UNIVERSITY OF NAIROBI

THE PREVALENCE, SEVERITY AND PATTERN OF HEAD INJURY AMONG MOTORCYCLE CRASH VICTIMS AT KENYATTA NATIONAL HOSPITAL

BY

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MMED-NEUROSURGERY

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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF THE UNIVERSITY OF NAIROBI FOR AWARD OF THE DEGREE OF MASTER OF MEDICINE IN NEUROSURGERY (MMED-NEUROSURGERY)

UNIVERSITY OF NAIROBI

DECLARATION

I, **Dr Humphrey Kunda**, declare that this is my original work. No part of it has been presented for the award of a degree at any other university.

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DEDICATION

I wish to dedicate this work to my lovely wife (Angelique) and our children (Natasha and Nathan) who suffered but yet tolerated my perpetual absence throughout the process of writing this dissertation. The unwavering support and encouragement from my wife was a pillar on which my inspiration lay.

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ABSTRACT

Introduction. Motorcycles represent the most dangerous form of motorized transportation, and their increased use has been associated with a rise in motorcycle related crashes. In last decade, Kenya witnessed an explosion of motorcycle numbers and a concomitant increase in motorcycle crash-related deaths and injuries has been noted. Head injury is the main cause of death, severe morbidity and long-term disability among motorcyclists. However, few hospital based studies have been conducted to evaluate the prevalence and severity of motorcycle crash related-head injuries (MCR-HIs) and none has determined the pattern of head injuries in this patient population in Kenya.

Objectives. This study aimed to determine the burden, evaluate severity and describe the pattern of MCR-HIs at Kenyatta National Hospital (KNH). The rate of helmet use among MCR-HI patients was also estimated. The desired outcome is prevention and reduction of motorcycle crash related head injuries, mortality and disability among motorcyclists in Kenya.

Methodology. Sixty consecutive patients with motorcycle accident related head injury seen between 5th December, 2017 and 28th February, 2018 were prospectively studied using a pre-designed questionnaire. Data analysis was done using Statistical Package for Social Sciences (SPSS) version 21.0 software.

Results. Head injury was present in 30.3% (n=60) of the patients with motorcycle crash injury (MCI) who presented to KNH during the study period. MCR-HI represented 25.0% of the total head injuries attended during the same period. Motorcycle operators (37, 61.7%) formed the largest proportion of patients with MCR-HI. Fifty-five (91.7%) subjects were male and the mean age was 29.4 years (SD 14.4 years, range 4 to 67 years), with majority (21, 35.0%) falling in the age group 20 – 29 years. More than two-thirds (44, 73.3%) of the patients were in the economically active age group (i.e. 20 - 49 years). There was a significant proportion of children younger than 10 years (8, 13.3%) and these made up 61.5% of the pedestrians. Motorcycle-vehicle collision (21, 35.0%) was the most common accident type. Thirty-nine (65.9%) of the patients had mild head injury, while seven (11.7%) and fourteen (23.3%) incurred moderate and severe head injury, respectively. Intracranial haemorrhage (42, 70.0%) was the most common craniocerebral injury type, with cerebral contusions (36, 63.2%) constituting the majority. Scalp injury (34, 56.4%), and skull fracture (31, 51.7%) were the other significant injuries. There was a notable low helmet use rate (11, 23.4%) among motorcyclists with MCR-HI, which was worse among passengers (1, 10.0%). Helmet use reduced the rate of severe head injury, scalp injury, skull fracture and extradural hematoma. However, helmets were not protective against cerebral contusions. Limb injuries represented the most common non-craniocerebral injury associated with MCR-HI.

Conclusion. MCR-HI is an important public health problem in Kenya. Being a preventable injury, every effort is needed to eradicate it. Helmet use among motorcyclists with MCR-HI is low, especially amongst passengers. Though protective against head injury, the helmet's efficacy has significant limitations. Therefore, measures to prevent MCR-HIs should not promote helmet use in isolation. Effective prevention efforts must, instead, be more holistic to include promotion of safe riding habits and behaviour, as well as enforcement of road traffic regulations.

Limitations. This study has the following important limiting factors; small sample size, recall bias, single-site study, and pre-hospital deaths.

TABLE OF CONTENTS

ABBREVIATIONS

A & E	Accident and Emergency
CI	Confidence Interval
CT	Computed Tomography
ED	Emergency Department
ERC	Ethics and Research Committee
GCS	Glasgow Coma Scale
H	Helmeted
HI	Head injury
KNBS	Kenya National Bureau of Statistics
KNH	Kenyatta National Hospital
MC	Motorcycle
MCI	Motorcycle crash injuries
MCR-HI	Motorcycle Crash-Related Head Injury
ME	Margin of Error
NH	Non-helmeted
NHTSA	National Highway Transport Safety Administration
NK	Helmet use status not Known
NTSA	National Transport and Safety Authority
Pvt	Private
RTC	Road Traffic Crash
RTI	Road Traffic Injury
SPSS	Statistical Package for Social Sciences
TBI	Traumatic Brain Injury
UON	University of Nairobi
USA	United States of America
USD	United States dollar
WHO	World Health Organisation

DEFINITIONS

The following definitions have been used in this study:

- **Head injury** is defined as any trauma to the head, excluding injuries to the face and mandible.
- **Motorcycle** refers to a two-wheeler motor vehicle.
- **Vehicle** refers to a four-wheeler motor vehicle including car, truck, bus, etc.
- The **motorcycle operator** (or simply operator) is a person operating a motorcycle.
- The **motorcycle passenger** (or simply passenger) is a person seated on, but not operating, the motorcycle.
- **Pedestrian** refer to a person involved in a collision with a motorcycle whist walking along a road used by motorised vehicles.
- The **motorcyclist, motorcycle rider or motorcycle occupant** is a general term referring to a motorcycle operator or passenger.
- **Motorcycle crash** refers to a road traffic mishap involving a motorcycle, which may result in damage to property, death or injury to people.
- A **motorcycle crash victim (MCV)** is any person involved in a motorcycle crash including the motorcycle operator, passenger, and pedestrian. The victim may die, sustain injury or escape injury.
- **Motorcycle crash injury (MCI)** refers to injury involving any body part sustained following a motorcycle crash.
- **Motorcycle crash-related head injury (MCR-HI)** is head injury caused by a motorcycle crash.
- A **fatal crash** is defined as one in which death occurs at the scene of the accident and/or within one day or one year as a result of injuries sustained in an accident.
- A **serious crash** is defined as a mishap in which a person(s) sustains injury warranting hospital admission or any of the following injuries whether or not one is admitted: fractures, concussion, internal injuries, crashing injury, severe cuts and lacerations.
- A **minor crash** is defined as vehicle damage only; no person is injured, regardless of the extent of damage on the vehicle or other property.

1.0 INTRODUCTION

Road traffic injuries are a global growing public health problem. An estimated 1.2 million people are killed on the roads each year. Additionally, about 50 million people are injured, whilst those suffering major injuries survive with long-term adverse health issues. Sadly, most of the burden of the world's road traffic injuries is borne by the low- and middle-income countries, which account for about 85% of the deaths and 90% of the annual disability adjusted life years (DALYs) lost because of road traffic injury. [1] In developing countries, pedestrians, cyclists and motorcycle riders comprise the majority of those injured in road traffic accidents. [2] These represent a category of least protected road users. [3]

Each year in Kenya, about 3,000 people die from road traffic accidents, with thousands more left incapacitated. This exerts a large cost burden on both the families and the health system. [4]

The motorcycle is a risky mode of transportation. This vehicle type lack external and internal protection, move at high speeds and is inherently unstable, hence making it a hazard to the occupants. [5] Per vehicle mile travelled, motorcyclist fatalities occur 26 times more frequent than passenger car occupant fatalities in motor vehicle traffic crashes, and motorcyclists are nearly 5 times more likely to be injured. [6]

The motorcycle is increasingly becoming a common means of transport in many developing countries. In these countries motorcyclists constitute the majority of those injured or killed in roads traffic accidents. [7] In East Africa, motorcycle crash related injuries contribute about 73% and 58.8% to all road traffic injuries in Uganda and Tanzania, respectively. [8, 9]

In Kenya, the proportion of injuries due to motorcycle crashes has been rising since 2004 - in tandem with an increase in motorcycle numbers. [10, 11] The National Transport and Safety Authority (NTSA) reported that, in 2014, motorcycle accidents had significantly increased. This was despite a noted reduction in the overall number of accidents and deaths from other categories of vehicles. [12] Hospital based studies in Kenya report motorcycle accident injury prevalence of about 19 – 39% among all road traffic injuries. [4, 13, 14]

Head and neck injuries are responsible for the majority of deaths, severe morbidity and disability among motorcyclists. Head injury is the main cause of death among motorcycle users in both the developed and developing world; contributing around 75% and 88% deaths in European and developing countries, respectively. Because of the specialized treatment and long-term care required in most cases, head injuries attract higher medical costs than any other type of injury. This has a significant bearing on the survivors and their families, the country's health care costs as well as the economy in general. [7]

Few hospital based studies have been conducted to examine the prevalence of head injuries among motorcycle accident victims in Kenya. A 12.1% head injury prevalence was reported in one study, [15] while a prevalence of up to 40% for head and neck injuries was found in other studies. [14, 16] These are significant findings, considering the potential grave consequences of head injury.

Brain contusions, intracerebral haemorrhage, extradural hematoma and skull fractures have been reported as common lesions sustained in MCR-head injuries. Eye and facial-maxillary injuries are frequently associated with MCR-HIs. [17, 18] No study describing the pattern of head injuries among motorcycle crash victims has been conducted in Kenya. This highlights a knowledge gap that needs to be bridged.

Helmets reduce the number and severity of head injuries among motorcycle crash victims. [7] Combined with law implementation, increase in helmet use has been shown to decrease head injury and mortality rates among motorcycle riders. [19] Several studies have confirmed the efficacy of helmets in preventing head injuries, reducing their severity and the subsequent mortalities, among motorcyclists. [2, 20, 21] Thus, motorcycle riders wearing no helmet run a much higher risk of sustaining severe head injury if involved in a crash.

In spite of the known protective benefits of helmets and the adverse impact of head injury on motorcycle users, low rate of helmet use is common place. Reported rates of helmet use in developing countries include 24.7% in Tanzania, 5.8% in Nigeria and 18.6% in Uganda. [9, 17, 22] Similar to other developing countries, helmet use in Kenya is low, with reported use rates of less than 50% and less than 20% for operators and passengers, respectively. [4, 10] The low rate of helmet use is an important public health problem, considering the adverse consequences of head injury such as high mortality and morbidity, prolonged hospital stay and chronic disability among the victims. [35] All these pose a huge burden on families, government and society.

Considering that motorcycle crash related head injuries are preventable, it is essential that an understanding of the magnitude, contributing factors and injury patterns is established. This is a prerequisite to the development of prevention strategies and sound treatment protocols. Very few hospital based studies have been conducted to study the burden of motorcycle crash-related head injuries in Kenya. Therefore, this study seeks to determine the burden and pattern of head injuries due to motorcycles crashes, as well as establish the rate of helmet use among motorcycle crash victims seen at Kenyatta National Hospital (KNH). KNH is Kenya's highest public referral hospital and serves as the largest trauma centre in the country. The information to be obtained will be used for policy formulation and treatment protocol development by administrators and clinicians, respectively. Further, the information shall be utilised as a baseline in future related research. Ultimately, the desired result is prevention and reduction of motorcycle crash related head injuries, mortality and disability among motorcyclists in Kenya.

2.0 LITERATURE REVIEW

2.1 The burden of road traffic injuries

Road traffic injuries (RTIs) are a global growing public health problem. An estimated 1.2 million people are killed on the roads each year. Additionally, about 50 million people are injured, whilst those suffering major injuries survive with long-term adverse health issues. [1, 3] Globally, the leading cause of death among young people (15–29 years) is road traffic accidents. [3] According to current estimates, road traffic injury is the ninth leading cause of death across all age groups globally. These injuries are predicted to become the seventh leading cause of death by 2030. [23] By 2020, without mitigating measures, RTIs are likely to become the third leading contributor to the global burden of disease and injury [24]
Sadly, most of the burden of the world's road traffic injuries is borne by the low- and middle-income countries, accounting for about 85% of the deaths and 90% of the annual disability adjusted life years (DALYs) lost because of road traffic injury [1] While the global rate for road traffic deaths is 17.5 per 100 000 population, the rates are more than twice as high in low- and middle-income countries than in the world's high income countries. [3] The highest rates are in the African Region (28.3 per 100,000 poppulation). [1]

In East Africa, most road traffic deaths occur in Tanzania and Kenya. The estimated road traffic mortality rates are, respectively, 34.4, 34.3, 31.6, 24.7 and 23.4 deaths per 100,000 for Tanzania, Kenya, Rwanda, Uganda and Burundi. [25] About 3,000 people die in road traffic accidents every year in Kenya, with thousands more incapacitated. This exerts a huge cost on families and the health system. [4]

The economic cost of road crashes is obvious. Around US$ 518 billion is spent on RTIs per year, globally. These injuries consume an estimated to be 1 - 2% of the gross national product (GNP), with developed countries spending more than the developing ones. Low-income and middle-income countries spend more resources on RTIs (about US$ 65 billion) than they receive in development assistance. [26] Household finances have not been spared by the scourge of RTIs. Families are driven into poverty by the loss of breadwinners, more also with the added burden/ cost of caring for members disabled by road traffic injuries [1]

Pedestrians, cyclists and motorcycle riders comprise the majority of those injured in road traffic crashes in developing countries. [2] These represent a category of least protected road users. [3]

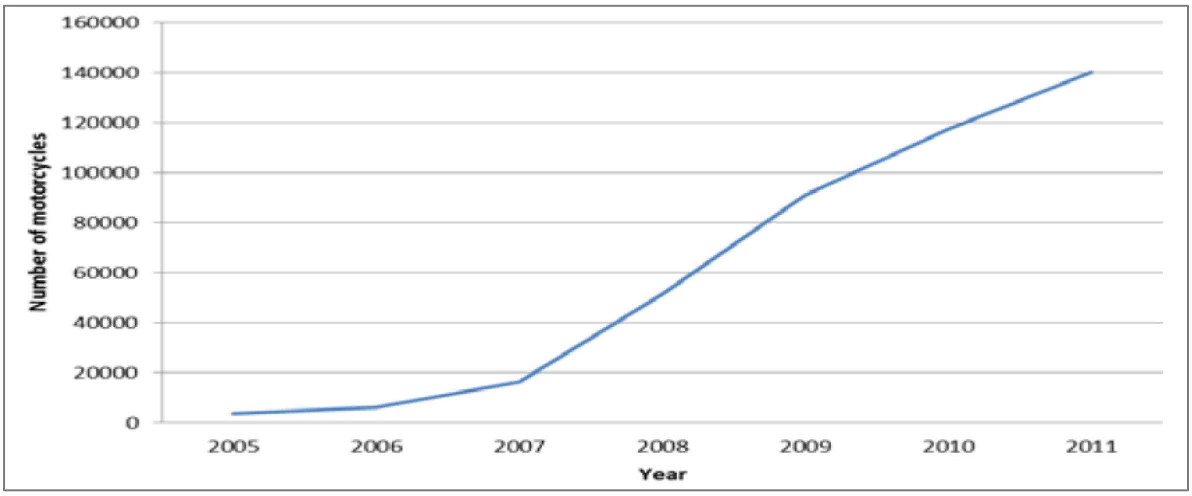
2.2 Motorcycle use in developing countries

In developed countries motorcycling is undertaken as a form of recreation and leisure. [27] On the other hand, motorcycles are used for transportation in developing countries. [28] The use of motorcycles for commercial transportation has resulted in the explosion of their number in these countries. It is estimated that developing countries consume about 90% of the world motorcycle consumption each year. [29] The growing use of motorcycles in developing countries have been attributed to socioeconomic reasons, convenience in negotiating traffic in congested cities with poorly maintained roads, political reasons and the ease of parking in narrow streets. [30]

2.3 Motorcycles in Kenya

Commonly known as "bodaboda," the motorcycle has recently become a popular means of commercial transport in Kenya. [14] This largely followed the Kenyan government's waiver of tax on imported motorcycles in 2008. Aimed at promoting job creation in the transport sector to the youth, this measure saw the number of motorcycles leap from 3757 units in 2005 to 91151 in 2009. [31]

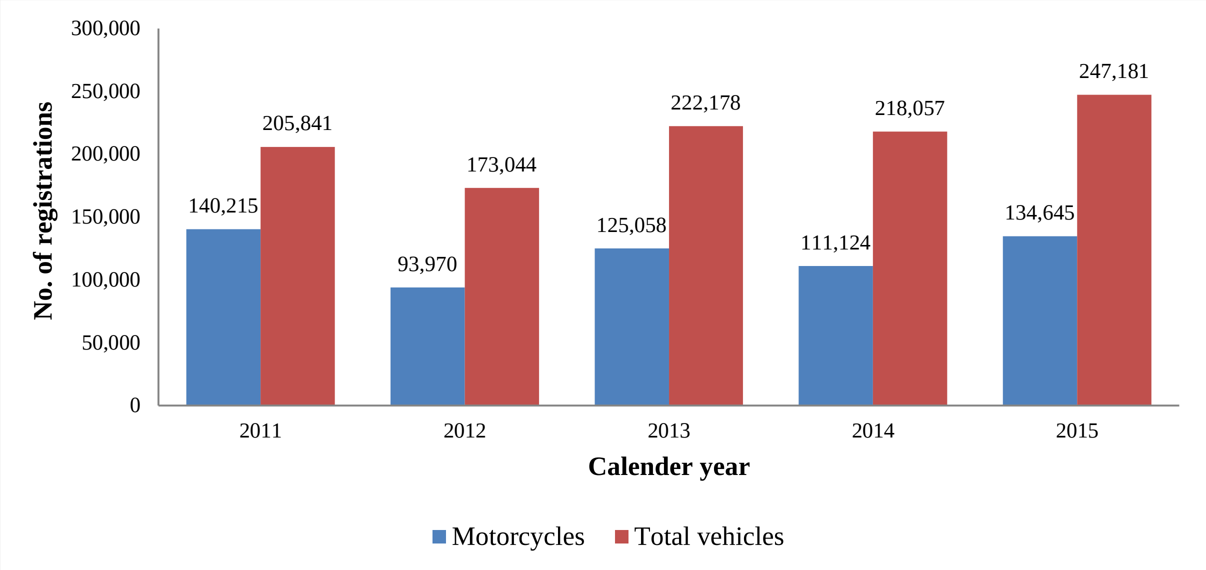
Figure 2.1: Number of newly registered motorcycles by year



Source: WHO (2012); Motorcycle-related road traffic crashes in Kenya; Facts & figures. RS10 Kenya project: Nairobi

A World Health Organization (WHO) report revealed that, in the period 2005 to 2011, motorcycle registration in Kenya rose by almost 40-fold and this vehicle-type made up 70% of all newly registered vehicles in 2011. [13] According to Kenya National Bureau of Statistics (KNBS), the annual vehicle registrations remained relatively stable in the period 2011 to 2015. During this period, however, motorcycles constituted more than 50% of the total vehicles registered. The report indicated that Kenya's motorcycle imports grew by 22.8% in 2015 and attributed the increase to the rising demand for motorcycles as an alternative mode of passenger transport. [32]

Table 2.1: New registration of road motor vehicles and motorcycles, 2011-2015



Modified from KNBS (2016) *National Economic Survey, 2016*. Kenya National Bureau of Statistics: Nairobi

2.4 Vulnerability of the motorcycle user

The motorcycle is a risky mode of transportation. This vehicle type lack external and internal protection, move at high speeds and is inherently unstable, hence making it a hazard to the occupants. [5] Other factors contributing to motorcyclist vulnerability on the road include sharing the traffic space with fast moving, heavier and bigger vehicles; less visibility to other road users; and lack of formal driving training among the motorcycle operators. [7, 33] Additionally, motorcycle operators often ignore safety measures, as well as disregard traffic regulations. [30]

Even in more developed countries, motorcyclists generally remain a vulnerable group among road users. In the USA, for example, motorcycle occupants are 26-fold likely to be involved in a fatal accident than their car counterparts, and are about 5 times more prone to injury when involved in a road mishap. [6] The situation is likely to be worse in developing countries where road traffic regulations are deficient and/ or poorly enforced; and roads are badly designed (narrow roads, uneven, steep slopes, and sharp turns/curves), not maintained and lack road signs. [3, 34]

2.5 Motorcycle related road traffic injuries

In developing countries where motorcycles are a common transport medium, motorcyclists constitute the majority of those injured or killed in road traffic crashes. [7] In East Africa, motorcycle crash related injuries contribute about 73% and 58.8% of all road traffic injuries in Uganda and Tanzania, respectively. [8, 9]

In Kenya, the proportion of injuries due to motorcycle crashes has significantly risen from 1.7% in 2005, to 4.2% in 2008 and 6.1% in 2009. [11] Abdulgafoor et al found that injuries due to motorcyclists increased at an annual rate of approximately 29% in the period 2004 to 2009. [10] According to the National Transport and Safety Authority (NTSA), motorcycle accidents had significantly increased in 2014. This was despite a noted reduction in the overall number of accidents, injuries and deaths from other vehicle categories. The report revealed that overall, the number of road crashes reported in the period January to September 2014 declined by 20.44% compared to the same period in 2013. To the contrary, motorcycle accidents increased from 7.96% in 2013 to 10.61% in 2014 and motorcyclists made up 13.50% of the road crash deaths in 2014, compared to 9.7% in 2013. [12]

A World Health Organization (WHO) report showed that, in 2010 motorcyclists represented 36% of the patients presenting to the emergency department at Naivasha hospital with road traffic crash injury. [13] In 2013 (between August and October), motorcycle crash injuries formed 39.4% of all road traffic injury patients seen at Kitale hospital and majority of those injured were operators; operators 45%, passengers 38.8% and pedestrians 15.9%. [14] In the 2009/ 2010 calendar year, Saidi et al found that 19% of total road traffic crash (RTC) admissions at KNH were motorcycle riders. [4] The disparity in the rates of motorcycle related injuries reported could be due to differences in the methodology and location of the studies. Sismwo et al and the WHO study considered all victims of motorcycle crashes presenting at the respective facilities. On the other hand, Saidi et al only considered those admitted; a population mainly consisting of more severe injuries, leaving out patients who died before admission and those successfully treated and discharged in the A & E department.

2.6 Motorcycle crash related Head Injuries (MCR-HIs) in Kenya

Head and neck injuries are responsible for the majority of deaths, severe morbidity and disability among motorcyclists. Head injury is the main cause of death among motorcycle users in both the developed and developing world; contributing around 75% and 88% of deaths in European and developing countries, respectively. Because of the specialized treatment and long-term care required in most cases, head injuries attract higher medical costs than any other type of injury. This has a significant bearing on the survivors and their families, the country's health care costs as well as the economy in general. [7]

Few hospital based studies have been conducted to examine the prevalence of head injuries among motorcycle accident victims in Kenya. Among motorcycle crash victims seen at Kitale hospital (Kenya), the prevalence of head and neck injury was 40%. [14] Head injuries were present in 12.1% of the motorcycle crash patients presenting to Kakamega hospital (Kenya). [15] Head and neck injuries constituted 32.07 % of all motorcycle trauma admissions at KNH. [16] These are significant findings, considering the potential grave consequences of head injury. The reported prevalence at Kitale and KNH included head and neck injuries in one category. This deprived the researchers an opportunity to assess the true prevalence of head injuries at these institutions. Only Sisimwo et al [15] had reported on the head injury severity (using Glasgow Coma Scale). From the foregoing, it is obvious that more studies are needed to get a complete understanding of the problem of head injury among motorcycle crash victims in Kenya.

2.7 Pattern of MCR-HIs

Brain contusions, intra-cerebral haemorrhage, extradural hematoma and skull fractures have been reported as common lesions sustained in MCR-head injuries. [17, 18] The presence of a skull fracture increases the risk of intracranial haemorrhage, especially extradural haematoma. In compound skull fractures, there is a direct communication between the environment and the cerebral surface, thus increasing the risk of meningitis. [18] The latter is important considering that motorcycle victims with open skull fractures have an especially increased risk of wound contamination due to lack of physical protection. Eye and facial-maxillary injuries are frequently associated with MCR-HIs. [17, 18]

No study describing the pattern of head injuries among motorcycle crash victims has been conducted in Kenya. This highlights a knowledge gap that needs to be bridged.

2.8 Helmet use

The helmet creates an additional layer for the head, thus protecting the wearer from severe head and brain injury. Motorcycle helmets reduce the number and severity of head injuries. [7] Combined with law implementation, increase in helmet use has been shown to decrease head injury and mortality rates among motorcycle riders. [19] Studies have confirmed the efficacy of helmets in preventing head injuries, reducing their severity and the subsequent mortalities, among motorcyclists. [2, 14, 20] Overall, helmets are effective in reducing head injuries by 69% and death by 42% among motorcycle crash victims. [2] They reduce the chance of fatal injury by 37% for motorcycle operators and by 41% for passengers. [20] Helmets further reduce the chance of non-fatal serious head injury and minor head injury by 13% and 8%, respectively. [21] Thus, motorcycle riders wearing no helmet run a much higher risk of sustaining severe head injury if involved in a crash.

In spite of the proven protective benefits of helmets and the known adverse impact of head injury on motorcycle users, low rate of helmet use is common place, especially in developing countries. The overall rate of motorcycle helmet use is about 60% and continue rising (in States with mandatory helmet law) in the United States. [6] Studies have shown lower rates of helmet use in middle and low-income countries. [9, 22] Reported rates of helmet use in developing countries include 24.7% in Tanzania, 5.8% in Nigeria, and 18.6% in Uganda. [9, 17, 22]

2.9 Helmet use in Kenya

There are few hospital based studies on the prevalence of helmet use among motorcycle crash victims in Kenya. Similar to other developing countries, helmet use in Kenya is low. Less than one third of motorcycle operators in Thika (30.37%) and Naivasha (21.29%) wore helmets. Even lower usage of helmets by passengers (3-4%) was observed in both districts. [10] These are lower rates compared to those reported at KNH by Saidi et al.; where helmet use was 18.2% and 45.8% for motorcycle passengers and operators, respectively. [4]

The low rate of helmet use is an important public health problem, considering the adverse consequences of head injury such as high mortality and morbidity, prolonged hospital stay and chronic disability among the victims. [35] All these pose a huge burden on families, government and society.

3.0 STATEMENT OF THE PROBLEM

Kenya has recently seen a rapid increase in the number of motorcycles, mainly for commercial transportation [14] As a consequence, a significant increase in the proportion of crashes resulting from motorcycles has been observed. [10, 11] Hospital based studies have reported motorcyclists to represent 19 to 39% of total RTIs in Kenya [4, 13, 14] Deaths resulting from motorcycle crashes are also on the rise i.e. motorcyclists accounted for 13.50% of road traffic accident deaths in 2014, compared to 9.7% in 2013. [12]

MCR-HI is the main cause of death, severe morbidity and long-term disability among users of motorcycles. [7] Though the efficacy of helmets in preventing head injuries, reducing their severity and the subsequent mortalities among motorcyclists has been demonstrated, [2, 20, 21] there is low helmet use among motorcyclists in Kenya; 21-48% and 3-18% for operators and passengers, respectively. [4, 10] Non-use of helmets by motorcyclists is a major clinical problem because the resultant head injury is associated with high mortality and morbidity, prolonged hospital stay and chronic disability among the victims. [35] Few studies have been done to evaluate the burden of HIs among motorcycle crash victims in Kenya. Further, no study has described the pattern of MCR-HIs in the country.

4.0 JUSTIFICATION OF THE STUDY

Despite the importance of the problem, head injury resulting from motorcycle accidents has not received the attention deserved. There is paucity of studies on MCR-HI in Kenya. To add to the body of knowledge on the subject, the current study aimed to determine the burden, evaluate severity and describe the pattern of MCR-HIs at Kenyatta National Hospital (KNH). The rate of helmet use among MCR-HI patients was also estimated. It is hoped the results of this study will be used,

- as a baseline for future related research,
- for policy formulation by administrators, and
- in the development of treatment protocols by clinicians.

The desired outcome is prevention and reduction of motorcycle crash related head injuries, mortality and disability among motorcyclists in Kenya.

5.0 STUDY QUESTIONS

i. How common is head injury among motorcycle crash victims seen at KNH?
ii. How serious are the head injuries due to motorcycle crashes at KNH?
iii. What type of head injuries are common among motorcycle crash victims seen at KNH?
iv. What is the contribution of MCR-HI to the total number of head injuries seen at KNH?
v. What is the rate of helmet use among motorcyclists with MCR-HI seen at KNH?

6.0 HYPOTHESIS

Considering the rise in motorcycle numbers, coupled with low rates of helmet use reported in Kenya, the prevalence of head injury is high among motorcycle crash victims and MCR-HIs contributes significantly to the total number of head injuries seen at KNH.

7.0 OBJECTIVES

7.1 Broad objectives

i. To evaluate the burden and pattern of MCR-HIs at KNH
ii. To establish the rate of helmet use among patients seen with MCR-HI at KNH

7.2 Specific objectives

i. Establish the prevalence of HI among motorcycle crash victims seen at KNH
ii. Ascertain the proportion of MCR-HIs among all head injuries seen at KNH
iii. Evaluate the severity of head injuries resulting from motorcycle crashes at KNH
iv. Describe the pattern of head injuries in patients with MCR-HI at KNH
v. Enumerate the rate of helmet use among patients with MCR-HI seen at KNH

8.0 METHODOLOGY

8.1 Study design

This study was a hospital based descriptive prospective cross-sectional study.

8.2 Study site

The study was undertaken at KNH in Kenya's capital, Nairobi. KNH is Kenya's highest public referral hospital and serves as the largest trauma centre in the country. Endowed with the largest neurosurgical service in the country, KNH has the capacity to handle even the severest form of head injury. Though situated in a metropolitan city, the hospital serves both urban and rural populations from most of the surrounding districts and counties. Its patient population has a wide ranging socio- economic profile.

8.3 Study population

All patients with motorcycle crash injuries (MCIs) who presented and were managed at KNH Accident and Emergency (A & E) department from the 5th December, 2017 to 28th February, 2018. This patient population included motorcycle operators, passengers and pedestrians.

8.3.1 Inclusion criteria

All patients with head injury due to motorcycle crash, regardless of the presence or absence of other associated injuries.

8.3.2 Exclusion criteria

i. Patients with no head injury.
ii. Patients with injuries confined to the maxillofacial and/ or mandibulo-dental regions of the head.
iii. Patients not consenting to participate in the study.
iv. Occupants of vehicles who sustained head injury in crashes with motorcycles
v. Patients with head injury but unable to do a head CT scan.

8.4 Sample size determination and calculation

The Fischer's formula (below) was used to calculate the sample size.

$$n = \frac{Z^2 \times P\,(1-P)}{d^2} = 163$$

Where,

- n is the sample size
- z is the z-score; estimated as 1.96 for 95% confidence interval,
- p is the estimated prevalence of head injury among motorcycle crash victims = 12.1% [15]
- **d** is the desired margin of error = 5%

To correct for the finite population, the following formula was used;

$$n' = \frac{NZ^2P(1-P)}{d^2(N-1)+Z^2P(1-P)} = 110$$

Where,

- ***n'*** is the sample size with finite population correction
- ***N*** is the size of target population = 330
- ***Z*** is the z-score for 95% confidence interval = 1.96
- ***P*** is the estimated prevalence of head injuries among motorcycle crash victims = 12.1% [15]
- ***d*** is the margin of error = 5%

Using 95% confidence interval (CI), 5% margin of error and 12.1% head injury prevalence found by Khanbhai and Lutomia [15] at Kakamega hospital (Kenya), the sample size was estimated as 163 subjects. This adjusted to 110 subjects after correcting for the finite population. Therefore, a minimum of 110 patients with MCI was required to estimate the prevalence of head injuries within 5% precision error.

There are no official records of how many motorcycle crash injury patients are seen at KNH because these injuries are lamped together with injury due to other types of motorized vehicles under the category "road traffic injuries." However, an observational study conducted at the KNH A & E department in the period September to November, 2016, showed that an average of about 110 motorcycle crash patients are seen per month. [Unpublished] Considering the planned three (03) month data collection period, a representative sample was to be drawn from an estimated 330 motorcycle crash victims, hence the required/ estimated sample size was feasible.

8.5 Data collection

8.5.1 Data collection procedure

After the initial management in the A & E department, patients were screened for eligibility. An informed consent was obtained for eligible subjects. Patients with altered level of consciousness had a close relative/ guardian consent for them. Eligible participants were interviewed, examined and had their head computed tomography (CT) scans reviewed by the researcher and/ or trained assistants. Findings were recorded in a pre-designed questionnaire.

Information collected included demographic data (age, gender, area of residence, occupation), accident location, crash type (lone, motorcycle-motorcycle, vehicle-motorcycle), time of accident, time of arrival at hospital, mode of transport to hospital, helmet use status (for motorcycle occupants), patient position (driver, passenger, or pedestrian) at the time of the crash, head injury severity using GCS, significant clinical signs, associated injuries, and imaging findings.

8.5.2 Data management and statistical analysis

Quantitative findings were entered in the Microsoft Excel 2013 data entry sheet. Statistical analysis was done using Statistical Package for Social Sciences (SPSS) version 21.0 software. Frequencies, means, median and standard deviations were computed for description of various variables. These presented in form of tables and charts, as well as prose. Qualitative information was presented in prose form. Test of significance was interpreted at a p-value less or equal 0.05.

9.0 ETHICAL CONSIDERATIONS

9.1 Informed consent

The aims and procedures of the study were explained, in a language (mainly Kiswahili) best comprehended by the patient, close relatives and/ or guardian. The subjects' questions and concerns were addressed before obtaining an informed consent. In cases where the patient was unable to consent due to the prevailing medical condition, a close relative or guardian gave consent. In conformity with Good Clinical Practice (GCP) guidelines, patients brought without relatives had two senior consultants consent for them. Consent was obtained for all subjects in our study.

9.2 Confidentiality

All information collected about the patients was treated with strict confidentiality. The data collection instrument (questionnaire) was devoid of personal identifiers (e.g. patients' names, hospital numbers, residential address) and documents containing patients' confidential information were neither photocopied nor recorded. The information on the questionnaire was only accessible to the investigators and the statistician.

9.3 Ethical Approval

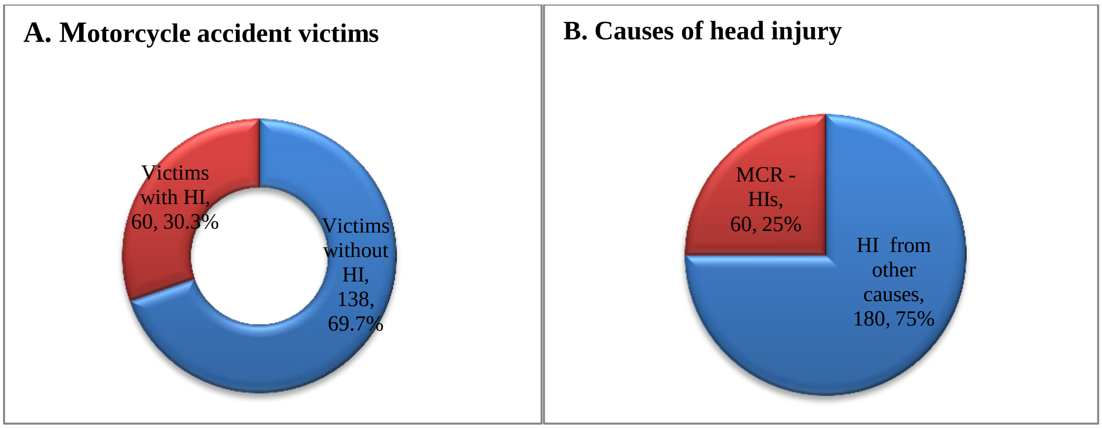
The proposal was submitted to the Kenyatta National Hospital-University of Nairobi Ethics and Research Committee (KNH/UON – ERC) and approval was granted on 10th May 2017 (P27/01/2017, Ref: KNH-ERC/A/166).

10.0 RESULTS

10.1 Burden of motorcycle crash related head injuries

In the period 5th December, 2017 to 28th February, 2018, a total of 198 motorcycle accident victims were seen in the accident and emergency (A & E) department at Kenyatta National Hospital (KNH). Sixty (30.3%) of these had head injuries. It is these patients with motorcycle crash-related head injuries (MCR-HIs) that were considered for further analysis in this study. During the same period, an overall number of 240 head injuries were attended to. Thus, MCR-HIs represented 25.0% of the total number of head injuries treated during the study period. (**Figure 10.1**) Patients with MCR-HI included 37 (61.7%) operators, 10 (16.7%) passengers and 13 (21.6%) pedestrians. (**Figure 10.2**)

Figure 10.1: Burden of motorcycle related head injury at KNH

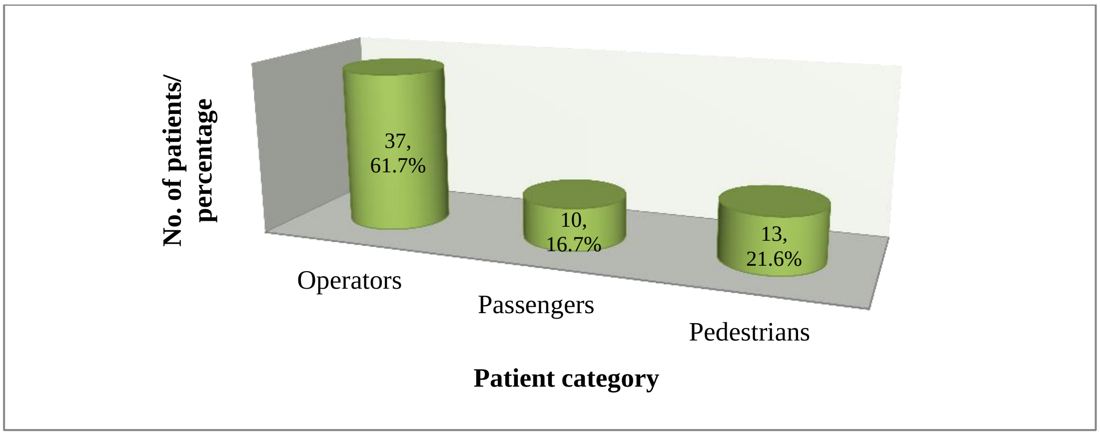


Note: HI = head injury, MCR-HI = motorcycle crash related head injury

10.2 Demographic characteristics

Overall, males constituted 91.7% (n=55) of patients seen with MCR-HI. All motorcycle operators were male, passengers consisted of 80.0 % (n=8) males and 20.0% (n=2) females, while pedestrians were made up of 76.9% (n=10) male and 23.1% (n=3) females. (**Table 10.1**)

Figure 10.2: Distribution of patients with MCR-HIs



The mean age for the patients with MCR-HI was 29.4 years (median 28 years). The commonest age group was 20 to 29 years. Though the age range was 4 to 67 years, majority (44, 73.3%) of the patients with MCR-HI were young aged 20 - 49 years. Overall, children younger than 10 years accounted for 13.3% (n=8), but constituted 61.5% of the pedestrians with MCR-HIs. Twenty-five (41.7%) of the patients with MCR-HI were married. (**Table 10.1**)

Commercial motorcycle operators represented 55.0% (33) of the patients with MCR-HI. Others were self-employed (farmers, masons, casual labourers, traders), motor-vehicle drivers and pupils/ students. Fourteen (23.3%) patients were neither in school nor involved in any economic activity. (**Table 10.1**)

Table 10.1: Patient characteristics

Gender					
Sex	**Overall**	Operators	Passengers	Pedestrians	p-value
Male	**55 (91.7%)**	37 (100.0%)	8 (80.0%)	10 (76.9%)	0.002
Female	**5 (8.3%)**	0	2 (20.0%)	3 (23.1%	
Total	**60 (100%)**	37 (100%)	10 (100%)	13 (100%)	
Age (years)					
Age interval	**Overall**	Operators	Passengers	Pedestrians	p-value
>10	**8 (13.3%)**	0	0	8 (61.5%)	< 0.001
10-19	**4 (6.7%)**	0	2 (20.0%)	2 (15.4%)	
20-29	**21 (35.0%)**	17 (45.9%)	3 (30.0%)	1 (7.7%)	
30-39	**12 (20.0%)**	11 (29.7%)	0	1 (7.7%)	
40-49	**11 (18.3%)**	7 (18.9%)	4 (40.0%)	0	
≥50	**4 (6.7%)**	2 (5.4%)	1 (10.0%)	1 (7.7%)	
Total	**60 (100%)**	37 (100%)	10 (100%)	13 (100%)	
Marital status					
Marital status	**Overall**	Operators	Passengers	Pedestrians	p-value
Married	**25 (41.7%)**	20 (54.1%)	4 (40.0%)	1 (7.7%)	**< 0.001**
Single	**22 (36.6%)**	14 (37.8%)	4 (40.0%)	2 (15.4%)	
N/A	**12 (20.0%)**	0	2 (20.0%)	10 (76.9%)	
Unknown	**1 (1.7%)**	3 (8.1%)	0	0	
Total	**60 (100.0%)**	37 (100.0%)	10 (100.0%)	13 (100.0%)	
Occupation					
Commercial MC operator	**33 (55.0%)**				
None	**14 (23.3%)**				
Self-employed	**6 (10.0%)**				
Pupils/ Student	**5 (8.4)**				
Motor-vehicle driver	**2 (3.3%**				
Total	**60 (100%)**				

Note: N/A = not applicable, and refer to patients below 19 years of age. Single include those never married before, separated or widowed. The self-employed included a farmer, a mason, 3 casual labourers, and a trader.

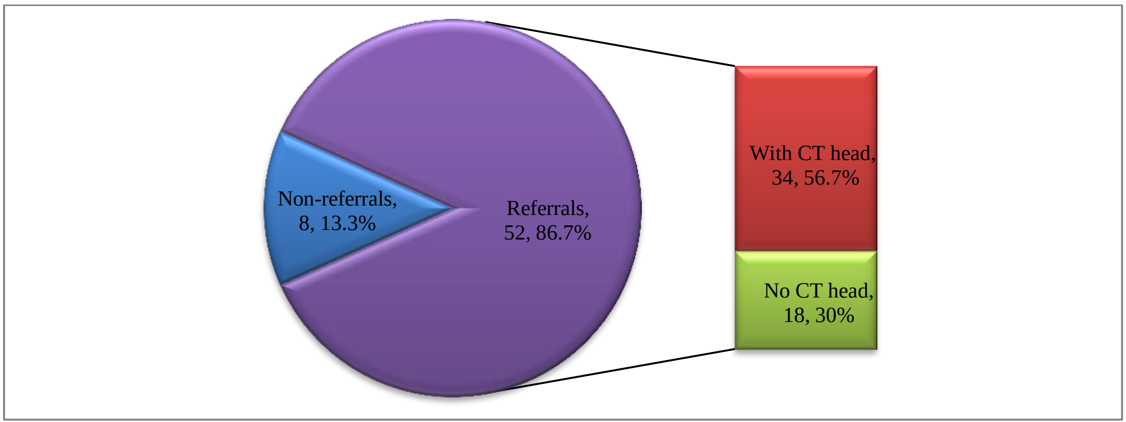
Table 10.2: Residence and crash location

Residence			Crash location		
County	**No. of patients**	**%**	**Town**	**No. of patients**	**%**
Nairobi	22	36.7	Nairobi	30	50.0
Kiambu	12	20.0	Murang'a	6	10.0
Murang'a	7	11.6	Naivasha	6	10.0
Machakos	6	10.0	Thika	6	10.0
Nakuru	3	5.0	Machakos	4	6.6
Kajiado	3	5.0	Kiambu	2	3.3
Kitui	2	3.3	Kajiado	1	1.7
Laikipia	2	3.3	Kangundo	1	1.7
Makueni	1	1.7	Kitengela	1	1.7
Nyandarua	1	1.7	Kitui	1	1.7
Nyeri	1	1.7	Nyeri	1	1.7
Total	**60**	**100**	Wote	1	1.7
			Total	**60**	**100**

Patients seen with MCR-HI were residents of Nairobi and surrounding areas, with more than 50% coming from Nairobi (22, 36.7%) and Kiambu (12, 20.0%) counties. Most of these patients were involved in mishaps occurring within Nairobi city (50.0%; n=30). The remainder of the accidents mainly occurred in the surrounding towns. (**Table 10.2**)

Referrals from other health facilities made up 86.7% (n=52) of MCR-HI patients seen in the study. Most of these were referred after a CT head had been done. Overall, 56.7% (n=34) of the patients already had a CT head done at the time of presentation to KNH. (**Figure 10.3**) Those who presented without an imaging had a CT head done on arrival. Therefore, all patients included in the study had a CT head done. No patient was excluded from the study on the account of imaging unavailability.

Figure 10.3: Referrals



10.3 Accident information

10.3.1 Time of accident

Most of the accidents (39, 65.0%) took place during the day, with the highest number of accidents recorded in the afternoon (22, 36.7%). Except for one pedestrian, rest of night mishaps involved motorcycle occupants. The average presentation delay, i.e. period from time of accident to time of presentation at KNH, was 23.4 hours (median 23.9, SD 15 hours, range 2 to 113hours). Less than half (27, 45.0%) of the patients with MCR-HI presented within 12 hours of injury and only 13.3% (n=8) had a presentation delay of 6 hours or below. Further, about a third of the patients (19, 31.7%) presented after 24 hours following injury. (**Figure 10.4**)

10.3.2 Accident type

In this study, majority sustained head injuries following vehicle-motorcycle collisions (21, 35.0%) and lone motorcycle crashes (20, 33.3%). Motorcycle-motorcycle collisions were less common (5, 8.3%). It is worth noting that one passenger, a known epileptic, fell off a moving motorcycle after suffering a seizure hence sustaining severe head injury. All pedestrians suffered head injuries after being hit by a motorcycle whilst crossing the road. (**Table 10.3**)

10.3.3 Helmet use

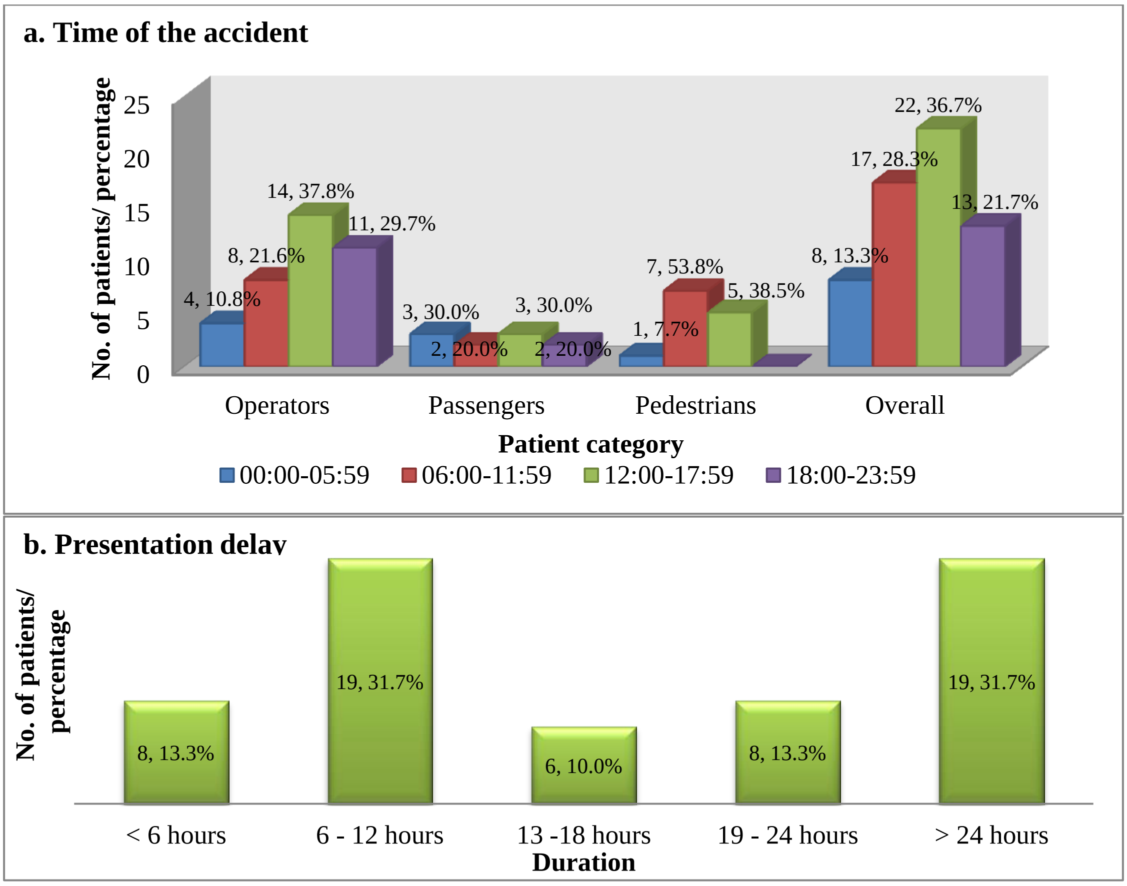
Only 23.4% (n=11) of the motorcycle occupants seen with MCR-HIs wore a helmet at the time of the accident. 51.1% (n=24) did not, while helmet use status was not known in 25.5%

(n=12) of these patients. Out of the 37 operators, 10 (27.0%) used the helmet. Comparatively, only one (10.0%) out of the 10 passengers wore a helmet. (**Table 10.3**)

10.3.4 Mode of transport to KNH

Patients seen with MCR-HIs were mainly brought to KNH by ambulance (51.7%; n=31) or private vehicle 43.3% (n=26). However, 3 (5.0%) stable patients came by public transport (i.e. by matatu). (**Table 10.3**)

Figure 10.4: Crash time and presentation delay



10.4 Signs, symptoms and other associated injuries

There was a history of loss of consciousness in 91.6% (n=55) of MCR-HI patients seen. Post traumatic convulsions occurred in 11.7% (n=7) of the patients. One patient, a known epileptic aboard a motorcycle, had a seizure episode and fell off a moving motorcycle, hence sustaining head injury. This patient suffered additional seizure episodes after injury. (**Figure 10.5**)

Scalp injuries were observed in 56.7% (n=34) of the patients with MCR-HI. Respectively, 48.6% (n=18), 50.0% (n=5) and 84.6% (n=11) of operators, passengers and pedestrians had scalp injuries. Amongst the motorcycle occupants, scalp injuries were more common in the non-helmeted (56.3% of non-helmeted operators; 50.0% of non-helmeted passengers) than the helmeted (10.0% of the helmeted operators). (**Figure 10.6**) There were a total of 38 scalp injuries comprising of bruises (8, 13.3%), hematomas (9, 15.0%) and open wounds (21, 35.0%). (**Figure 10.5**)

Twenty-two (36.6%) patients had features suggestive of skull base fracture. The features noted included otorrhea (5, 8.3%), rhinorrhea (1, 1.7%), racoon eyes (14, 23.3%) and the Battle's sign (1, 1.7%). Abnormal pupillary findings were present in 26.6% (n=16) of the patients. (**Figure 10.5**) Neurologic deficits including facial palsy, hemiparesis and monoparesis were found in 3 (5.0%) patients.

Associated injuries were noted in 31.5% (n=19) of the patients. Limb (10, 16.7%) and maxillofacial (5, 8.3%) injuries were the most common associated injuries. Other injuries involved the eyes (2, 3.3%) and the thoracic region (2, 3.3%). No patient had suffered cervical spine, lower spine or abdominal-pelvic injuries. (**Figure 10.5**)

Seven (11.7%) patients were intoxicated with alcohol at presentation. All these were operators. (**Figure 10.5**) However, no laboratory test (or any other objective confirmatory test e.g. alcohol breathalyser) was used to confirm intoxication as well as ascertain the blood alcohol levels.

10.5 Head injury severity

Post resuscitation, 65.0% (n=39) of the patients with MCR-HI had mild head injury, while 11.7% (n=7) and 23.3% (n=14) suffered moderate and severe head injury, respectively. There was no patient with severe head injury amongst motorcycle occupants who had worn a helmet at the time of the accident. On the other hand, severe head injury was noted amongst pedestrians, motorcycle occupants with no helmet and motorcycle occupants with unknown helmet use status. (**Table 10.4**)

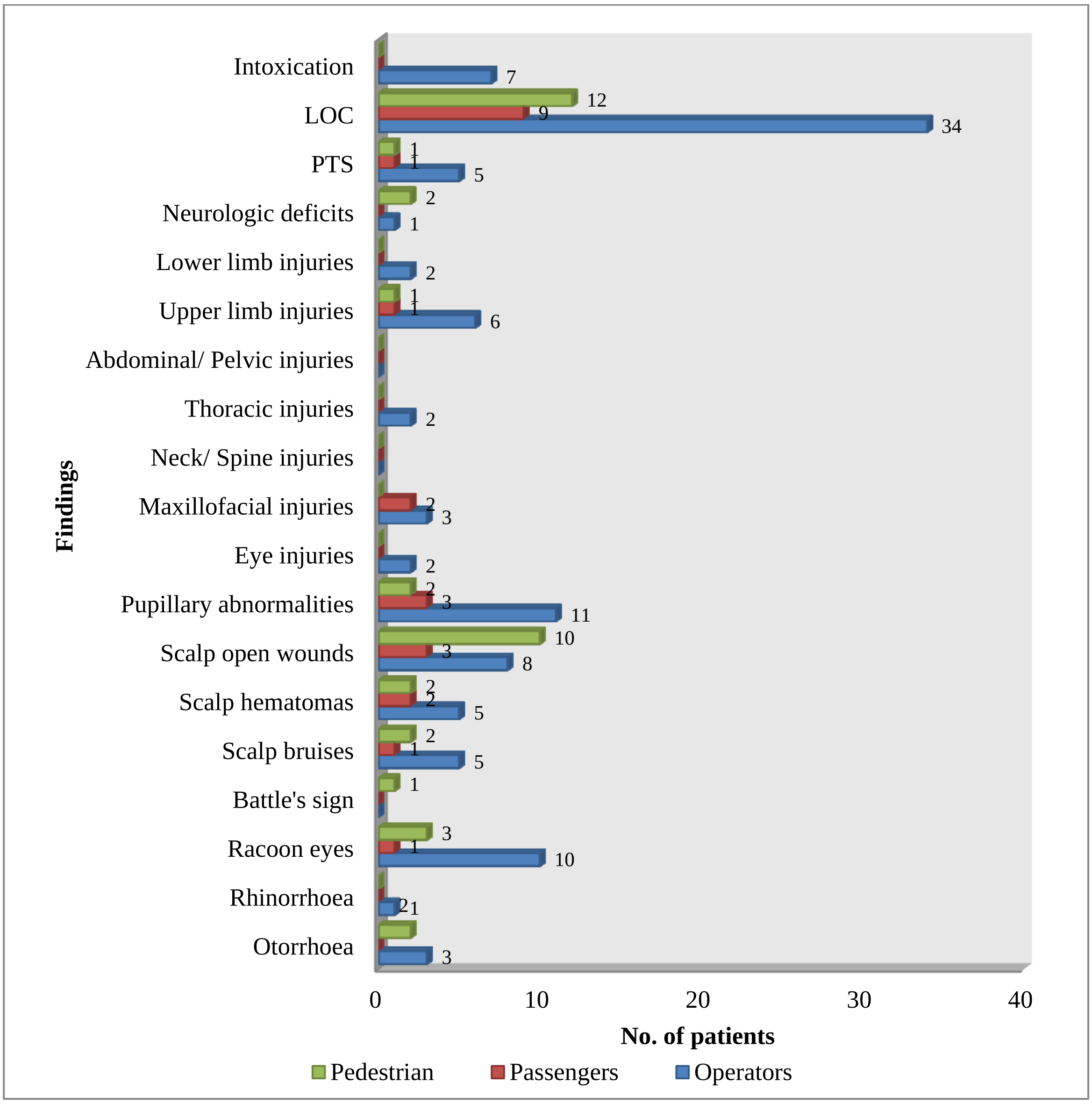
Table 10.3: Helmet use, accident type and mode of transport

Helmet use				
Helmet use status	**Overall**	Operators	Passengers	p-value
Helmet used	**11 (23.4)**	10 (27.0%)	1 (10.0%)	0.915
No helmet used	**24 (51.1)**	16 (43.2%)	8 (80.0%)	
Unknown	**12 (25.5%)**	11 (29.7%)	1 (10.0%)	
Total	**47 (100%)**	37 (100%)	10 (100%	
Crash type				
Vehicle-Motorcycle collision	**21 (35.0%)**			
Lone motorcycle crash	**20 (33.3%**			
Motorcycle-pedestrian collision	**13 (21.7%)**			
Motorcycle-Motorcycle collision	**5 (8.3%)**			
Other*	**1 (1.7%)**			
Total	**60 (100%)**			
Mode of transport				
Ambulance	**31 (51.7%**			
Private vehicle	**26 (43.3%)**			
Public service vehicle	**3 (5.0%)**			
Total	**60 (100%)**			

Note: *One passenger, a known epileptic, fell off a moving motorcycle after suffering a seizure. Three stable patients came to KNH by minibus.

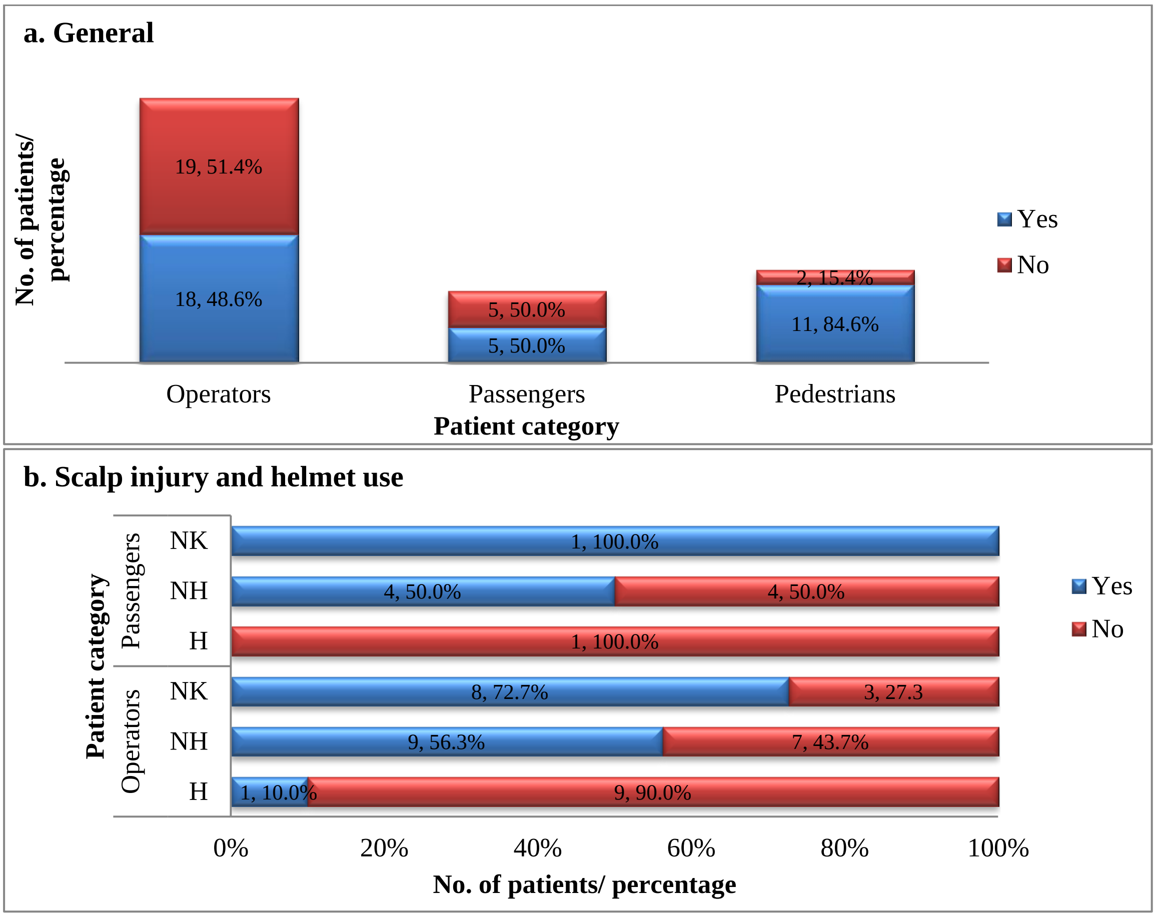
In respect of the 37 operators, 62.2% (n=23), 18.9% (n=7) and 18.9% (n=7) had mild, moderate and severe head injury, respectively. Though noted in 18.8% (n=3) of the non-helmeted, none of the helmeted operators had sustained severe head injury. Operators with unknown helmet use status suffered the highest rate of severe head injury 36.4% (n=4) in this patient category. (**Table 10.4**)

Figure 10.5: Signs, symptoms and associated injuries



Note: Scalp open wounds include lacerations, cuts, contusions and degloving injury. Maxillofacial injuries included soft tissue injuries and fractures (maxillary, zygomatic, mandibular). Thoracic injuries included soft tissue injuries, rib fractures and hemopneumotharax. Limb injuries included soft tissue injuries and fractures/ dislocations. Abnormal pupillary findings included dilated pupils, constricted pupils, anisocoria, sluggish reaction to light and non-reactive pupils. Neurologic deficits included facial palsy, hemiparesis and monoparesis. Intoxication = alcohol intoxication. PTS = post-traumatic seizures, LOC = loss of consciousness.

Figure 10.6: Scalp injuries



Only mild (7, 70.0%) and severe (3, 30.0%) head injury was noted amongst passengers. The helmeted passenger sustained mild head injury. Severe head injury was present in the passenger with unknown helmet use status, as well as 25.0% (n=2) of the non-helmeted. (**Table 10.4**) Regarding pedestrians, 30.8% (n=4) incurred severe head injury, while 69.2% (n=9) had mild head injury.

There was a high proportion of severe head injury (4, 50.0%) among patients involved in accidents that occurred between 00:00 hours and 06:00 hours. Morning time (i.e. 06:00 to 12:00 hours) recorded the second highest (4, 23.5%), while the lowest proportion of severe head injury (2, 15.4%) occurred between 18:00 and 24:00 hours. (**Table 10.4**)

Table 10.4: Head injury severity

Head injury severity and patient category

Patient category		Mild HI	Moderate HI	Severe HI	Total	p-value
Operators		23 (62.2%)	7 (18.9%	7 (18.9%)	37 (100%)	0.260
Passengers		7 (70.0%)	0	3 (30.0%)	10 (100%)	
Pedestrians		9 (69.2 %)	0	4 (30.8%)	13 (100%)	
Overall		39 (65.9%)	7 (11.7%)	14 (23.3%)	60 (100%)	
Head injury severity and helmet use						
Helmet use status		Mild HI	Moderate HI	Severe HI	Total	p-value
Helmeted	Operators	7 (70.0%)	3 (30.0%)	0	10 (100%)	0.540
	Passengers	1 (100.0%)	0	0	1 (100%)	
	Overall	8 (72.7%)	3 (27.3%)	0	11 (100%)	
Non-helmeted	Operators	12 (75.0%)	1 (6.2%)	3 (18.8%)	16 (100%)	0.862
	Passengers	6 (75.0%)	0	2 (25.0%)	8 (100%)	
	Overall	18 (75.0%)	1 (4.2%)	5 (20.8)	24 (100%)	
Unknown	Operators	4 (36.4%)	3 (27.2%)	4 (36.4%)	11 (100%)	0.288
	Passengers	1 (100.0%)	0	0	1 (100%)	
	Overall	4 (33.3%)	3 (25.0%)	5 (41.7%)	12 (100%)	
Head injury severity and time of crash						
Time of accident		Mild HI	Moderate HI	Severe HI	Total	p-value
00:00-05:59		3 (37.5%)	1 (12.5%)	4 (50.0%)	8 (100%)	0.610
06:00-11:59		11 (64.7%)	2 (11.8%)	4 (23.5%)	17 (100%)	
12:00-17:59		16 (72.7%)	2 (9.1%)	4 (18.2%)	22 (100%)	
18:00-23:59		9 (69.2%)	2 (15.4%)	2 (15.4%)	13 (100%)	

HI = head injury

10.6 Radiological findings

Out of the 60 patients seen with MCR-HI, 86.7% (n=52) had abnormal head CT-scan findings. Present in 70.0% (n=42) of the patients, intracranial haemorrhage was the commonest lesion seen. Intracranial haemorrhagic lesions found included cerebral contusions (28, 46.7%), extradural haematomas (11, 18.3%), subdural haematomas (7, 11.7%), intracerebral haematomas (2, 3.3%) and subarachnoid haemorrhage (1, 1.7%). In the second and third places were skull fracture (31, 51.7%) and generalized cerebral edema (20, 33.3%), respectively. Other lesions noted in the study were brainstem ischaemic infarct (1, 1.7%) and pneumocephalus (3, 5.0%). (**Figure 10.7**) Some patients had more than one lesion.

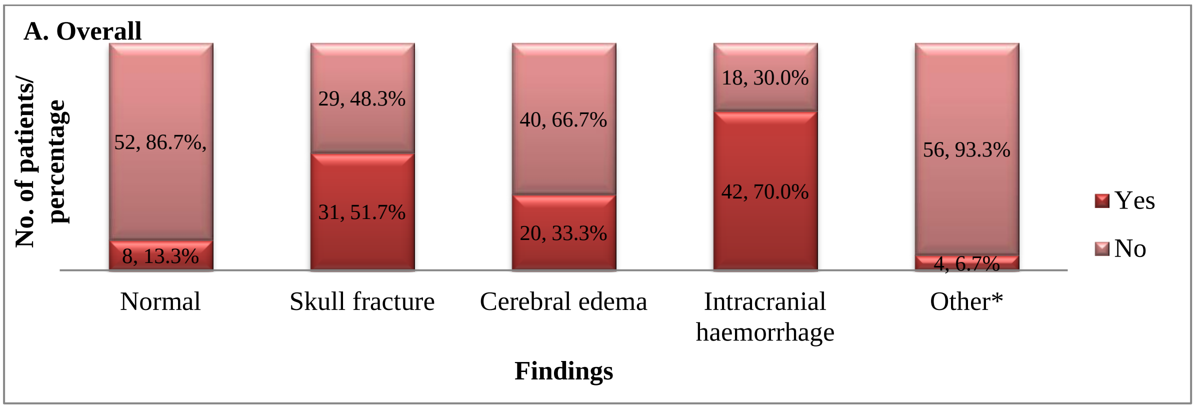
There were 116 separate lesions noted on head CT scans of the MCR-HI patients seen in the study. These included cerebral contusions (36, 31.0%), skull fractures (35, 30.2%), generalized cerebral edema (20, 17.3%), extradural hematomas (11, 9.5%), subdural hematomas (7, 6.0%), pneumocephalus (3, 2.5%), intracerebral hematomas (2, 1.7%), subarachnoid haemorrhage (1, 0.9%) and brainstem infarct (n=1, 0.9%). (**Figure 10.8**)

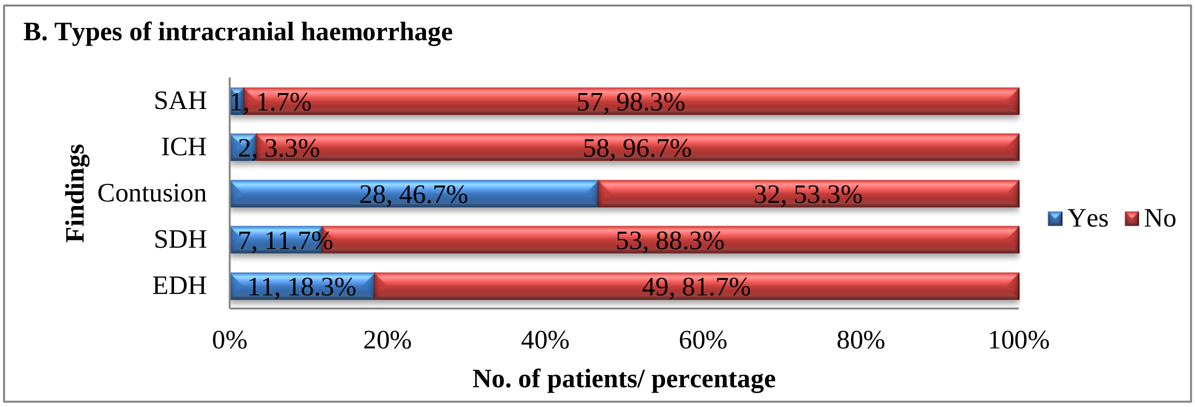
10.6.1 Skull fractures

From the 60 patients seen with MCR-HIs in the study, 31 (51.7%) had skull fractures confirmed by head CT scan. (**Figure 10.7**) Three (5.0%) patients (all non-helmeted motorcycle occupants) had multiple skull fractures while 28 (46.7%) sustained a single fracture. Skull fractures were noted in 45.9% (n=17) of the operators, 50% (n=5) of the passengers and 69.2% (n=9) of the pedestrians. (**Table 10.5**)

A total of 35 individual skull fractures occurred in MCR-HI patients seen. These consisted of 22 (62.9%) linear and 13 (37.1%) depressed fractures. Overall, 18 (51.4%) skull fractures were compound. (**Figure 10.9**) Frontal (9, 25.7%) was the most commonly involved region, though fractures were distributed in almost all the regions of the skull; 6 (17.1%) parietal, 6 (17.1%) temporal, 5 (14.3%) frontobasal, 5 (14.3%) temporobasal and 4 (11.5%) occipital. (**Figure 10.10**) Six (17.1%) skull base fractures (i.e. 5 temporobasal and 1 frontobasal) were associated with CSF leakage. (**Table 10.6**)

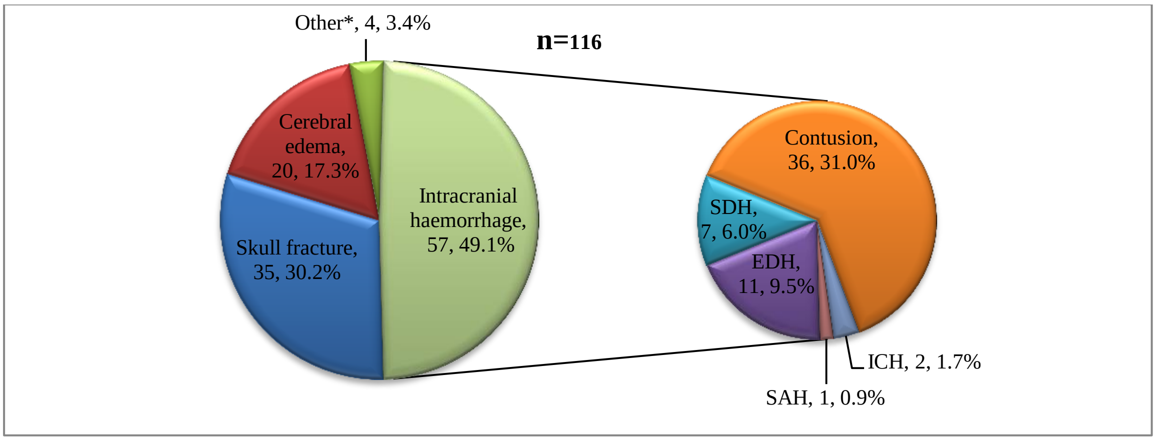
Figure 10.7: Head CT findings





Note: *Other findings included brainstem ischaemic infarct and pneumocephalus found in one (1.7%) and 3 (5.0%) individuals, respectively. Some patients had more than one lesion. EDH = extradural hematoma, SDH = subdural hematoma, ICH = intracerebral hematoma, Contusion = cerebral contusion, SAH = subarachnoid haemorrhage.

Figure 10.8: Skull and intracranial lesions



Note: *Other findings included brainstem infarct (1, 0.9%) and pneumocephalus (3, 2.5%). EDH = extradural hematoma, SDH = subdural hematoma, ICH = intracerebral hematoma, Contusion = cerebral contusion, SAH = subarachnoid haemorrhage.

10.6.1.1 Operators

Skull fractures were present in 45.9% (n=17) of the operators. Two (5.4%), both non-helmeted, had sustained multiple skull fractures and the rest (15, 40.5%) harboured a single lesion. The fractures were seen in 10.0% (n=1) of the helmeted, 75.0% (n=12) of the non-helmeted and 36.4% (n=4) of the operators with unknown helmet use status. (**Table 10.5**)

Twenty individual skull fractures were seen amongst operators, comprised of 14 (70.0%) linear and 6 (30.0%) depressed fractures. Most fractures (15, 75.0%) occurred in the non-helmeted. Forty-five per cent (n=9) of these fractures were compound. (**Figure 10.9**) These fractures were distributed throughout the skull (4, 20.0% frontal; 4, 20.0% parietal; 4, 20.0% temporal; 4, 20.0% frontobasal; 3, 15.0% temporobasal; 1, 5.0% occipital), though predominantly in the anterior regions. (**Figure 10.10**) Four (20.0%) skull base fractures, including all temporobasal (3, 15.0%) and one frontobasal (5.0%), were associated with CSF leakage. (**Table 10.6**)

10.6.1.2 Passengers

Fifty per cent (n=5) of the passengers with MCR-HI had a skull fracture and all these occurred in the non-helmeted. Patients with skull fractures represented 62.5% (n=5) of the non-helmeted passengers. Neither the helmeted passenger nor the one with unknown helmet use status had a skull fracture. Only one (10.0%) passenger had more than one skull fracture. (**Table 10.5**) The six individual skull fractures seen among passengers included 4 (66.7%) linear and 2 (33.3%) depressed fractures. There was only one (16.7%) compound fracture in this patient category. (**Figure 10.9**) Fractures were located in the frontal (3, 50.0%), parietal (2, 33.3%) and frontobasal (1, 16.7%) regions. None occurred in the temporal, temporobasal or occipital region. (**Figure 10.10**) The skull base fracture was not associated with CSF leakage. (**Table 10.6**)

Table 10.5: Skull fractures

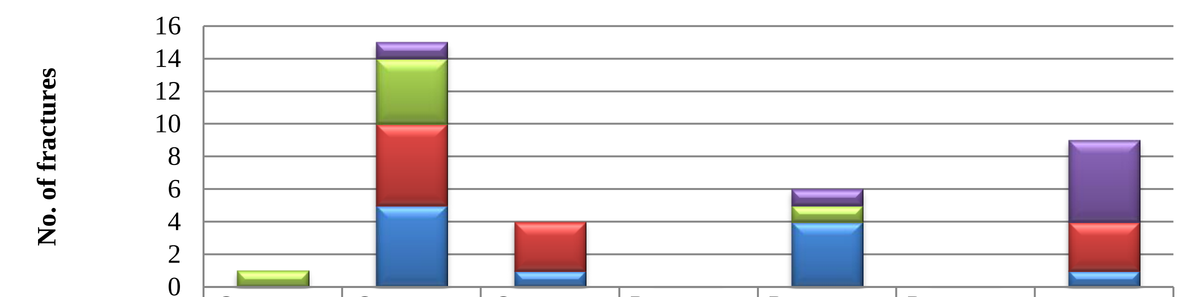
Skull fractures- general						
Patient category		Single	Multiple	None	Total	p-value
Operators		15 (40.5%)	2 (5.4%)	20 (54.1%)	37 (100%)	0.398
Passengers		4 (40.0%)	1 (10.0%)	5 (50.0%)	10 (100%)	
Pedestrians		9 (69.2%)	0	4 (30.8%)	13 (100%)	
Overall		**28 (46.7%)**	**3 (5.0%)**	**29 (48.3%)**	**60 (100%)**	
Skull fracture and helmet use						
Helmet use status		Single	Multiple	None	Total	p-value
Helmeted	Operators	1 (10.0%)	0	9 (90.0%)	10 (100%)	0.752
	Passengers	0	0	1 (100%)	1 (100%)	
	Overall	**1 (9.9%)**	**0**	**10 (90.1%)**	**11 (100%)**	
Non-helmeted	Operators	10 (62.5%)	2 (12.5%)	4 (25.0%)	16 (100%)	0.525
	Passengers	4 (50.0%)	1 (12.5%)	3 (37.5%)	8 (100%)	
	Overall	**14 (58.3%)**	**3 (12.5%)**	**7 (29.2%)**	**24 (100%)**	
Unknown	Operators	4 (36.4%)	0	7 (63.6%)	11 (100%)	0.480
	Passengers	0	0	1 (100%)	1 (100%)	
	Overall	**4 (33.3%)**	**0**	**8 (66.7%)**	**12 (100%)**	

Note: Single = single fracture, multiple = more than one fracture, none = no fracture present

10.6.1.3 Pedestrians

Out of the 13 pedestrians with MCR-HI, 69.2% (n=9) incurred skull fractures and all had a single fracture. (**Table 10.5**) There were 5 (%) depressed and 4 (%) linear fractures among the pedestrians. Eight (88.9%) of the skull fractures were compound. (**Figure 10.9**) The fractures were located in the occipital (3, 33.3%), frontal (2, 22.2%), temporal (2, 22.2%) and temporobasal (2, 22.2%) regions. (**Figure 10.10**) Both Skull base fractures (2, 22.2%) were associated with CSF leakage. (**Table 10.6**)

Figure 10.9: Types of skull fracture



Fracture type	Operators: H	Operators: NH	Operators: NK	Passengers : H	Passengers : NH	Passengers : NK	Pedestrians
DC fracture	0	1	0	0	1	0	5
DS fracture	1	4	0	0	1	0	0
LC fracture	0	5	3	0	0	0	3
LS fracture	0	5	1	0	4	0	1

DC = depressed compound, DS = depressed simple, LC = linear compound, LS = linear simple, H = helmeted, NH = non-helmeted, NK = helmet use status not known

Figure 10: Location of skull fractures

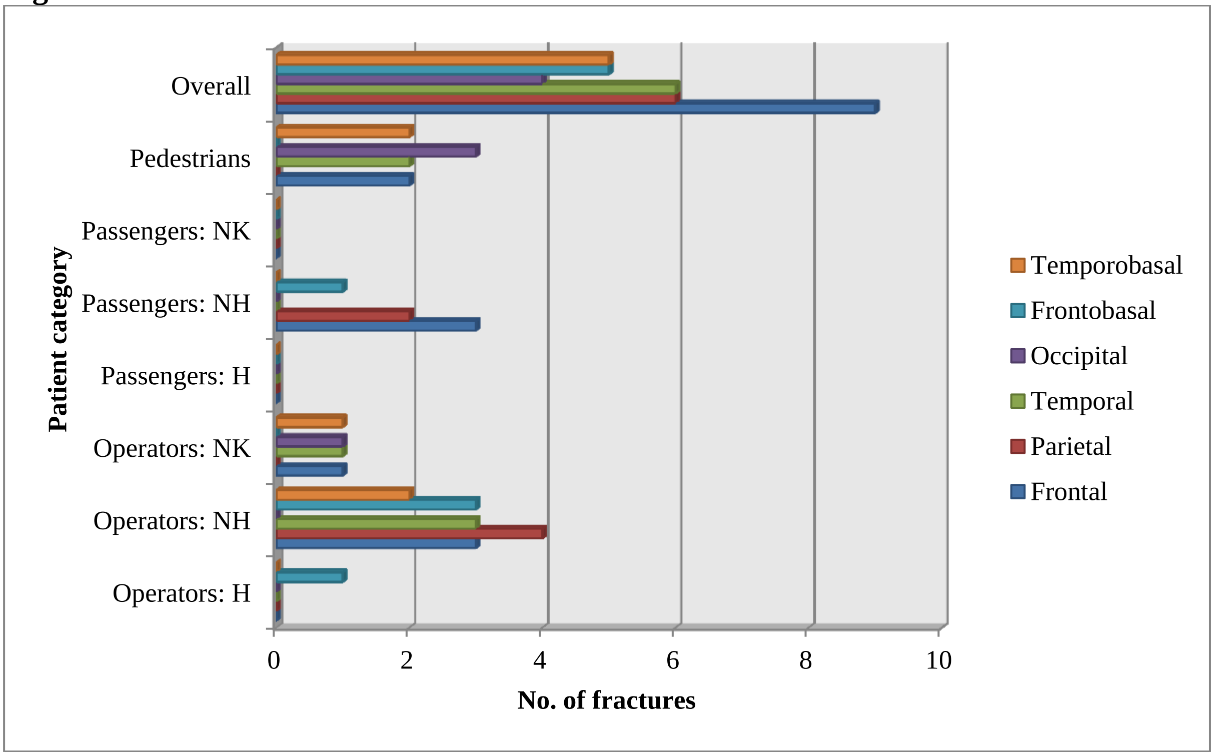


Table 10.6: Distribution and characteristics of skull fractures

		Operators			Passengers			Pedestrians	Total
		H	**NH**	**NK**	**H**	**NH**	**NK**		
Frontal	LS fracture	0	0	1	0	2	0	0	**3**
	LC fracture	0	2	0	0	0	0	0	**2**
	DS fracture	0	1	0	0	1	0	0	**2**
	DC fracture	0	0	0	0	0	0	2	**2**
Frontobasal	LS fracture	0	1	0	0	1	0	0	**2**
	LC fracture	0	0	0	0	0	0	0	**0**
	DS fracture	1	1	0	0	0	0	0	**2**
	DC fracture	0	1*	0	0	0	0	0	**1**
Parietal	LS fracture	0	1	0	0	1	0	0	**2**
	LC fracture	0	1	0	0	0	0	0	**1**
	DS fracture	0	2	0	0	0	0	0	**2**
	DC fracture	0	0	0	0	1	0	0	**1**
Temporal	LS fracture	0	3	0	0	0	0	1	**4**
	LC fracture	0	0	1	0	0	0	0	**1**
	DS fracture	0	0	0	0	0	0	0	**0**
	DC fracture	0	0	0	0	0	0	1	**1**
Temporobasal	LS fracture	0	0	0	0	0	0	0	**0**
	LC fracture	0	2*	1*	0	0	0	2*	**5**
	DS fracture	0	0	0	0	0	0	0	**0**
	DC fracture	0	0	0	0	0	0	0	**0**
Occipital	LS fracture	0	0	0	0	0	0	0	**0**
	LC fracture	0	0	1	0	0	0	1	**2**
	DS fracture	0	0	0	0	0	0	0	**0**
	DC fracture	0	0	0	0	0	0	2	**2**
Total		**1**	**15**	**4**	**0**	**6**	**0**	**9**	**35**

NOTE: Frontobasal and temporobasal constituted skull base fractures. *Compound frontobasal and temporobasal fractures were associated with CSF leakage. LS= linear simple, LC= linear compound, DS= depressed simple, DC= depressed compound, H= helmeted, NH= none helmeted, NK= helmet use status not known.

10.6.2 Intracranial haemorrhage

Intracranial haemorrhage occurred in 70.0% (n=42) of the MCR-HI patients seen. Twenty per cent (n=12) of the MCR-HI patients had multiple intracranial haemorrhagic lesions, while 50.0% (n=30) incurred only one lesion. 70.3% (n=26) of operators, 80.0% (n=8) of passengers and 61.5% (n=8) of pedestrians sustained an intracranial haemorrhagic lesion. (**Table 10.7**)

Table 10.7: Intracranial haemorrhage

General					
Patient category	Single lesion	Multiple lesions	None	Total	p-value
Operators	17 (46.0%)	9 (24.3%)	11 (29.7%)	37 (100%)	0.674
Passengers	6 (60.0%)	2 (20.0%)	2 (20.0%)	10 (100%)	
Pedestrians	7 (53.8%)	1 (7.7%)	5 (38.5%)	13 (100%)	
Overall	**30 (50.0%)**	**12 (20.0%)**	**18 (30.0%)**	**60 (100%)**	

Intracranial haemorrhage and helmet use						
Helmet use status		Single lesion	Multiple lesions	None	Total	p-value
Helmeted	Operators	4 (40.0%)	2 (20.0%)	4 (40.0%)	10 (100%)	0.312
	Passengers	1 (100%)	0	0	1 (100%)	
	Overall	**5 (45.5%)**	**2 (18.2%)**	**4 (36.3%)**	**11 (100%)**	
Non-helmeted	Operators	9 (56.2%)	3 (18.8%)	4 (25.0%)	16 (100%)	0.599
	Passengers	5 (62.5%)	2 (25.0%)	1 (12.5%)	8 (100%)	
	Overall	**14 (58.3%)**	**5 (20.8%)**	**5 (20.8%)**	**24 (100%)**	
Unknown helmet use	Operators	4 (36.4%)	4 (36.4%)	3 (27.2%)	11 (100%)	0.221
	Passengers	0	0	1 (100%)	1 (100%)	
	Overall	**5 (41.7%**	**4 (33.3%)**	**3 (25.0%)**	**12 (100%)**	

Association of intracranial haemorrhage and skull fracture				
Haemorrhage type/ Frequency (n=57)	Fracture present	No fracture	Total	p-value
Extradural hematoma (11, 19.3%)	7 (63.6%)	4 (36.4%)	11 (100%)	0.649
Subdural hematoma (7, 12.3%)	2 (28.6%)	5 (71.4%)	7 (100%)	
Subarachnoid haemorrhage (1, 1.7%)	0	1 (100%)	1 (100%)	
Cerebral contusion (36, 63.2%)	17 (47.2%)	19 (52.8%)	36 (100%)	
Intracerebral hematoma (2, 3.5%)	1 (50.0%)	1 (50.0%)	2 (100%)	
Overall	**27 (47.4%)**	**30 (52.6%)**	**57 (100%)**	

Extraparenchymal haemorrhagic lesions = extradural hematoma, subdural hematoma, and subarachnoid haemorrhage. Intraparenchymal haemorrhagic lesions = cerebral contusion and intracerebral hematoma.

Overall, 57 individual intracranial haemorrhagic lesions were seen amongst the MCR-HI patients in this study. There were 38 (66.7%) intraparenchymal and 19 (33.3%) extraparenchymal lesions. Twenty-seven (47.4%) intracranial haemorrhagic lesions were associated with a skull fracture. Extradural haematomas (7, 63.6%) exhibited the strongest association. Intracranial haemorrhage occurred in 79.1 % (n=19) of the non-helmeted motorcycle users. Similarly, 63.7% (n=7) of the helmeted had sustained intracranial haemorrhage. (**Table 10.7**)

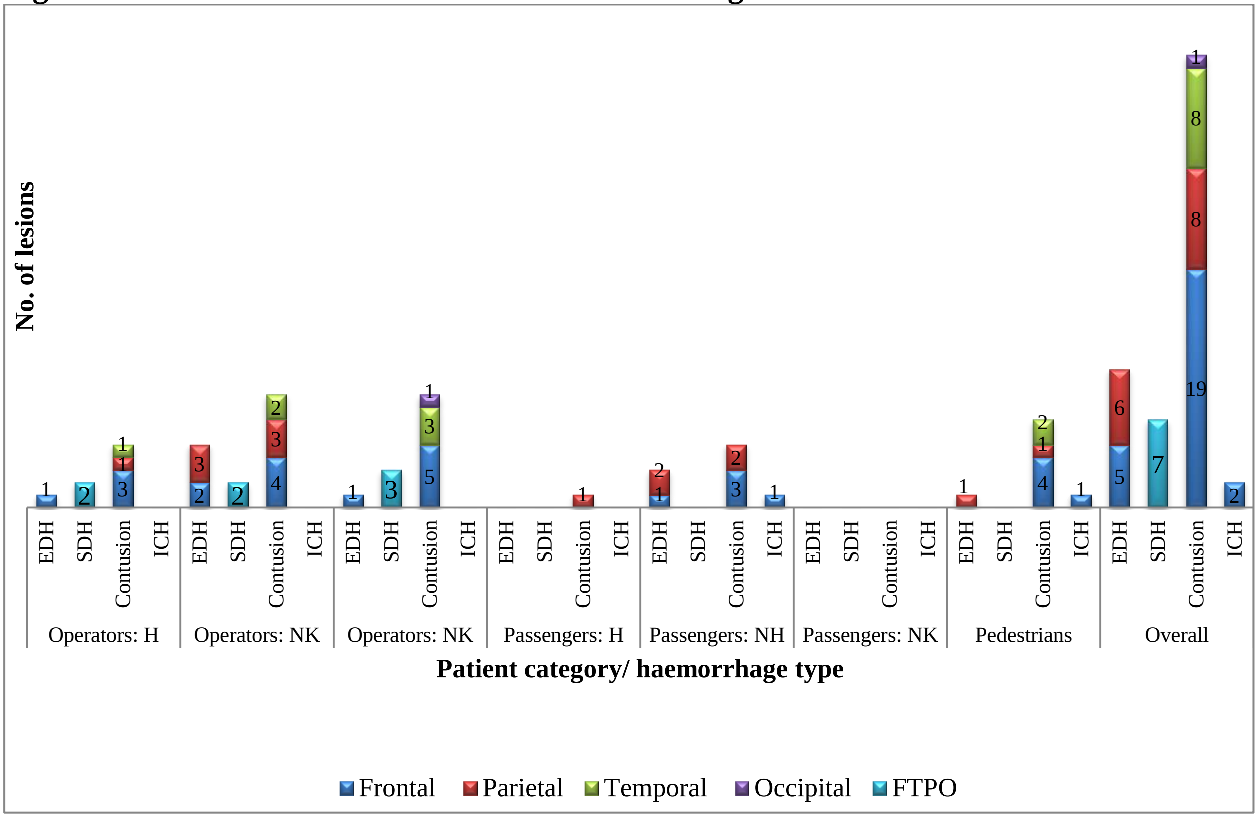
Cerebral contusions (36, 63.2%) and intracerebral hematomas (2, 3.5%) constituted the intraparenchymal haemorrhagic lesions and were distributed in essentially all the lobes (frontal 21, 36.8%; parietal 8, 14.0%; temporal 8, 14.0%; occipital 1, 1.8%), though a predominance in the frontal lobes was notable. Both intracerebral haematomas were found in the frontal lobes. Extraparenchymal haemorrhagic lesions comprised extradural hematomas (11, 19.3%), subdural hematomas (7, 12.3%) and subarachnoid haemorrhage (1, 1.7%). Extradural haematomas were located in the frontal (5, 8.8%) and parietal (6, 10.5%) regions with almost equal frequency whereas all the subdural hematomas were extensive, involving the fronto-temporo-parieto-occipital region. The subarachnoid haemorrhage was on the frontoparietal convexity, within the sulci, and was associated with frontotemporal cerebral contusions. (**Figure 10.11**)

10.6.2.1 Operators

In this study, 70.3% (n=26) of the operators with MCR-HI sustained an intracranial haemorrhagic lesion. Forty-six per cent (n=17) of the operators with MCR-HI harboured a single lesion, whereas multiple lesions were present in 24.3% (n=9) of the patients. Intracranial haemorrhage was noted in 60.0% (n=6) of the helmeted, 75.0% (n=12) of the non-helmeted and 72.8% (n=8) of the operators with unknown helmet use status. (**Table 10.7**)

A total of 38 intracranial haemorrhagic lesions were observed amongst the operators. There were 23 (60.5%) intraparenchymal and 15 (39.5%) extraparenchymal haemorrhagic lesions. With no intracerebral hematoma observed, cerebral contusion (n=23) was the only intraparenchymal haemorrhage type seen. Cerebral contusions were mainly located in the frontal lobe (12, 31.6%), with the remainder found in the parietal (4, 10.5%), temporal (6, 15.8%) and occipital (1, 2.6%) lobes. Extradural hematomas (7, 18.4%) and subdural hematomas (7, 18.4%) formed the majority of extraparenchymal haemorrhagic lesions, with subarachnoid haemorrhage (1, 2.6%) being the least observed. Extradural haematomas were found in the frontal (4, 10.5%) and parietal (3, 7.9%) regions. The subdural hematomas (7, 18.9%) encountered were extensive, involving the fronto-temporo-parieto-occipital region. (**Figure 10.11**) All subdural haematomas seen in the study occurred amongst the operators.

Figure 10.11: Distribution of intracranial haemorrhagic lesions



Note: Extraparenchymal haemorrhage included EDH, SDH and SAH. Intraparenchymal haemorrhage included cerebral contusions and ICH. The only subarachnoid haemorrhage was not included in the above figure. The haemorrhage occurred in an operator with unknown helmet use status, was located in frontoparietal convexity (within the sulci) and associated with frontotemporal cerebral contusions. EDH = Extradural hematoma, SDH = Subdural hematoma, SAH = subarachnoid haemorrhage, ICH = Intracebral hematoma, Contunsion = Cerebral contusion, FTPO = Fronto-temporo-parieto-occipital.

10.6.2.2 Passengers

Eight (80%) of the ten passengers seen with MCR-HI sustained an intracranial haemorrhagic lesion. Sixty per cent (n=6) of the passengers had a single intracranial haemorrhagic lesion, whereas 20.0% (n=2) harboured more than one lesion. The only helmeted passenger had an intracranial haemorrhage, as were 87.5% (n=7) of the non-helmeted passengers. The passenger with unknown helmet use status had no intracranial haemorrhage. (**Table 10.7**)

Ten intracranial haemorrhagic lesions were present amongst the passengers. These comprised of 7 (70.0%) intraparenchymal and 3 (30.0%) extraparenchymal lesions. Intraparenchymal intracranial haemorrhagic lesions included 6 (60.0%) cerebral contusions and one (10.0%) intracerebral hematoma. Intraparenchymal intracranial haemorrhagic lesions were located in the frontal (4, 40.0%) and parietal (3, 30.0%) lobes. All extraparenchymal haemorrhagic lesions occurred in the non-helmeted and were extradural haematomas (3, 30.0%). These were located in the frontal (1, 10.0%) and parietal (2, 20.0%) regions. (**Figure 10.11**)

10.6.2.3 Pedestrians

Intracranial haemorrhagic lesions were noted in 8 (61.5%) of the pedestrians with MCR-HI. Seven (53.8%) sustained a single intracranial haemorrhagic lesion, while 1 (7.7%) had more than one lesions. (**Table 10.7**)

There were 9 individual intracranial haemorrhagic lesions in this patient category. Except for one extraparenchymal lesion, the rest were intraparenchymal (8, 88.9%). The former was an extradural haematoma 1 (11.1%) while the latter consisted of cerebral contusions 7 (77.8%) and an intracerebral haematoma 1 (11.1%). The extradural haematoma was located in the parietal region, while intraparenchymal lesions were distributed in the frontal (5, 55.6%), parietal (1; 11.1%) and temporal (2; 22.2%) lobes. (**Figure 10.11**)

11.0 DISCUSSION

This is the first study to describe the pattern of motorcycle crash related head injury in Kenya. It is also one of the few to estimate the contribution of motorcycle crash related head injury to the total burden of head trauma in the country. The study revealed that motorcycle accident is an important cause of head trauma amongst patients attended at Kenyatta National Hospital, and the scourge of motorcycle crash related head injury mainly involves the economically active young men. Intracranial haemorrhage is the commonest craniocerebral injury type, while helmet use is low amongst patients with head injury due to motorcycle accidents. Though protective against head injury in general, helmets' protection from intracranial haemorrhage is limited.

11.1 Patient characteristics

Patients with motorcycle crash related head injury comprised of operators (37, 61.7%), passengers (10, 16.7%) and pedestrians (13, 21.6%). Other studies exploring motorcycle related injuries have also observed a high rate of operators in their cohorts. [14, 33, 36-38] This may be because operators, most of whom ride motorcycles for business, are ever on the roads and as such are exposed to a higher risk of road traffic injury than passengers and pedestrians.

The male dominance (55, 91.7%) found reaffirms previous observations by both local and international studies. [8, 14-17, 22, 36-38] In fact, all the patients in a study done in Uganda by Kamulegaya L.H. et al. [22] were male. According to Khanbhai and Lutomia, [15] the male predominance may be due to the fact that most of the riders are young men in business trying to make money through commercial motorcycle transportation. This assumption has been given credence in the current study, since all motorcycle operators were male.

The mean age of the patients was 29.4 years (SD 14.4 years, range 4 to 67 years). The age group 20 – 29 years old was the commonest. Forty-four (73.3%) patients were in the age group 20 - 49 years. Thus more than 70.0% of the patients with motorcycle crash related head injury were young people in the economically active age group. The economic importance of this group is highlighted by the finding that majority (41, 68.3%) of the patients in our cohort were involved in some form of economic activity. This picture is not peculiar to our study.

Many studies from developing countries, including those from Kenya, implicate the young aged between 20 and 40 years as the most commonly affected by motorcycle related injuries. [8, 14-17, 33, 36-38] Explaining similar findings in Nigeria, Nnadi et al. [37] blamed traffic congestion (in the cities) which compels many commuters to resort to using motorcycles as a way of circumventing the holdups. In the face of lacking formal jobs, the practice encourages many young ones to join commercial motorcycle driving as a source of living. [37] Different from results of previous studies on motorcycle related injuries in Kenya is the high proportion of children younger than 10 years old in this study. These children represented 13.3% (n=8) of the total patients and made up 61.5% of the pedestrians in our study cohort. Studies examining motorcycle related injuries in Kenya have reported rates of < 3.0%. [14-16, 36] Notably, none was reported by Sisimwo et al. [14] and Sisimwo and Onchiri. [36] Even Nigerian studies focussed on head injury due to motorcycle crashes did not report such a significant proportion of young children in their cohorts; 3.1% by Nnadi et al. [37] and < 1.9% by Yusuf et al. [17] However, a comparative figure (about 10%) was reported by Kigera and Naddumba in Kampala (Uganda). [8] These are significant findings since mortality, disability, and morbidity associated with motorcycle crash related head injury not only deprives the economy of the much needed human resource, but also threatens the future of Kenya; as even the very young are equally affected.

11.2 Accident characteristics

Motorcycle-vehicle collision (21, 35.0%) was the most common accident type. The observation has been noted in previous studies. [14, 15, 22, 36, 38] Reason advanced is that motorcycles are not visible to the vehicle drivers when in traffic. [36] Moreover, motorcycle riders are known to disregard road traffic regulations, [30] thus further exposing themselves to the risk of collision with vehicles sharing the roads with them. Therefore, implementation of safety measures aimed at increasing visibility of motorcycle riders whilst on the road (e.g. reflective clothing, keeping motorcycle lights on) and enforcement of road traffic regulations may help mitigate the problem of vehicle-motorcycle crashes and hence reduce the number of motorcycle accidents. Of note, in our study, is the relatively high rate of lone motorcycle crashes (20, 33.3%). This may be explained by the small sample size, and therefore calls for a further, larger study on the subject. In the current study, one (1.7%) passenger, a known epileptic, sustained severe head injury after falling off a moving motorcycle following a seizure episode. This highlights the vulnerability and lack of protection motorcycle riders are exposed to whilst on the road. [5] There is urgent need for the enactment and enforcement of legislation restricting the use of motorcycles by high risk patients (such as epileptics) to protect them from preventable injuries, including head injury. Compared to motorcycle occupants, no form of head protection exists for pedestrians. All pedestrians in our cohort suffered head injuries after being hit by a motorcycle whilst crossing the road. Education on road safety to pedestrians and enforcement of road traffic regulations to motorcycle riders will help reduce motorcycle-pedestrian crashes.

Most of the accidents (39, 65.0%) took place during the day, with the highest number of accidents recorded in the afternoon (22, 36.7%). Saidi and Mutiso [16] and recently Sisimwo and Onchiri [36] have reported similar observations. The finding may be related to an increase in transport activities associated with urban residents going to work in the early morning and as they make return trips in the late afternoon. These periods are typically associated with traffic jams, forcing a number of commuters to opt for motorcycles as a means of transportation. Increase in demand for the motorcycles leads to over speeding, overloading, use of wrong lanes or pedestrian walk ways, disregarding of traffic light signals and wrongful cutting-in by commercial motorcycle operators in order to beat the traffic and make a killing during these peak hours. These vices increase the risk of road traffic accidents and may explain the finding. Sisimwo and Onchiri hypothesised that the high number of crashes in the afternoon and evening may be attributed to rider fatigue, traffic rush hours and poor visibility. [36]

11.3 Burden of motorcycle crash related head injury

The prevalence of head injuries among motorcycle accident victims seen at Kenyatta National Hospital during the study period was 30.3% (n=60). This rate does not differ much with the 22.2% found by Saidi and Mutiso [16] at the same facility, eight years earlier. However, methodological differences between these two studies should be noted. Our study included everyone seen with motorcycle crash related head injuries, including those attended and discharged at Accident and Emergency department, whereas the earlier authors only considered those admitted, thus some cases might have been missed. More recently (2018), a study by Sisimwo and Onchiri [36] reported a higher prevalence (42.0%) at Kitale, in Western Kenya. The disparity in the rates between this and our findings may be explained by the differences in the study settings. In Nairobi, where our study was carried out, there are many other health facilities (private and public), a number of which have the capacity to handle head injuries. It is likely some of the head injury patients were treated at these facilities, hence reducing the number of cases presenting to KNH. Sisimwo and Onchiri, [36] on the other hand, did their study in Kitale; a smaller town with only few other facilities existing. [39]

Reviewing previous local studies [15, 16, 36] and our findings show an upward trend for motorcycle crash related head injury prevalence in Kenya. In western Kenya, Khanbhai and Lutomia (2009) [15] found a rate of 12.1% in a retrospective study done at Kakamega hospital, while Sisimwo and Onchiri (2018) [36] reported a prevalence of 42.0% at Kitale in the same region. Similarly, in Nairobi a dismal increase is obvious; 22.2% found by Saidi and Mutiso [16] in 2010, versus 30.3% reported in the current study. This observed progressive increase in the prevalence of head injuries among motorcycle accident victims may be related to the rise in number of motorcycles, [32] coupled with a lack of proportionate increase in the regulation of the subsector and education of the riders and pedestrians. Nine years ago, a 20.0% estimate was made by Kigera and Naddumba [8] in Kampala (Uganda). A later study (2013) at the same site by Kamulegeya et al. [22] reported a very high prevalence of 71.3%. Similarly, a high prevalence rate (63.4%) was noted by Solagberu et al. [38] in Nigeria. Considering the potential grave consequences of head injury, it is hoped that the rate of head injury among motorcycle crash victims in Kenya does not follow the trend exhibited in Uganda and Nigeria. Instead, appropriate and timely intervention should be undertaken thereby directing the rate of motorcycle crash related head injury towards a downward trajectory.

Motorcycle accident represents an important cause of head trauma at Kenyatta National hospital. This is demonstrated by the finding that motorcycle crash related head injury represented 25.0% of the total number of head injuries attended during the study period. This compares with both local and international studies. [40, 41] In Nakuru (Kenya), Nasio [40] found that motorcycle crash related head injuries accounted for 19.3% of the total head injuries seen at the local facility. Similarly, a study on severe traumatic brain injury in Uganda, Tran et al. [41] reported that 34% of the patients in their cohort sustained head injury from motorcycle mishaps. This knowledge is cardinal since measures aimed at preventing motorcycle accidents will lead to a proportionate reduction in the overall head injury burden.

11.4 Head injury severity

The Glasgow Coma Scale (GCS) was introduced in 1974 as a method for determining objectively the severity of brain dysfunction and coma after the occurrence of head trauma. [42] Though now used in other settings, it is by far the most widely used score to assess the severity of head trauma in clinical research and to compare series of patients. The main advantage of this scale is its simplicity; can be utilized by physicians, nurses, and other care providers with ease. The GCS is an important tool for prognostication, communication among health care personnel as well as management planning in patients with head trauma. [43] In the current study, the GCS was used to classify the severity of head injury into mild (GCS 13-15), moderate (9-12) and severe (3-8). More than one-fifth (14, 23.3%) of the patients in our cohort had sustained severe head injury. This is higher than that reported by Sisimwo et al. [15] (7.0%) at Kitale, Kenya. Our findings, however, agree with two Nigerian studies on the same subject. [17, 37] Yusuf et al. [17] and Nnadi et al. [37] found severe head injury was present in 19.2% and 24.0% of their patients, respectively. Considering the high cost associated with the management of severely head injured patients, [44] the severe head injury prevalence of more than 20.0% noted in our study highlights the huge burden exerted by the scourge of motorcycle crash related head injury on both our health care system and families.

11.5 Pattern of head injury

In order of decreasing frequency, common craniocerebral injuries/ lesions noted in this study were intracranial haemorrhage (42, 70.0%), scalp injury (34, 56.4%), and skull fracture (31, 51.7%). Cerebrospinal fluid otorrhea/ rhinorrhea (6, 10.0%), pneumocephalus (3, 5.0%), and brainstem infarct (1, 1.7%) were rare findings. To the best of our knowledge, this is the first local study to describe the pattern of craniocerebral injuries among patients with motorcycle crash related head injury in Kenya. Internationally, both clinical [17, 18, 45, 46] and autopsy

[47-49] studies have also reported intracranial haemorrhage, scalp injury, and skull fracture as the common lesions sustained by patients with motorcycle crash related head injury.

11.5.1 Intracranial haemorrhage

Intracranial haemorrhage was noted in all patient categories (operators 26, 70.3%; passengers 8, 80.0%; pedestrians 8, 61.5%), and there was no significant difference in distribution among the various motorcycle accident victims. Cerebral contusion (28, 46.7%), was the most common intracranial haemorrhagic lesion encountered. More than half (21 out of 38 or 55.3%) of the intraparenchymal haemorrhagic lesions (i.e. cerebral contusions and intracerebral haematomas) were located in the frontal lobes. Of the extraparenchymal haemorrhagic lesions (n=19), extradural hematomas were found in the parietal (6, 31.6%) and frontal (5, 26.3%) regions with almost equal frequency, whereas all the subdural hematomas (7, 38.9%) were extensive involving the fronto-temporo-parieto-occipital region. In international literature, Yusuf et al. [17] (Nigeria), Ankarath et al. [18] (United Kingdom) and Shehzad et al. [48] (Pakistan) also reported cerebral contusion as the most common intracranial haemorrhagic lesion; 33.3%, 26.7% and 28.3%, respectively. However, none of these studies have described the location of the intracranial haemorrhages. Therefore, our study has added an additional dimension to the understanding of the pattern of motorcycle crash related head injuries.

More than half (22, 52.4%) of the patients with intracranial haemorrhage had an associated skull fracture. The strongest association was observed amongst those who had sustained extradural haematomas (7, 63.6%). A similar finding was reported by Yusuf et al. [17] (Nigeria) who observed that extradural haematoma was more commonly associated with skull fractures. However, a report by Ankarath et al. [18] (United Kingdom) asserted that there was no association between the presence of a skull fracture and intracranial bleeding in their multi-centre retrospective study. Notable in this latter study [18] is the high rate of helmet use in their cohort i.e. patients had some protection against fractures; thus not easily comparable with the Nigerian [17] or our study, where helmet use rate was low.

11.5.2 Scalp injuries

Though not reported in most clinical studies, scalp injuries are a common finding in autopsy studies [49, 50] looking at pattern of head injuries among motorcycle accident victims. These injuries were present in 56.4% (n=34) of the patients in the current study, with pedestrians recording the highest rate (11, 84.6%). Scalp injuries were more common in the non-helmeted (13, 54.2%) than the helmeted (1, 9.1%) motorcycle occupants. Though, only looking at motorcycle occupants, an autopsy study by Sharma et al. [49] found scalp injuries in 84.3% of their cohort, overall. They reported that 66.1% of the helmeted and all the non-helmeted had scalp injuries. Scalp injuries, depending on the location, have the potential to cause cosmetic deformities of the head. Promotion and enforcement of helmet use may reduce the rate of these injuries among motorcycle users.

11.5.3 Skull fractures

Skull fractures were present in 51.7% (n=31) of the patients. It was the third commonest craniocerebral lesion seen on head CT scan, after intracranial haemorrhage and scalp injuries. A preponderance was noted among the pedestrians (9, 69.2%) compared to the motorcycle occupants (operators 17, 45.9%; passengers 5, 50.0%). Hospital based studies [17, 18, 45] conducted elsewhere have also shown skull fracture to be a common finding, with a number of reports variably observing rates of between 22 and 32%. Even higher figures have been reported in autopsy studies; 73.1% and 67.8% by Sharma et al. [47] and Ravikumar, [49] respectively. Compared to other hospital based studies, the rate of skull fractures in the current study (51.7%) is relatively higher. This finding may be explained by the observed low rate of helmet use in our study. The higher rate of skull fractures among pedestrians in the current study may be a reflection of the lack of head protection among these vulnerable road users. Secondly, younger children made up the majority (8, 61.5%) of patients in this patient category (pedestrians). Younger children are more susceptible to skull fracture than adults because a child's skull is thinner and more pliable. [50] The higher rates observed in autopsy studies may be related to the large mechanical impacts associated fatal injuries, which are sufficient to cause skull fracture, even in patients with helmets. [47, 51]

Calvarial fractures comprised more than two-thirds (25, 71.4%) of the skull fractures while skull base fractures (10, 28.6%) constituted the remainder. Regarding type, linear fractures (22, 62.9%) made up majority of the skull fractures, overall. However, depressed fractures were more prevalent among the pedestrians (5, 55.6%) compared to the operators (6, 28.6%) and passengers (2, 33.3%). In their reports, both Zargar et al. [45] and Faduyile et al. [48]

observed an almost equal frequency of calvarial and skull base fractures. Similar to our finding, a study by Ravikumar [49] also reported linear fracture (55.4%) as the commonest fracture type encountered. The high rate of depressed skull fractures observed among pedestrians in the current study may be related to the weak skull; which is characteristic in younger children who constituted majority of the pedestrians in this study. [50] Depressed skull fractures carry an increased risk of primary injury to the brain because of intrusion of the bone fragment(s) and, depending on the location, may have significant cosmetic sequelae. [52]

Compound skull fractures result in a communication between the environment and the intracranial cavity, thus increasing the risk of central nervous system (CNS) infection. [17] Overall, more than half (19, 54.3%) of the skull fractures were compound. Importantly, almost all fractures (8, 88.9%) found among pedestrians were compound. This may be due to the weaker soft tissue cover (i.e. the scalp) found in the young children who made up the majority of pedestrians (8, 61.5%). The high rate of compound skull fractures among patients with motorcycle crash related head injury is worrying because these patients have no physical protection; therefore, the wounds are prone to contamination at the time of the accident and during transportation to the hospital. Contamination of compound skull fractures increases the risk of CNS infection.

Overall, frontal region (9, 25.7%) was the commonest location for fractures, though occipital fractures (3, 33.3%) were the commonest amongst pedestrians. No significant difference in skull fracture location was noted among the motorcycle occupants; frontal region was the commonest location. None of the literature consulted has described the location of skull fractures among patients with motorcycle related head injury. Thus our study identifies a knowledge gap for future research on motorcycle crash related head injury.

11.6 Helmet use

Helmets reduce the number and severity of head injuries among motorcycle users. [7] Combined with law implementation, increase in helmet use has been shown to decrease head injury and mortality rates among motorcycle riders. [19] Several studies have confirmed the efficacy of helmets in preventing head injuries, reducing their severity and the subsequent mortalities, among motorcyclists. [2, 14, 20-22, 36] Overall, helmets are effective in reducing head injuries by 69% and death by 42% among motorcycle crash victims. [2] They reduce the chance of fatal injury by 37% for motorcycle operators and by 41% for passengers. [20] Helmets further reduce the chance of non-fatal serious head injury and minor head injury by 13% and 8%, respectively. [21]

The overall rate of helmet use is about 60% and continue rising in States with mandatory helmet law in the United States. [6] However, a lower rate of helmet use is common place in middle and low-income countries. [9, 22] Hospital based studies have reported rates of helmet use of 24.7% in Tanzania, [9] 5.8% in Nigeria, [17] and 18.6% in Uganda. [22] Low rates of helmet use have also been reported in Kenya. [4, 16, 36, 53] A systematic observational study revealed rates of 35.1% and 37.4% in Thika and Naivasha, respectively. [53] In the current study, the rate of helmet use among the motorcycle occupants with motorcycle related head injury was low (11, 23.4%). Helmet use rates were 27.0% (n=10) and 10.0% (n=1) for operators and passengers, respectively. The observed rate compares with the finding in Kitale (28.0%), [36] but it is lower than the 43.0% reported much earlier by Saidi and Mutiso [16] at Kenyatta National Hospital. The relatively higher helmet use rate found by the earlier authors (Saidi and Mutiso [16]) may be explained by the fact that their study included all motorcycle crash victims admitted with all injury types, including a large number of those protected from head injury by the helmet. To the contrary, our study only examined victims with head injuries; a cohort likely to have high rate of defaulters. Our study cannot be compared with the study in Thika and Naivasha [53] because it was not hospital based, like ours. Though our study was not powered to explore the reasons for non-compliance, Saidi and Mutiso [16] implicated a lack of awareness on the importance of helmet use, cost of buying a helmet, and the hot tropical climate.

In Kenya, the law dictates mandatory use of helmets by motorcycle users. [54] However, uptake has been low as evidenced by persistently low helmet use rates reported by various local studies, [4, 16, 36, 53] including the current one. The low prevalence of helmet use highlighted in this study call for the urgent need to institute sustained efforts aimed at mitigating this problem in Kenya. This is will help reduce the risk of head injuries and their consequences among motorcyclists, whose number has been on the rise (alongside the rising motorcycle numbers) in recent years.

In the current study, severe head injury occurred in 20.8% (n=5) of the non-helmeted whereas none was recorded amongst the helmeted motorcycle occupants. Scalp injuries were found in 54.2% and 9.1% of the non-helmeted and helmeted, respectively. Further, less than ten per cent (1, 9.1%) of the helmeted motorcycle riders sustained skull fractures, compared to 70.8% (n=17) noted among the non-helmeted. These findings demonstrate that helmets are protective against severe head injury, scalp injury and skull fracture. This is in agreement with several previous studies. [2, 14, 20-22, 36, 47]

An autopsy study by Sharma et al. [47] found that 65% of the non-helmeted victims sustained intracranial haemorrhages as compared to 32% of the helmeted ones, thus concluding that helmets were protective against intracranial haemorrhage. In our study (and contrary to Sharma et al. [47]) intracranial haemorrhage was observed in 63.3% (n=7) of the helmeted motorcycle occupants, as was in 79.2% (n=19) non-helmeted motorcycle occupants. A notable protective effect against extradural hematomas was found, however; only 9.1% of the helmeted, compared to 33.3 % of the non-helmeted, had extradural hematomas. This demonstrates the helmet's poor efficacy in preventing intracranial injury other than extradural haemorrhage. This positive preventive effect of the helmet on extradural hematomas is likely related to its efficacy in preventing skull fractures; which were closely associated with extradural hematomas in this study. Though such a generalization should be made with caution, considering our small sample size, a study on biomechanics of motorcycle helmets [50] supports our conclusion. The authors asserted that motorcycle helmets perform inadequately in terms of mitigating the forces responsible for causing traumatic brain injury because they were originally intended/ designed to reduce the risk of potentially fatal head injuries caused by skull fracture fragments penetrating the brain. [50] Moreover, the higher impact speeds associated with motorcycle collisions result in life threatening cranial fractures, even in areas covered by the helmet. [50] Looking at pattern of injuries in helmeted motorcyclists in Singapore, Tham et al. [56] opined that there is a limit to the protection by helmets against head injury beyond which other factors, such as crash characteristics, will affect the severity of head injury even in helmeted motorcyclists. From the foregoing, it is apparent that helmet use promotion and enforcement among motorcycle users should be prioritised if motorcycle crash related head injuries are to be prevented or reduced. However, such measures should not implement helmet promotion/ enforcement in isolation because the protective benefits of the helmet are limited. Instead, a broader approach aimed at prevention of motorcycle accidents in general should be adopted. As Tham et al. [56] pointed out, this has important bearings on public health and education in that safe riding habits and behaviour must be promoted together with helmet use to see a reduction in the number of motorcycle casualties, altogether.

11.7 Associated injuries

Unlike vehicle occupants, motorcyclists and pedestrians are unprotected, thus when involved in an accident, traumatic injury to the head is often accompanied by injuries involving other parts of the body. [17] Associated injuries affect the head injury severity score (GCS in this study), [43] calls for a multidisciplinary approach to management, as well as influence outcome in head injury patients. [55] In this study, about one-third (19, 31.5%) of the patients with motorcycle related head injury had other injuries. Observed in 16.7% (n=10) of the patients, limb injuries (soft tissue injury, fractures and dislocations) were the commonest, followed by maxillofacial injuries (5, 8.3%). Injuries to the eyes (2, 3.3%) and the thoracic region (2, 3.3%) were the other injuries seen. Previous studies have also reported limb and maxillofacial injuries as common injuries associated with motorcycle crash related head injury. Shehzad et al. [46] had reported associated injuries in 41.9% of patients, with limb and facial injuries being the commonest. However, facial injuries (17.8%) were more than those involving the limbs (6.4%) in their study. Yusuf et al. [17] reported an even higher rate (77.8%) of associated injuries in their study. Though these authors found eye (38.3%) injury as the most frequently encountered, maxillofacial (24.7%) and limb (23.5%) injuries represented significant proportions. In India, an autopsy-based study [49] looking at the pattern of head injuries, found associated injuries in 65.7% of motorcyclists with head injury who had died following a road traffic accident. In that study chest (36.7%), followed by limb (10.6%), injuries formed majority of the associated injuries.

Associated spine injury has been reported in previous studies on motorcycle related head injury. [17, 47, 49] Spine injury has been found to influence outcome in severe head injury patients. [55] A study by Yusuf et al. [17] found spine injuries in 6.7% of their cohort. Though considering motorcyclists only, two autopsy-based studies reported similar results; 8.2% and 5.3% by Sharma et al. [47] and Ravikumar, [49] respectively. No patient had sustained cervical or lower spine injury in our study. Probably, such patients had died before reaching the hospital.

Overall, even if the helmet law was successful in changing the pattern of head injury among motorcyclists, they remain vulnerable to associated injuries. [56] These injuries require follow up, thus resulting in higher health resource utilisation, and economic loss (through sick leave) for the motorcyclists and society. [56]

11.8 Summary

Motorcycle crash related head injury is an important public health problem in Kenya. Though a law requiring mandatory helmet use exists, helmet use rate remains low amongst motorcyclists, especially passengers. Moreover, the helmet has limitations in protecting against head injury. Therefore public health and education efforts must be more holistic, emphasizing helmet use and safe riding habits/ behaviour, if the scourge of motorcycle crash related head injury is to be eradicated or reduced.

12.0 LIMITATIONS OF THE STUDY

The small sample size coupled with the fact that this was a single site study precludes generalization of our findings. The small sample size also affected calculations of the p-values for various variable associations; such a calculation on small numbers leads to inconclusive outcomes. Collection of information on helmet use in a clinical setting is not reliable because some motorcyclists may falsely indicate use of a helmet at the time of the accident, because the knowledge that not using one amounts to a traffic offence and therefore liable to prosecution. Motorcycle crash accident victims who died on the way to the hospital were not captured in this study. Thus the prevalence found may not reflect the true burden of the problem. There was no consultant radiologist among the researchers. This represents a potential for missing out some radiological findings critical in describing the pattern of head injury in motorcycle crash victims. Lastly, this study did not look at cost and outcome.

Inclusion of such would have given a more comprehensive understanding of the burden of motorcycle crash related head injury in our setting.

13.0 RECOMMENDATIONS

A. KNH

1. Improvement in recording of information on RTA victims, including motorcycle accident victims, in A & E department at KNH
2. Conduct more studies on motorcycle crash injuries

B. NTSA

1. Step up efforts to enforce the helmet law
2. Promotion of good/ appropriate road safety practices to all road users
3. Ensure strict regulation of the motorcycle subsector

C. Policy makers

Enactment of a law prohibiting use of motorcycles by certain risk groups, including (but not limited to) epileptics

D. Local authorities

1. Construction of pedestrian walk ways on major roads/ highways
2. Allocation of a special lane for motorcycles on major roads/ highways

E. Further studies

1. A similar large, multicentre study should be conducted
2. Further studies on cost and outcome of motorcycle crash related head injury recommended

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APPENDICES

Appendix 1: Glasgow coma scale

Glasgow Coma Scale (for age 4yrs and above)

Points†	Best eye opening	Best verbal	Best motor
6	–	–	obeys
5	–	oriented	localizes pain
4	spontaneous	confused	withdraws to pain
3	to speech	inappropriate	flexion (decorticate)
2	to pain‡	incomprehensible	extensor (decerebrate)
1	none	none	none§

Children's Glasgow Coma Scale (for children < 4yrs)

Points†	Best eye	Best verbal		Best motor
6	–	–		obeys
5	–	smiles, oriented to sound, follows objects, interacts		localizes pain
		Crying	Interaction	
4	spontaneous	consolable	inappropriate	withdraws to pain
3	to speech	inconsistently consolable	moaning	flexion (decorticate)
2	to pain	inconsolable	restless	extensor (decerebrate)
1	none	none	none	none

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Appendix 2: Questionnaire

QUESTIONNAIRE

Study topic: The prevalence, severity and pattern of head injury among motorcycle crash victims at Kenyatta national hospital

A. Demographic information

1. Age……………………………

2. Sex: (a) Male [ ] (b) Female [ ]

3. Marital status: (a) Single [ ] (b) Married [ ] (c) Divorced [ ]

4. Occupation ………………………………………………………………………………

5. Area of residence ...……………………………………………………………………

B. Accident information

6. Crash location……………………………………………………………………………

7. Date/ Time of:

(a) Crash …../..…/2017 ....AM/PM

(b) Arrival at KNH …../..…/2017 ....AM/PM

8. Referral: (a) Yes [ ] (b) No [ ]

9. Crash type: (a) Lone crash [ ] (b) Motorcycle-motorcycle [ ] (c) Vehicle-motorcycle [ ]

10. Patient position during crash: (a) Operator [ ] (b) Passenger [ ] (c) Pedestrian [ ]

11. History of loss of consciousness: (a) Yes [ ] ……………… (duration) (b) No [ ]

12. Helmet used at time of crash: (a) Yes [ ] (b) No [ ]

13. Mode of transport to KNH: (a) Ambulance [ ] (b) Police vehicle [ ] (c) Pvt vehicle [ ] (d) Other (specify)…………………………

C. Clinical examination findings

14. Post-resuscitation GCS ……………/15

15. Pupillary status:

- Size: (a) Normal [ ] (b) Constricted [ ] (c) Dilated [ ]
- Reaction to light: (a) Normal [ ] (b) Sluggish [ ] (c) Non-reactive [ ]

16. Scalp injuries (Specify Location: A = frontal; B = parietal; C = temporal; D = occipital; E = multiple): (a) Bruises [ ] (b) Scalp hematoma [ ] (c) Cut/ open wound [ ]

17. Signs of skull base fracture: (a) otorrhoea [ ] (b) rhinorrhoea [ ] (c) Racoon eyes [ ] (d) Battle's sign [ ]

18. Neurological deficit(s) (specify): ……………………………………………………

19. Associated injuries (specify injury type):

a. Eye [ ] ...…………………………………………………………………………
b. Maxillofacial, dental and mandibular injuries [ ] …………………………………..
c. Spine injury [ ] ...……………………………………………………………….
d. Neck injury [ ] ………………………………………………………………….
e. Thoracic injury [ ] ..…………………………………………………………….
f. Abdominal-pelvic injury [ ] ……………………………………………………
g. Limbs [ ] ..……………………………………………………………………….
h. Others (specify) ..……………………………………………………………..

D. Radiological (CT head) findings

Location: A = frontal; B = parietal; C = temporal; D = occipital; E = skull base; F = multiple

a. Normal [ ]

b. Skull fracture [ ]
c. Extradural hematoma [ ]
d. Subdural hematoma [ ]
e. Cerebral edema [ ]
f. Cerebral contusion [ ]
g. Intracerebral hematoma [ ]
h. Others (specify) ……………………………………………………………………….

HEAD INJURY DIAGNOSIS (based on clinical and radiological evaluation)

……………………………………………………………………………………

Appendix 3a: Consent information document [English]

CONSENT INFORMATION DOCUMENT

Study topic: The prevalence, severity and pattern of head injury among motorcycle crash victims at Kenyatta national hospital

Principle investigator: Dr Humphrey Kunda

Background. Motorcycles represent the most dangerous form of motorized transportation, and their increased use has been associated with a rise in motorcycle related crashes. With the rapid explosion of motorcycle numbers recently witnessed in Kenya, an increase in motorcycle crash-related deaths and injuries has been noted. Head injury is known to be the main cause of death, severe disease and long-term disability among motorcycle users.

In Kenya, little information is available on the problem of head injuries due motorcycle crashes. This study, therefore, seeks to establish some medical evidence about head injury among motorcycle crash victims seen at Kenyatta National Hospital (KNH). This information will be used in formulating measures to mitigate the problem of head injuries among motorcyclists, with regards to prevention and treatment.

Objectives. The objectives of this study are as follows:

i. Establish the prevalence of HI among motorcycle crash victims seen at KNH
ii. Ascertain the proportion of MCR-HIs among all head injuries seen at KNH
iii. Evaluate the severity of head injuries resulting from motorcycle crashes at KNH
iv. Describe the pattern of head injuries in patients with MCR-HI at KNH
v. Enumerate the rate of helmet use among patients with MCR-HI seen at KNH

Voluntary participation and right to withdrawal. Participation in the study is voluntary, i.e. the patients reserve the right to take part or not. Even after opting in, participants have the right to opt out of the study at any time, if they wish to. Information collected, thus far, shall not be used in the study. Declining to participate or withdrawal from the study will not result in any penalty or loss of benefits to which the patient is otherwise entitled, including treatment and care.

Confidentiality. All the information used in the study will be handled with strict confidentiality, and shall only be used for the purposes of this study. Participants' names and hospital numbers shall not be used and none will be published. However, knowledge gained from this study shall be shared with other experts throughout the world through conferences and publications.

Benefits of participation. There are no direct benefits (financial or otherwise) to the individual patient for taking part in this study. However, the results of the study will be vital in finding a lasting solution to prevent and/ or decrease deaths, disease and disability resulting from head injuries due to motorcycle accidents.

Risks of participation. This study will not alter, or interfere with, the course of patient treatment. Therefore, no physical or mental injury is anticipated to result from participating in this study.

Cost of treatment. No extra cost will be incurred for participating in this study. However, the normal cost of treatment [including necessary investigations] at KNH shall apply and will be borne by the participating patient.

Signed …………………………..

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Appendix 3b: Consent information document [Kiswahili]

HATI YA KUKUBALI KUSHIRIKI KATIKA UTAFITI

Mada ya utafiti: Kiwango cha maambukizi, ukali na muundo wa kuumia kichwa kati ya wanaopata ajali za pikipiki katika Hospitali ya Taifa ya Kenyatta

Mpelelezi Mkuu: Dr Humphrey Kunda

Mandharinyuma: Pikipiki zinawakilisha aina hatari sana ya usafiri kwa njia ya kutumia nchini. Kuongezaka kwa matumizi yake kunahusishwa na kuongezeka kwa ajali za pikipiki barabarani. Kutokana na kuongezeka maradufu kwa nambari za pikipiki inchini Kenya, vifo na majeraha kutokana na ajali za pikipiki zimeonekana. Kuumia kichwa ni sababu kuu ambayo husababisha kifo, maradhi makali na kulemaa kwa muda mrefu kati ya wenye kutumia pikipiki.

Nchini Kenya, habari kuhusu tatizo la majeraha ya kichwa kutokana na ajali za pikipiki ni nadra. Kwa hivyo, utafiti huu una lengo la kuonyesha kwa kiasi ushahidi wa matibabu kuhusu majeraha ya kichwa kwenye waadhiriwa wa ajali za pikipiki katika Hospitali ya Taifa ya Kenyatta. Habari hii inaweza kutumika katika mfumo wa kupunguza shida za majeraha ya kichwa kwenye waendeshaji pikipiki kwa upande wa kuzuia na matibabu.

Malengo. Malengo ya utafiti ni kama yafuatayo:

i. Kuzindua kiwango cha HI kati ya majeruhi wa ajali za pikipiki wanaoonekana katika Hospitali ya Taifa ya Kenyatta (KNH)
ii. Kuhakikisha uwiano wa MCR-HI kati ya majeraha yote ya kichwa inaonekana KNH
iii. Kutathmini uzito wa namna ya majeraha ya kichwa inayosababishwa na ajali za pikipiki kati wa wagonjwa wanaokena KNH
iv. Kuthibitisha muundo wa MCR-HIs kati ya wangonjwa wanaonekana KNH
v.
vi. Kuorodhesha kiwango cha matumizi ya kofia za chuma kati ya majeruhi wa ajali za pikipiki wanaonekana KNH

Ushiriki wa hiari na uhuru wa kujiondoa: Ushirika kwa utafiti ni wa hiari. Kuna haki ya kushiriki ama kutoshiriki. Hata baada ya kukubali kushiriki, kuna uhuru wa kujiondoa kutoka utafiti wakati wowote na habari iliyokusanywa haitatumiwa. Kukataa kushiriki ama kujiondoa kutoka utafiti huu hakutasababisha kupoteza faida ambayo ni haki ya mgonjwa kama kutibiwa na kuhudumiwa.

Usiri: Habari ambazo zitakusanywa katika utafiti zitashughulikiwa kwa usiri dhabiti na zitatumika kwa ajili ya utafiti huu pekee. Majina ya washiriki na nambari zao za hospitali hazitatumiwa wala kuchapishwa. Hata hivyo, habari zitakazo tokana na utafiti huu zita shirikishwa kwa wataalam kote duniani kupitia mikutano na kuchapishwa.

Manufaa ya kushiriki: Hakuna manufaa ya moja kwa moja (kifedha ama vinginevyo) kwa mgonjwa binafsi kwa kushiriki kwa utafiti huu. Hata hivyo, matokeo ya utafiti yatakuwa na umuhimu wa kutafuta suluhisho la kudumu ili kuzuia na/ama kupunguza vifo, ugonjwa na ulemavu kutokana na majeraha ya kichwa yanayopatikana kwa sababu ya ajali za pikipiki.

Adhari za kushiriki: Utafiti huu hautabadilisha wala kuingilia kati ya matibabu ya mgonjwa. Kwa hivyo, hakuna mathara ya mwili wala ya mawazo yanayotarajiwa kutokana na kushiriki katika utafiti huu.

Gharama ya matibabu: Hakuna gharama ya ziada kutokana na kushiriki katika utafiti huu. Hata hivyo, gharama za kawaida za matibabu [ikiwa ni pamoja na uchunguzi unaohitajika] za KNH zitahitajika na zitagharamiwa na mgonjwa anayeshiriki katika utafiti.

Sahihi …………………………..

DR HUMPHREY KUNDA
Idara ya Neurosurgery
Idara ya Upasuaji
Chuo Kikuu cha Nairobi – Shule ya Matibabu

Hospitali ya Taifa ya Kenyatta
S.L.P. 1976-00202
Nairobi
Nambari ya simu ya rununu: 0706741186; Barua pepe: hklubwa@gmail.com

Appendix 4a: Consent certificate [English]

CONSENT CERTIFICATE

Study topic: The prevalence, severity and pattern of head injury among motorcycle crash victims at Kenyatta national hospital

Principal investigator: Dr Humphrey Kunda

I, ________________________________ have read/ have been explained to and clearly understand the content of the consent information document. My questions and concerns have been addressed. I hereby DO AGREE [ ] / DO NOT AGREE [ ] to participate in this study.

Signature of participant/ relative/ guardian ________________________________

Signature of witness _____________________ Date_________________________

Signature of researcher____________________ Date _________________________

Investigator's declaration

As the Principal Investigator in this research I declare that:

1) Any change to this protocol and/or procedure shall be notified to the Scientific Steering Committee and effected only after approval by the Ethical Review Committee.
2) The results of this study shall not be published, presented in any journal and/or conference without the written approval of the Director of the Institute.
3) Other members of the research team are bound by 1) and 2) above.

____ Date____________________

Principal Investigator's Signature

The principle investigator, **DR HUMPHREY KUNDA,** can be contacted at the following address;

Division of Neurosurgery
Department of Surgery
University of Nairobi- School of Medicine
Kenyatta National hospital
P.O Box 1976-00202

Nairobi

Cell number: 0706741186; Email: hklubwa@gmail.com

Contacts and address for the supervisors are as follows;

<table>
<tr><td>PROF. MWANG'OMBE N.J.M

Cell number: 0736222191
Email: nimrod@uonbi.ac.ke,
nim.juniahs@gmail.com</td><td rowspan="2">Division of Neurosurgery
Department of Surgery
University of Nairobi- School of Medicine
Kenyatta National hospital
P.O Box 1976-00202
Nairobi</td></tr>
<tr><td>MR AKUKU P.O.

Cell number: 0722518844
Email: patrickakuku@gmail.com</td></tr>
</table>

Contact address for KNH/ UoN-ERC is,

The KNH/ UoN Ethics and Research Committee (KNH/ UoN-ERC)

University of Nairobi

College of Health Sciences

P.O Box 1976-00202

Nairobi

Tel: 020 2726300 Ext 44355

OR

Kenyatta National Hospital

P.O Box 20723-00202

UNIVERSITY OF NAIROBI

Nairobi

Tel: 726300-9

Fax: 725272

Appendix 4b: Consent certificate [Kiswahili]

CHETI CHA RIDHAA

Mada ya utafiti: Kiwango cha maambukizi, ukali na muundo wa kuumia kichwa kati ya wanaopata ajali za pikipiki katika Hospitali ya Taifa ya Kenyatta

Mpelelezi Mkuu: Dr Humphrey Kunda

Mimi, ______________________________ nimesoma/nimeelezewa na nimeelewa wazi yaliyo ndani ya fomu ya kukubali kushiriki katika utafiti. Nimejibiwa maswali na yaliyokuwa yakinipatia wasi wasi yameshughulikiwa. Kwa hivyo NIMEKUBALI [ ] / SIJAKUBALI [ ] kushiriki katika utafiti huu.

Sahihi ya mshiriki/ jamaa/ mlezi ______________________________

Sahihi ya shahidi ____________________ Tarehe________________________

Sahihi ya mtafiti___________________ Tarehe ________________________

Azimio la Mtafiti

Mimi kama mpelelezi mkuu wa utafiti huu, natangaza ya kuwa:

Mabadilisho yoyote katika itifaki hii na/ama utaratibu yatajulishwa kwa kamati ya uendeshaji wa kisayansi na kutekelezwa mara moja baada ya kupitishwa na kamati ya maadili na utafiti.

1. Matokeo ya utafiti huu hayatachapishwa, kuwasilishwa kwa jarida na/ama mkutano bila ruhusa iliyoandikwa na Mkurugenzi wa Taasisi.
2. Washiriki wengine wa timu ya utafiti wamefungwa na masharti yaliyotangulia.

______________________________________ Tarehe____________________

Sahihi ya Mpelelezi Mkuu

Unaweza kuwasiliana na Mpelelezi Mkuu, **DR HUMPHREY KUNDA,** kupitia anwani ifuatayo;

Idara ya Neurosurgery
Idara ya Upasuaji
Chuo Kikuu cha Nairobi – Shule ya Matibabu
Hospitali ya Taifa ya Kenyatta
S.L.P. 1976-00202
Nairobi
Nambari ya simu ya mkononi: 0706741186;
Barua pepe: hklubwa@gmail.com

Anwani za wasimamizi wa upelelezi ni kam ifuatavyo

PROF. MWANG'OMBE N.J.M Simu ya rununu: 0736222191 Barua pepe: nimrod@uonbi.ac.ke, nim.juniahs@gmail.com	Idara ya Neurosurgery Idara ya Upasuaji Chuo Kikuu cha Nairobi – Shule ya Matibabu Hospitali ya Taifa ya Kenyatta S.L.P. 1976-00202 Nairobi
MR AKUKU P.O. Simu ya rununu: 0722518844 Barua pepe: patrickakuku@gmail.com	

Anwani ya kamati ya maadili ya Chuo Kikuu cha Nairobi na Hospitali ya kitaifa ya Kenyatta ni,

The KNH/ UoN Ethics and Research Committee (KNH/ UoN-ERC)
Chuo Kikuu cha Nairobi
Shule ya Matibabu
S.L.P 1976-00202
Nairobi
Nambari ya simu: 020 2726300 Ext 44355

AU

Hospitali ya Taifa ya Kenyatta
S.L.P 20723-00202
Nairobi
Nambari ya simu: 726300-9
Fax: 725272

Appendix 5.0: Work plan and budget

Appendix 5a: **The table illustrates the estimated time-frame for the study**

Period	**Activity**	**Deliverable outcome**
January – March 2017	Proposal development	-Complete research proposal document
April – August 2017	Ethics committee proposal evaluation	-Ethical approval of the proposed research
December 2017 - February 2018	Data collection	-Complete data collection -Sample size achieved
March - July 2018	Data analysis, report writing	-Presentation of research

	and presentation of results	findings -Complete thesis report -Submission of the thesis to the university

Appendix 5b: The table shows the expenditure breakdown for the study.

	Item (qty)	Unit cost (KSH)	Total cost (KSH)
1	Training of research assistants	10,000.00	10,000.00
2	Stipend for research assistants (04)	10,000.00	40,000.00
3	Stationary	14,000.00	14,000.00
4	Printing, photocopying and binding	35,000.00	35,000.00
5	Communication	10,000.00	10,000.00
6	Statistician fee	40,000.00	40,000.00
7	Research fee (KNH/UoN - ERC)	5,000.00	5,000.00
8	Incidentals	32,000.00	32,000.00
	GROSS TOTAL		**186,000.00**