Kshs)
Consent form (2 pages)	1	10	1000
Questionnaire form (2 pages)	1	10	1000
Ethical Review fee	1	2,000	2,000
Photocopying	1	5,000	5,000
Statistician Consultation	1	30,000	30,000
Binding Fees	4	250	1,000
	Total Cost		**40,000**

APPENDICES

Appendix I: Consent Information Document (English)

Title:

Patterns and early outcomes of firearm-related musculoskeletal injuries in patients presenting at KNH.

Investigator

Dr. Mustafa Ngeiywe Masai

Introduction

Firearm injuries among civilians are increasing in Kenya. Healthcare providers should have basic understanding of the management of such patients in order to reduce the complications associated with it.

Objective for Study

The aim of this study is to determine the patterns and early outcomes of firearm-related musculoskeletal injuries in patients presenting at KNH.

Study Procedure

If you agree to participate in this study. Information will be sought about your injuries including time of injury, place of injury e.t.c. You will be examined and treated as per KNH protocols. Your injuries will be re-examined on the 2nd day and after 2nd week. Radiographs may be requested on the 3rd month after injury according to your injury. Information obtained will be entered into questionnaire forms and kept for analysis of this study. The purpose of this consent is to give you enough information so that you decide if to participate or not in this study.

Benefits

You will not be paid for participating in this study, but your participation will provide us with information about firearm injuries and help improve care given to patients with similar injuries in future.

Voluntarism

Your participation in this study is completely voluntary. If you decide to withdraw from participating in this study, your decision will be respected, and thus this will not in any way interfere with your right to treatment in KNH.

Confidentiality

Information obtained from you will be handled with utmost confidentiality.

Consent Certificate

I, the participant do certify that the study has been fully explained to me and I will voluntarily participate in it.

Participant's signature (or thumb print)……Date……..

I the investigator do confirm that I have explained to the participant the nature of the study and answered all relevant questions about this study and the participant has decided to participate voluntarily without coercion.

Investigator's signature …… Date ……

Witness signature …… Date……..

For any inquiries, please contact:

1. Dr. Mustafa Ngeiywe Masai (Investigator)
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College of Health Sciences

P.O. Box 19676-00202

Nairobi, Kenya

E-mail: uonknh_erc@uonbi.ac.ke

Appendix II: Fomu Ya Idhini

Maelezo ya Fomu Idhini

Kichwa:

Majeraha kwa mifupa yanayotokana na kupigwa risasi kulingana na visa vilivyoripotiwa katika Hospitali Kuu ya Kenyatta.

Mtafiti

Dkt. Mustafa Ngeiywe Masai

Utangulizi

Nchini Kenya, visa vya majeraha ya bunduki miongoni mwa wananchi yanazidi kuongezeka kila kukicha. Mwenendo huu wahitaji wahudumu wa afya wawe na uelewa msingi na mbinu mahsusi jinsi ya kuwashughulikia wagonjwa kama hao kwa minajili ya kupunguza matatizo tatanishi yanayohusiana na matibabu ya majeraha ya bunduki.

Malengo ya Utafiti

Lengo la utafiti huu ni kuangazia kwa kinamajeraha ya bunduki na matokeoya matibabuwa muda mfupi.

Utaratibu wa utafiti

Ukikubali kushiriki katika utafiti huu,data kuhusu majeruhi yakoyataulizwa kama ifuatavyo; wakati wa kitendo cha jeraha na sehemu katika mwili ulio na jeraha au majereha.Majeruhi watachunguzwa na kutibiwa kulingana na itifaki ya Hospitali Kuu ya Kenyatta.Uchunguzi wa majeraha kwa majeruhi utafanyika siku ya 2 na baada ya wiki 2. Data itakayokusanywa itahifadhiwa kwenye fomu dodoso kwa ajili ya uchambuzi kina wa utafiti huu. Madhumuni ya idhini hii ni kukupa habari ya kutosha ili kufanikisha uamuzi wako wa kushirki au kutoshiriki katika utafiti huu.

Faida

Ushiriki katika utafiti huu ni bure, maana yake ni kwamba hakuna malipo kwa mchango wako.Ilhali, kushiriki kwako utatupa taarifa muhimu kuhusu majeraha ya bunduki na kusaidia katika uboreshaji wa huduma za afya zitakazotolewa kwa wagonjwa watakaouguza majeraha kama hayo siku zijazo.

Uhiari

Ushiriki wako katika utafiti huu ni kwa hiari.Uamuzi wako wa kuondoa ushiriki kwenye utafiti huu utaheshimika, na uamuzi huo hautahujumu wala kulemaza haki yako ya kupata matibabu kwa njia yoyote ile kutoka hospitali kuu ya Kenyatta.

Usiri

Data itakayokusanywa kutoka kwako utashughulikiwa kwa usiri mkubwa.

Idhini Cheti

Mimi, mshiriki nathibitisha kuwa utafiti huu nimeelezwa kikamilifu na nimejitolea kwa hiari ili kutoa mchango wangu kama mshiriki.

Saini ya mshiriki (au kidole cha gumba) ……. Tarehe……

Mimi, mtafiki nathibitisha kwamba nimelieleza kwa mshiriki asili ya utafiti huu na pia kujibu maswali yote muhimu kuhusu utafiti huu na mshiriki ameamua kushiriki kwa hiari bila kushurutishwa.

Saini ya mtafiki ……...Tarehe……

Saini ya shahidi ……..Tarehe ……..

Kwa maswali yoyote, wasiliana:

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Appendix III: Questionnaire

i) Patients information

Serial number ……..... Age …….....

Sex: Male…….....Female …….....

Phone number……..... Date of injury.....

Time of Injury:-6.00-11.59 a.m.....00.00-5.59 p.m…….....

-6.00-11.59 p.m.....00.00-05.59 a.m.....

Place of injury…….....BP..... Pulse.....

ii) Circumstances of firearm injury

Armed robbery attack…….. Police encounter…….....

Cattle rustling ……..... Interpersonal violence…….....

Suicide attempts……..... Accidental discharge ……..…….....

Others (specify)……...

iii) Region of the body injured

Upper limb: Shoulder region….....Arm…..... Forearm ….....Hand….....

Lower limb: Hip &Pelvis……..... Thigh……...Leg……..... Foot…….....

Spine: Cervical…….....… Thoracic…... Lumbar…….....

Cord injury.....

Bone fractured…….....Retained Bullet.....

Soft tissue injury.....

iv)Gustilo-Anderson classification

Type I …….....Type II ……

Type IIIA …….. Type IIIB ……..... Type IIIC ……..

v)Management

Non-operative (Wound care, Casting and Antibiotics only).....

Type of antibiotic given: -In theatre…….....

-In the ward.....

Tetanus prophylaxis.....

Operative: -Debridement …….....

-Debridement and K-Wiring.....

-Debridement and External fixation …….....

-Debridement and ORIF: -IM Nailing…….....

-Plating …….....

Operator: Consultant..... Registrar.....

vi)Associated Injuries: Neural Injury…..…..…..... Vascular Injury…….....
Visceral injury.....

vii) Early Outcomes: (Signs and symptoms of infection e.g. purulent discharge, pain, swelling, redness etc.)

Infection at: Day 2 ……..... Week 2 ……..…….....

Delayed union at 3 months (radiographically).....

Death (while undergoing treatment).....

Appendix IV: Ethical Approval Letter

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Facebook: https://www.facebook.com/uonknh.erc
Twitter: @UONKNH_ERC https://twitter.com/UONKNH_ERC

KENYATTA NATIONAL HOSPITAL
P O BOX 20723 Code 00202
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP, Nairobi

Ref: KNH-ERC/A/155

May 9, 2018

Dr. Mustafa Ngelywe Masai
Reg. No.H58/75633/ 2014
Dept.of Orthopaedic Surgery
School of Medicine
College of Health Sciences
University of Nairobi

Dear Dr. Masai

RESEARCH PROPOSAL – PATTERNS AND EARLY OUTCOMES OF FIREARM-RELATED MUSCULOSKELETAL INJURIES IN PATIENTS PRESENTING AT KENYATTA NATIONAL HOSPITAL (P132/03/2018)

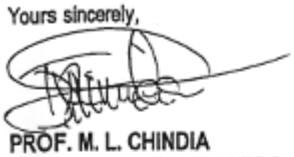
This is to inform you that the KNH- UoN Ethics & Research Committee (KNH- UoN ERC) has reviewed and approved your above research proposal. The approval period is from 9th May 2018 – 8th May 2019.

This approval is subject to compliance with the following requirements:

a) Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b) All changes (amendments, deviations, violations etc) are submitted for review and approval by KNH-UoN ERC before implementation.
c) Death and life threatening problems and serious adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH-UoN ERC within 72 hours of notification.
d) Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH- UoN ERC within 72 hours.
e) Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
f) Submission of an *executive summary* report within 90 days upon completion of the study. This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/ or plagiarism.

For more details consult the KNH- UoN ERC website http://www.erc.uonbi.ac.ke

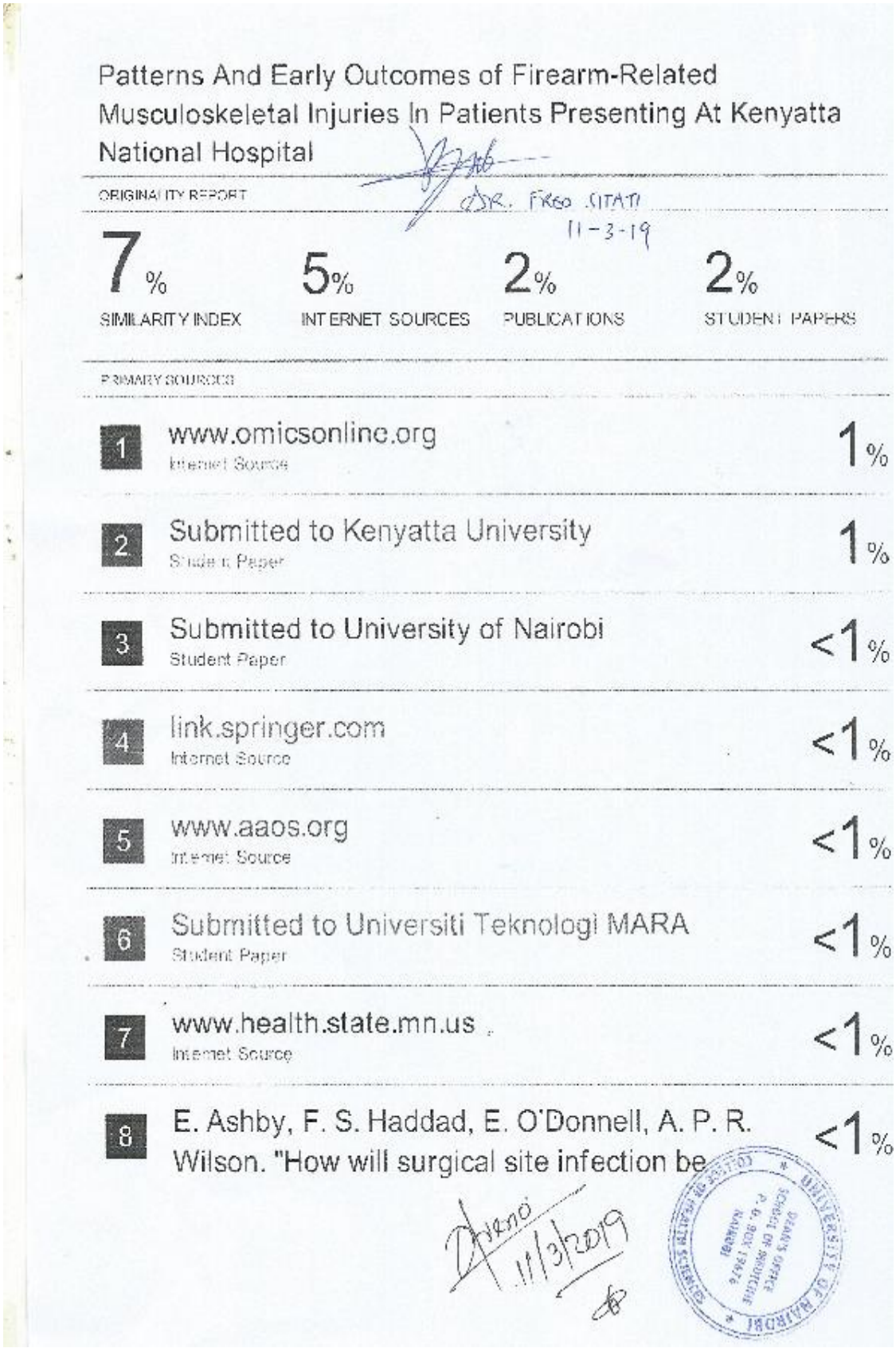
Yours sincerely,



PROF. M. L. CHINDIA
SECRETARY, KNH-UoN ERC

c.c. The Principal, College of Health Sciences, UoN
The Deputy Director, CS, KNH
The Chairperson, KNH-UON ERC
The Assistant Director, Health Information, KNH
The Dean, School of Medicine, UoN
The Chairman, Dept.of Orthopaedic Surgery, UoN
Supervisors: Prof. J. A.O. Mulimba, Dr. Fred Sitati

Appendix V: Turnitin Report



Patterns And Early Outcomes of Firearm-Related Musculoskeletal Injuries In Patients Presenting At Kenyatta National Hospital

DR. FRED SITATI
11-3-19

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