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FACTORS ASSOCIATED WITH HEAD INJURIES AMONG MOTORCYCLE CRASH VICTIMS (MCVs) REPORTING AT THE TAMALE TEACHING HOSPITAL

BY

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DECLARATION

I, Anthony Baffour Appiah, declare that except articles and books which have been quoted, cited, and duly acknowledged in the references of this project, all information produced from this thesis is as a result of my original research undertaken under the supervision and that it has neither in whole nor part been presented for another degree in this university or elsewhere.

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DEDICATION

I dedicate this research to my family, beloved one, and Dr. Martin Morna for their immense support throughout my education

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ABSTRACT

Background: Motorcycle crashes contribute 91.2% to all causes of head injury-related deaths in the Northern region. The northern region of Ghana host about 60-70% of the country's motorcycle population. Motorcycle registrations increased to over 8000 motorbikes annually in the Tamale Metropolis. Despite the reported increase in motorcycle population and head injury-related deaths in the Northern region, little is known about underlying risk factors of traumatic head injuries among motorcycle users in the region. This study examined the factors contributing to head injuries among motorcycle crash victims (MCVs) reported at the Tamale Teaching Hospital.

Methods: An unmatched case-control study was employed to understand the factors contributing to head injuries in motorcycle crash victims (≥16 years) reported at the Tamale Teaching Hospital, from December 2019 to May 2020. The study population was all motorcycle crash victims (MCV) of age 16 years and above, with cases being those having moderate/severe head injuries (GCS<13 and AIS-head >1), while those without head injury (GCS ≥13 and AIS-head ≤1) were selected as controls. Consecutive sampling was used to recruit participants. A total of 469 out of 548 MCVs recruited met the inclusion criteria. Of this number, 265 were selected as cases while 204 were selected as controls. A semi-structured questionnaire was used to interview patients and as well as to review their medical records for clinical data. Frequencies, percentages, and mean were used to describe data. Chi-square test was used to assess the difference in proportion between the cases and controls while both bivariate and multivariate logistic regression analyses were used to estimate the crude and adjusted odds ratios respectively, with their corresponding 95% confidence intervals to examine risk factors of head injury in motorcycle crashes. All statistical analyses were considered significant at p-value ≤ 0.05.

Results: The overall age range of crashed victims was 16 to 89 years with a mean age of 34.2 (±13.5) years. Most of the crashed victims were in the age group 21–40 (cases: 57.4%, controls: 66.2%) and were mostly males (cases: 84.2%, controls: 63.2%). The proportion of motorcycle crash victims with head injury was high (56.5%, 265/469). A greater proportion of the cases 84.9% (225/265) were not wearing a helmet as compared to 43.1%(88/204) of the controls. The occurrence of motorcycle crashes in the darkness was relatively higher in cases (20.4%,54/265) than in controls (12.7%, 26/204). Only riding experience of 11 to 15 years (aOR = 2.91, 95%CI: 1.01, 8.39), partial helmet use (aOR = 4.78, 95%CI: 1.38, 16.55) and riding in darkness (aOR= 2.69, 95%CI: 1.28, 5.67) remained significant with head injury after controlling for confounders.

Conclusion: Significant factors associated with head injuries among motorcycle crash victims were riding experience (between 11 to 15 years), partial helmet use, and night-time driving (darkness). Education programs on road safety laws (e.g. helmet laws) particularly among young males as well as road safety law enforcement at night time, may result in a reduction of head injuries from motorcycle crashes.

Keywords: Motorcycle, head injury, case-control, crash victims, Northern region, Tamale Teaching Hospital

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LIST OF ABBREVIATIONS

AOR	Adjusted Odds Ratio
CCTH	Cape Coast Teaching Hospital
COR	Crude Odds Ratio
GCPS	Ghana College of Physicians and Surgeon
MCV	Motorcycle Crash Victims
MTTD	Motor Traffic & Transport Department
NRSC	National Road Safety Commission
RTA	Road Traffic Accident
RTI	Road Traffic Injury
SPSS	Statistical Package for Social Sciences
TTH	Tamale Teaching Hospital
WHO	World Health Organization

DEFINITION OF OPERATIONAL TERMS

TERMS	DEFINITION
Head injury	Damage to structures of the head as a result of trauma, i.e. a person with Glasgow Coma Scale (GCS) of moderate (GCS 9–12) to severe (GCS 8 or less) and Abbreviated (head) injury score (AIS) of moderate (2) to critical (6).
Teaching hospital	A referral hospital and serves as a training center for medical and allied health trainees
Motorcycle	A two or three-wheeled motorized vehicle
Motorcycle crash	A fatal or non-fatal injury caused by collisions involving at least one moving motorcycle
Mechanism of injury	The exact circumstance leading to the head injury, the objects involved, and the direction of energy.
Motorcycle rider	A person driving a two or three-wheeled motorized vehicle
Motorcycle passenger	A person drove on a two or three-wheeled motorized vehicle
Mild injury	Injury with an abbreviated injury score of 1
Moderate injury	Injury with an abbreviated injury score of 2
Serious/severe injury	Injury with an abbreviated injury score of 3 to 4
Critical injury	Injury with an abbreviated injury score of 5

CHAPTER ONE

INTRODUCTION

1.1 Background

A motorcycle crash is a crash involving at least one motorcycle where a motorcycle is defined as a motorcycle with a sidecar, police motorcycle, motor scooter, mini-bike, motorized pedal cycle, or special mobility vehicle such as bicycle and tricycles (NSW Centre for Road Safety, 2017). Motorcycle and bicycle contribute significantly to means of transportation worldwide (Yusuf, Odebode, & Adeniran, 2014). However, a major health concern has been linked to the increasing use of motorcycles most especially for commercial services in some developing countries. Extensive use of motorcycles has a potential threat to serious safety problems concerning injury frequency and severity (Chih-wei, Yi-chu, Hsiao-yu & Ping-ling, 2017).

Head injuries are the first among the top 20 non-fatal injuries sustained due to road traffic accidents worldwide mostly among motorcycle crashes (WHO, 2014). Both head and the extremities (including pelvic) injuries are the leading causes of deaths among motorcycle crash victims (Adeleye, 2017; Agrawal, Munivenkatappa, Rustagi, Mohan, & Subrahmanyan, 2017; Hofmann, Babbitt-jonas, Khoury, Perez, & Stephen, 2018; Sung et al., 2016).

The Global Assembly of the World Health Organization set a global target (3.6) to reduce road traffic morbidity and mortality by 50% in 2020 (WHO, 2018). However, the world recorded hundreds of millions of injuries and 1.35 million people die each year from road traffic injuries (WHO, 2018). More than 286,000 are motorcycle crash victims (RoSPA, 2017; WHO, 2014). About 80% of motorcycle fatalities occurred in Low and Middle-Income Countries (LMICs), making safety among motorcyclists a global concern (WHO, 2014). In the United State of America (USA), 5,286 motorcyclists are killed on roadways, which indicates that fatalities among motorcyclists occur 28 folds frequently compared to passengers of vehicle fatalities in vehicle accidents (National Center for Statistics and Analysis, NCSA, 2017).

Africa contributes about 60% of the world road traffic injury burden and higher proportions are recorded in the Sub-Saharan African region (WHO, 2014). In Nigeria, for instance, 22.8% of road traffic injuries (RTIs) are motorcycle-related injuries (Kipsaina, Eze, & Ozanne-smith, 2014). Motorcycle-related injuries account for 51.4% of injuries in Rwanda, and 55.8% of victims in motorcycle crashes are likely to sustain head injury (Mbanjumucyo et al., 2016).

Ghana is rated as the 31st accident-prone country in the world (WHO, 2017). According to the National Road Safety Commission (NRSC), Ghana recorded 6844 crashes among 11,167 vehicles resulting in 7,043 injuries and 12,52 fatalities in the first half of 2019. In another report, NRSC revealed that about 411deaths occurred between January-February of 2019 in Ghana, and 108 of these deaths are due to motorcycles crashes, representing 26.3% of all crashes. Further, motorcycle crashes contribute 28.6% (n=3546) out of the Motor Transport and Traffic Directorate (MTTD) records of 12,396 road crashes in 2018, and may have a proportional share in the 2,118 fatalities and 12,318 injuries recorded (Nyarko-Yirenkyi, 2019). Previously, MTTD had reported that the number of deaths among motorcycle riders increased from 200 cases in 2010 to 400 incidents in 2017 across the country. This represents a rise of 100% in the number of deaths over the seven years. The report further indicates that commercial motor riders (Okada riders) contribute 25% of the total incidents recorded within the period (Kwofi, 2019).

More than half of the people killed in traffic crashes are young adults aged between 15 and 44 years (Ghazali, Anuar, Pozi, & Tahir, 2012; World Health Organization, 2004).

Motorcycle-related injuries in the South-East Asia Region account for 50–60% of injuries and deaths from road traffic injuries in children aged < 15 years (WHO, 2014). The risk of motorcycle crash injuries is higher for males (91%) than females (9%) (Mccarthy, Walter, Hutchins, Tong, & Keigan, 2007).

The World Health Organization categorizes the risk factors of road traffic injuries (RTIs) (including motorcycle crash injuries) into four main categories: factors influencing risk exposure; risk factors influencing crash involvement; risk factors influencing injury severity; and risk factors influencing post-crash injury outcome (World Health Organization, 2009). The epidemiological studies focus on pre-event and event factors, which cover the first three categories of risk factors for RTIs. These factors are described as follows: (1) Factors influencing risk exposure are mainly underlying causes of RTIs and serve as the basis for other factors. These factors include rapid motorization; demographic factors; transport, land use, and road network planning the increased need for travel; and choice of less safe forms of travel (WHO, 2009). (2) The risk factors influencing crash involvement include road user factors, vehicle-related factors, and environmental or weather-related factors. The following factors have been documented to be the main risk factors influencing crash involvement among road users include speeding, mobile telephones use, cyclists and pedestrians, young rider, consumption of alcohol and recreational drugs, driver fatigue, and poor visibility (WHO, 2014). (3) The last category of risk factors for RTIs are those factors influencing injury severity. The most identified factors of this category include lack of protective or safety gear, not wearing crash helmets, and roadside objects (WHO, 2014).

1.2 Problem statement

Although the Ghana Road Traffic Act of 2004 (ACT 683) bans the use of motorcycle for commercial passenger transportation (Nelson, 2016), motorcycling is the leading mode of transport in the northern regions and contribute significantly to transport in the southern parts of Ghana (Ministry of Roads and Highways, 2013). Motorcycles are used as commercial taxis, ambulances in rural settings, delivery of purchased goods in urban cities, and other personal services (Turkson et al., 2013; Nelson, 2016). According to the Ministry of Roads and Highways Second National Household survey (2013) about 57.7% of transportation to health facilities, and schools, are by two-wheel motorcycles (34%) and bicycles (23.7%) in the Northern region.

The increased use of motorcycles has a cumulative effect on overall public safety. Studies have associated the use of motorcycles with higher road fatalities and multiple injuries such as head injuries (Chumpawadee et al., 2015;kudebong, 2009; Nyatundo et al., 2014; Solagberu et al., 2006; WHO, 2014a).

Head injury is the leading cause of deaths among the motorized two-wheeler users (Mabula et al., 2010; Pruthi et al., 2012; Sanyang et al., 2017; Tumwesigye, Atuyambe, & Kobusingye, 2016). An estimated 91.2% of head injuries are as a result of motorcycle-related road traffic crash in the Northern region of Ghana (Adam, Alhassan, & Yabasin, 2016).

The risk of sustaining a fatal head injury among motorcyclists has been linked to non-wearing of safety helmets in studies from different settings (Adeleye, 2017; Chih-wei et al., 2017; Hofmann et al., 2018; Sung et al., 2016; Turkson, Akple, Biscoff, Dzokoto, & Klomegah, 2013). A higher risk of head injury and fatality among motorcyclists have been linked with sociodemographic factors (such as younger age less than 25 years, male sex, education, inexperience, and driver training), safety factors (which include lack of protection, alcohol and drug use, riding speed, and risk-taking behavior), environmental or road condition (including poor visibility, time of the day, slippery road, untarred road) and mechanism of injury (single motorcycle accident, multiple motorcycle collision, motorcycle versus car or bicycle collision) (Chumpawadee et al., 2015; Mabula et al., 2010; Tumwesigye et al., 2016; Yusuf et al., 2014).

Severe head injuries from motorcycle crash prolong the length of hospitalization, increase disabilities and the incidence of fatalities (Adam et al., 2016; Adeleye, 2017; Jayasinghe, 2017; Solagberu et al., 2006; Tumwesigye et al., 2016; Yusuf et al., 2014; WHO, 2016). An increase in the duration of hospital stay accounts for a rise in the financial burden on the victim and their families as well as the health facilities (WHO, 2006). It is however unclear which of these several factors may be contributing to head injuries among cyclists in the Northern region.

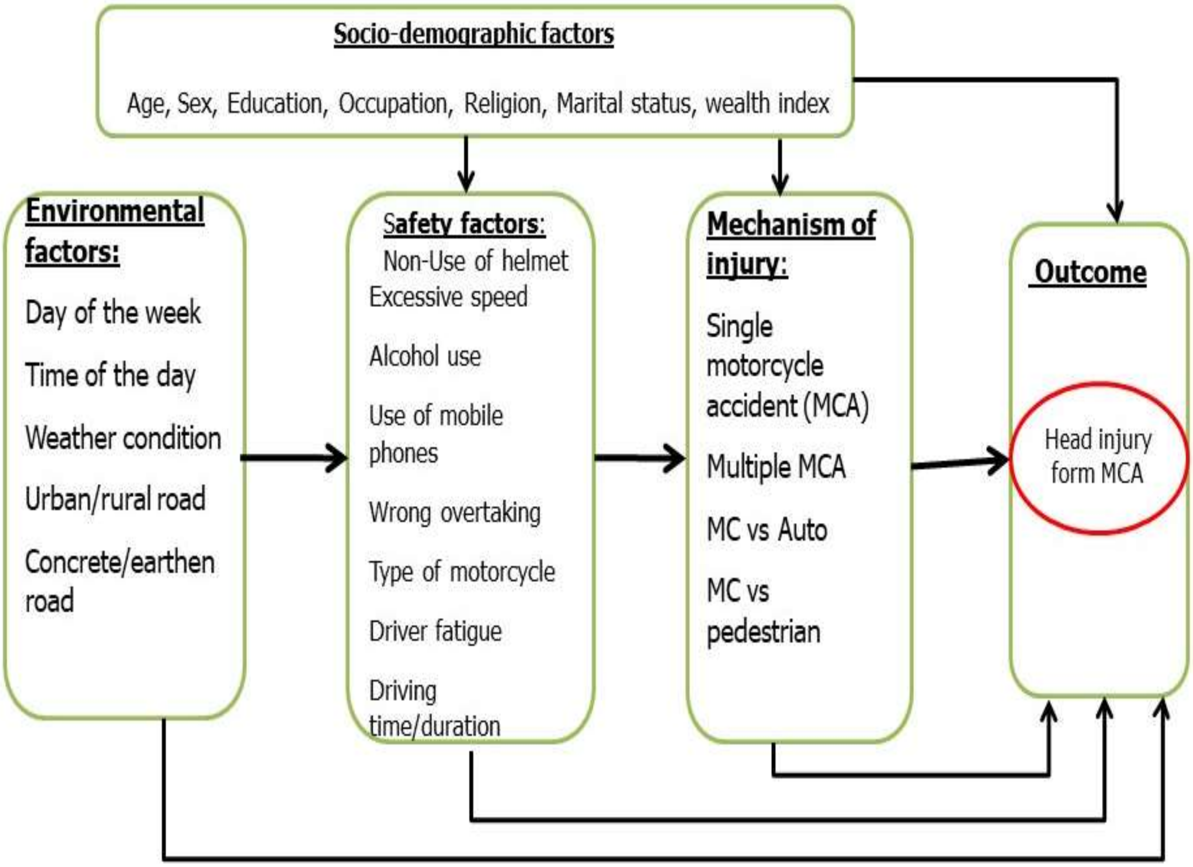
This study, therefore, determined the key risk factors associated with head injuries among motorcycle users in the Northern region of Ghana.

1.3 Justification

Based on the knowledge of possible risk factors for motorcycle injuries, advanced countries have developed effective injury prevention and control strategies for motorcycle injuries; which include mass-education, training, enforcement of motorcycle safety laws, and surveillance. This study estimated the proportion of head injuries linked to motorcycle crashes and associated head injuries in motorcycle crash victims with factors such as non-helmet use, ridding experience, mechanism of injury, environmental conditions like darkness, and others. The findings of this study provide vital information, contribute to knowledge and guide key stakeholders such as the Motor Traffic & Transport Department (MTTD), Ghana Private Road Transport Union (GPRTU), National Road Safety Commission (NRSC), Ministry of Health (MoH), Ghana Health Services (GHS), Kumasi Fogarty Trauma Project, Ghana College of Physicians and Surgeons and other policymakers in designing targeted prevention programs and taking evidence-based decisions to minimize the burden of head injury among motorcyclists.

1.4 Conceptual framework

The World Health Organization, in 2014 global report, proposed four categories of risk factors influencing the occurrences of road traffic injuries that include motorcycle injuries (Figure 1.1 below). These encompass factors influencing exposure to the risk of motorcycle crash like demographic factors; factors influencing crash involvement mainly of safety factors; factors influencing injury severity also include safety and environmental factors; and pre-hospital and hospital care are factors influencing post-crash injury outcome (WHO, 2014). With this concept, most epidemiological studies focus on the first three sets of factors that target exposure, crash involvement, and injury severity. This concept was adapted and modified to include factors contributing to head injuries among motorcycle users in motorcycle accidents(MCA).



Sources: Researcher own construct based on findings from the literature review

Figure 1.1: Conceptual framework of factors associated with head injury among motorcycle crash victims

The occurrence of head injury among motorcycle users could be influenced by users' sociodemographic factors, behavioral and safety factors, environmental and road conditions, and mechanism of injury.

The sociodemographic factors such as age, sex, education, occupation, religion, and marital status are likely to influence users' exposure to motorcycle crashes and adherence to motorcycle safety regulations. As the population increases the dependence on motorcycles (for either personal or commercial purposes) as a means for transport increases. In a limited resource country like Ghana, younger road users, males, and individuals with low economic status are the predominant group involved in motorcycle crashes. An unmarried young male (<40 years) may engage in more risky driving behaviors compared to married men with children. For instance, a case-control study found that married motorcycle crash victims are less likely to sustain injuries as compared to Single/separate/widow (OR=0.43, 95%CI=0.29–0.64) (Tumwesigye et al., 2016). Through education, one is made aware and could make informed choices to follow safe driving regulations compared to the less educated and uninformed ones. For instance, motorcyclists' knowledge of the benefit of helmet use (as a protective factor of head injuries) is likely to promote helmet use among such motorcyclists.

Environmental or road conditions including poor visibility, road congestion, roadside objects, time of the day, slippery road due to raining and road type are likely to influence crash involvement. These environmental factors coupled with safety factors will influence the frequency, injury mechanisms, and the severity of head injuries among motorcycle users. The day and time of riding a motorcycle are likely to be linked with the rider's age, sex, and occupation.

On safety factors: non-use of the helmet, excessive speed, alcohol or drug use, and driver fatigue have been strongly linked to crash injuries among motorcyclists.

Helmet use has long been established to have a higher protective effect on head injuries among motorcycle users worldwide(Peltzer & Pengpid, 2014; World Health Organization, 2004). Although Ghana has existing legislation that forbids not wearing helmets among motorcyclists, the rate of helmet use is low from 33% to 54% (Ackaah & Afukaar, 2010; Musah, Marfo, & Akpade, 2018; Turkson et al., 2013). Helmet use is influenced by age, sex, knowledge of benefits, driving experience, and others. The low rate of helmets use may imply that a higher proportion of motorcycle crash victims hit their heads against objects or vehicles, hence, higher incidence and severity of head injuries. Similarly, excess speed has corresponding effects on motorcycle crashes and subsequent head injuries. A rider's choice of speed is influenced by driving time, distance to be covered, type of road, and environmental conditions such as weather, natural light, speed limit, lighting system, and others. Alcohol or drug use above the Blood Alcohol Concentration (BAC) level will promote reckless driving and is influenced by sociodemographic factors like age, sex, religion, and marital status. Studies have confirmed a higher risk of traffic injuries like head injuries among people with BAC above 0.05 g/dl limit (Ngunu, 2015; WHO, 2015a; World Health Organization, 2004). Hence, alcohol consumption among motorcycle users may result in the occurrence of fatal head injuries.

Other safety factors that may influence the incidence of head injuries among motorcycles users include the use of mobile phones while driving, inappropriate overtaking, and the type of motorcycle used whether two-wheeled or three-wheeled.

The mechanism of injuries such as single motorcycle accidents, multiple motorcycle collisions, motorcycle versus a car, and motorcycle versus pedestrian/animal also has a direct impact on head injury. A study confirmed that motorcycle versus vehicle and that of the pedestrian are the common causes of head injuries (Mabula et al., 2010).

This study seeks to assess the influences of socio-demographic factors, environmental and road factors, safety factors, and the type of mechanism of injury on the occurrences of head injuries in Tamale, Northern Region, Ghana.

1.5 Research Questions

1. What proportion of motorcycle crash victims are with head injury?
2. What mechanism of injuries are associated with head injury among motorcycle crash victims reported at Tamale Teaching Hospital?
3. Which safety or behavioral factors are associated with head injury among motorcycle crash victims reported at Tamale Teaching Hospital?

4. Which environmental factors are associated with head injury among motorcycle crash victims reported at Tamale Teaching Hospital?

1.6 Objectives

1.6.1 Main Objective

To determine factors associated with head injury among motorcycle crash victims reporting to the Tamale Teaching Hospital in Ghana.

1.6.2 Specific Objectives

1. To estimate the proportion of motorcycle associated head injury
2. To identify the mechanisms of injuries associated with head injury
3. To determine the safety or behavioral factors associated with head injury
4. To determine the environmental factors associated with head injury

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This section reviews related studies on the proportion of head injuries and associated factors among Motorcycle Crash Victims (MCVs). The section has been organized systematically under the following headings: the trend of registered motorcycle, motorcycle use, the burden of motorcycle crashes, the burden of head injuries, and factors associated with head injuries which have been captured under subsections such as sociodemographic factors, mechanisms of injury, safety or behavioral factors, and environmental factors.

2.2 Trends of Motorcycle Registration

According to the World Health Organization (2014), there were around 90 million motorcycles in the WHO South-East Asia Region accounting for 70% of all registered vehicles. A total of 329 425 registered motorcycles were recorded in 2003, accounting for 42% of all registered vehicles in Bangladesh. Data by the Society of Indian Automobile Manufacturers (SIAM) estimates Africa contributes 1% of 313 million global motorcycle population(Organization for economic co-operation and development, 2008). According to transport statistics for three cities in Africa (2011), the population of commercial motorcycles was 43,000 in Kampala (Uganda), 200,000 in Lagos (Nigeria), and 22,000 in Douala (Cameroon) (Kumar, 2011).

Hesse and Ofosu (2014), conducted a 21 year (1991-2011) comparative analysis of the regional distribution of road traffic casualties and vehicle registrations in Ghana. This study showed that the rate of motor vehicle registration including motorcycles exceeded the population growth rate in Ghana. For instance, the estimated national population growth from 1991 to 2011 was 69.3%, however, the estimated population of registered vehicles increased by 828.2% (Hesse & Ofosu, 2014). This study also revealed that the odds of being injured or dying from road traffic accident is much higher in the Northern region. The region recorded a little above 233 road traffic casualties out of every 100 accidents (Hesse & Ofosu, 2014).

Ayuekanbey (2016) conducted a retrospective review of motorcycle registration on Drivers and Vehicle License Authority (DVLA) records in the WA Municipality between 2004 and 2008. His findings generally showed an increase in motor vehicular registration over the period, and 98% of 15, 475 registered vehicles in the municipality were motorcycles. His study further revealed that motorcycle registration rate was significantly higher than cars over the period studied (p=0.015).

According to the Northern region branch of the Drivers and Vehicle License Authority (DVLA), motorcycle registration is increasing considerably in the Northern regions and major cities in Ghana (DVLA, 2018). The Graphic Online on June 29, 2013, reported that "Tamale: Ghana's merging motor City with over 8000 motorbikes registered annually." This estimation was devised from 10 years of data from the DVLA. Further, the DVLA in Tamale registered over 10,500 motorcycles in 2017 (Frimpong, & Nurudeen, 2013, June 29).

2.3 Uses of Motorcycles

Motorcycle has been classified into three major classes: street (mainly two- and three-wheeled motorcycles), dual-purpose, and off-road (Governors Highway Safety Association, 2017). The street bikes are the most commonly used in both developed and developing countries. Motorcycle has varying stability, performance, rider visibility, and handling, and they provide less protection when involved in a crash. Users of motorcycles have a higher risk of injury in road crashes since motorcycles do not have an enclosure like a passenger vehicle (Ayuekanbey, 2016; GHSA, 2017).

However, motorcycles have increasingly become a common mode of transport worldwide particularly in Low and Middle-Income Countries (LMICs). According to Darido (2010), motorcycles are popularly used since they are cheaper than other motor vehicles in terms of purchase and maintenance costs, and easier to operate in terms of road use. Increasingly, motorcyclists are seen easily evading traffic jams, dropping off their passengers and making quick money through faster routes compared to other forms of transportation and this is making them an attractive means of transport in Ghana (Sowa, 2013). Also, riders use motorcycle more often for work-related journeys, including commuting to and from their normal place of work as compared to car drivers and bicyclists, (Mayor and Transport for London, 2015).

The transport sector is increasing as a result of population growth and urbanization, and passengers look for alternatives to quicken their movement (World Bank Group, 2015). A national household survey in Ghana indicated that one of the major challenges faced by road users in Greater Accra (27.3%) and Ashanti (13.9%), Northern (34.7%), Eastern (33.6%), and Volta (29.6%) was inadequate access of road network to their workplace (Ministry of Roads and Highways, 2013). Motorcycles used for commercial purposes are commonly known in West Africa as “Okada”, and it constitutes 8% of all modes of public transportation in Ghana as of the year 2015 (Frimpong, & Nurudeen, 2013).

Turkson et al. (2013), conducted an observational study to determine the level of helmet use among motorcycle users in Ghana. This study involved 21,408 motorcycle users observed from the southern (10, 428) and northern (10,980) sectors of Ghana in six months period. It was observed that most of the motorcycle riders from the southern (57.9%) and northern (71.4%) sectors did not have passengers. Also, a significant proportion of motorcycle users in both southern (42%) and northern (22.1%) sectors were not wearing helmet. The study described that almost every household in the northern sector owned a motorcycle, and it is a major means of transporting goods and services (Turkson et al., 2013). However, they failed to specify the selected cities used for this study.

Ackaah and Afukaar (2010) conducted an observational study at the roadside to observe motorcycle riders and pillion rider's helmet use within just two weekdays and in the hours of 07:00 am and 12 pm in Tamale Metropolis, Ghana. A total of 3115 riders and 1058 pillion riders were observed from 10 sites. Adult groups of ages between 26 and 50 years were the most age group who used motorcycles either as rider or pillion rider.

Although studies of Turkson et al. (2013) and Ackaah and Afukaar (2010) failed to estimate the rate of motorcycle use within the study period, their findings provided preliminary information on motorcycle patronage and its demand in Tamale metropolis.

2.4 Burden of motorcycle injuries

Road traffic injuries have been on a steady increase, despite the global agenda of halving it by 2020 (WHO, 2014). According to the World Health Organization (2014), the global burden of road traffic fatality is 19 per 100,000 population annually, and 90% of these deaths occurred in developing countries. The WHO African Region recorded the highest deaths (23 per 100,000 people) above the global estimate. It further identified motorcyclists as one of the most vulnerable road users of injury-related deaths, and that the dependence of motorcycles in LMICs has contributed to the high prevalence of motorcycle crash injuries. Motorcycles are the most commonly involved in transport injuries in children (40–70%) of all child vehicle users in transport injuries (World Health Organization, 2014).

A study assessed the annual rate of road traffic fatality using data from the Global Burden of Disease Study from 2010 to 2013 (Ning et al., 2016). This was done to examine the global progress in reducing road traffic mortality in four years. The rate of deaths by motorcyclists in 2010 and 2013 have been summarized in Figure 2.1. Findings from this study indicated a significant contribution of motorcycle to the rate of road traffic mortalities worldwide. The rate of mortality from motorcycle-related injuries in developing countries (4 per 100,000) exceeds the rate of injuries at the global level (3.4 per 100,000) and that of developed countries (0.7 per 100,000).

Figure 2.1. Age-adjusted road traffic fatality between 2010 and 2013 by development status and type of road user.

Status	Category	2010		2013		Annual percent change (%)	
		Rate	95% UI	Rate	95% UI	Percent	95% CI
Global	All road injuries	20.6	(18.8, 21.8)	19.9	(18.4, 21.3)	-1.12*	(-1.20, -1.04)
	Pedestrian	8.2	(6.9, 9.5)	8.0	(6.7, 9.2)	-0.99*	(-1.11, -0.87)
	Pedal cyclist	1.4	(1.1, 1.6)	1.3	(1.1, 1.6)	-1.24*	(-1.54, -0.94)
	Motorcyclist	3.6	(2.9, 4.2)	3.4	(2.8, 4.0)	-1.43*	(-1.62, -1.24)
	Occupant	7.2	(6.3, 8.0)	6.9	(6.1, 7.8)	-1.09*	(-1.22, -0.96)
Developed countries	All road injuries	11.2	(10.7, 12.2)	10.1	(9.5, 11.0)	-3.23*	(-3.48, -2.98)
	Pedestrian	2.9	(2.2, 3.8)	2.6	(1.9, 3.4)	-3.77*	(-4.26, -3.28)
	Pedal cyclist	0.7	(0.5, 0.8)	0.7	(0.4, 0.8)	-2.43*	(-3.41, -1.46)
	Motorcyclist	1.4	(0.9, 1.7)	1.3	(0.8, 1.6)	-2.96*	(-3.66, -2.27)
	Occupant	6.0	(5.2, 7.2)	5.5	(4.7, 6.5)	-3.08*	(-3.42, -2.74)
Developing countries	All road injuries	24.0	(21.4, 25.5)	23.4	(21.2, 25.2)	-0.93*	(-1.01, -0.85)
	Pedestrian	10.2	(8.5, 11.8)	10.0	(8.3, 11.6)	-0.82*	(-0.95, -0.70)
	Pedal cyclist	1.6	(1.3, 1.9)	1.5	(1.3, 1.9)	-1.07*	(-1.37, -0.76)
	Motorcyclist	4.2	(3.3, 5.0)	4.0	(3.2, 4.8)	-1.47*	(-1.67, -1.28)
	Occupant	7.7	(6.5, 8.7)	7.5	(6.4, 8.6)	-0.70*	(-0.84, -0.56)

Notes:
Annual percent change in age-adjusted mortality was estimate based on negative binomial regression.
95% UI: 95% uncertain interval based on GBD 2013 estimates.
95% CI: 95% confidence interval based on negative binomial regression.
*: P<0.05.

Source: Ning et al., (2016)

A comparative analysis of motorcycle accident data from two sources: United Kingdom (UK) On The Spot (OTS) and the European Motorcycle Accident In-Depth Study (MAIDS), revealed that the prevalence of motorcycle injuries were 2% and 6% respectively in Europe (Mccarthy et al., 2007). Another publication in London reported that 80% of killed or seriously injured (KSI) victims were pedestrians (37%), cyclists(22%), and motorcyclists(21%) (Mayor and Transport for London, 2015). The publication further observed that motorcyclist KSI casualties remained disproportionately high with regards to the true level of motorcycle use (Mayor and Transport for London, 2015).

Kipsaina et al. (2014) conducted a prospective cross-sectional study to explore the challenges in establishing a mortuary-based injury surveillance system in a resource-limited setting in Nigeria and the aim was to quantify the burden of reported fatal injuries in Ibadan, using a data collection tool developed by WHO and Monash (Kurg et al., 2012). It was observed that 75.1% of 1184 deaths recorded were transport-related, and motorcycle associated injuries (22.8%) was the leading cause of deaths. Further, most of these deaths happened among persons of ages 20 to 64 years, and higher in males(Kipsaina et al., 2014). A household survey in the Mbarara Municipality of Uganda also employed a multi-stage sampling technique to recruit 212 households with 966 household members derived from the World Health Organization (WHO) formula for calculating households in a community survey (WHO, 2004). The study found the prevalence of all non-fatal injuries to be 18.2% of which 92% were unintentional non-fatal injuries more than 26% of these were caused by Road Traffic Injuries (RTI). The findings further revealed that more than half 53.2% of the RTIs victims were traveling on motorcycles (Nuwematsiko et al., 2018).

In Ghana, such a household survey on motorcycle injuries is little known. However, the National Road Safety Commission (NRSC) statistics provide routine data on the proportion of motorcycles injuries nationwide. More than 21% of road fatalities are among motorcycle users, and it is the second-highest after pedestrians, more than the fatalities reported among occupants of buses (17.5%) and cars (10.7%). The country experienced an annual increase of 35.3% in motorcycles crashes (NRSC, 2016). The latest NRSC report showed that Ghana recorded 411 road traffic fatalities in the first two months of 2019, and 26.3% resulted from motorcycles crashes (NRSC, 2019). According to the MTTD, motorcycle crashes contributed 28.6% (n=3546) out of the MTTD records of 12,396 road crashes in 2018, and had a share of 2118 fatalities and 12318 injuries (Nyarko-Yirenkyi, 2019). This represents a 100% increase in the number of deaths by motorcycle crashes over the seven years. The data also indicates that commercial motor riders (commonly known as Okada riders) contribute 25% of the total incidents recorded within the period. And the age characterization shows that most of the victims' were between the ages of 18 years and 37 years, and 70% of them were males. A review of the literature in this section showed that studies on the burden of motorcycle injuries in the Northern Region are limited.

2.5 Burden of head injuries

Head injury is defined as damage to/deformity of anatomical structures of the head. Common pathology among patient diagnosed with head injuries includes subdural hematoma (SDH), brain contusion, subarachnoid hemorrhage (SAH), epidural hematoma (EDH), skull fractures, diffuse axonal injury (DAI), depressed injury, and mixed injury (Parambil, Vattaparambil, Pankaj, & Chauhan, 2019; Yusuf et al., 2014; Lin & Kraus, 2009). These structural deformities may result in temporal or permanent neurological defects in victims of serious head injuries. In practice, Glasgow Coma Scale (GCS) score, skull X-ray, and/or CT scan are used to diagnosed persons with head injury whether mild, moderate, serious or severe (Yusuf et al., 2014).

Injuries of the head rank first among the top 20 leading non-fatal injuries sustained (WHO, 2014). Head injury is the most common cause of mortality and disability in young people (Ghajar, 2000). Motorcycle crashes contribute a significant percentage to the proportion of head injuries worldwide, making motorcycle-related injuries a major public health problem. Head injuries alone constitute 21-65% of motorcycle-related injuries. About 80% of head injuries are mild (GCS 14-15), 10% are moderate (GCS 9-13) and the remaining 10% are severe (GCS 3-8) (Mccarthy, 2014).

A summary of the proportion of motorcycle and head injuries from reviewed studies is presented in Table 2.1. Most of these studies are from Africa with only one from Pakistan. An injury-surveillance data in Pakistan documented 140,107 motorcycle-related injuries, but the analysis included 77.9% (n = 109,210) patients with data on helmet use. This analysis showed that 34.3% (n = 37, 439) of the patients had head injury and 30.3% (n = 33,130) had a facial injury (Bhatti et al., 2018).

Lin & Kraus, (2009) conducted a systematic review of risk factors and patterns of motorcycle injuries, in this review, they compared head injury, death, required hospitalization, the average length of hospital stay, average hospital charge, and the number of subjects by helmet status in the USA. In this study, the proportion of head injuries ranged from 2.8% - 40.6% in victims with helmet and 8.4% - 65.9% victims without helmet and contributed 1%-9.1% and 4% - 16% deaths in motorcycle users with and victims without helmet respectively. Generally, the prevalence of hospitalization among these patients was relatively high with 4.2 days and 7 days minimum duration of hospital stay among motorcycle crash victims with helmet and without helmet respectively. Further, this study also reviewed estimated hospital charges up to $11,879 and $18,940 respectively among motorcyclists with helmet and without a helmet (Lin & Kraus, 2009).

A population-based case-control study of hospitalization among motorcycle crash victims with head injuries in Taiwan revealed an increase in the duration of hospitalization among victims with head injuries (Chih-wei et al., 2017). In a hospital-based study to describe the characteristics of head injuries among 337 patients in India, it was revealed that 60.5% of the patients with head injuries used motorcycles and 7.3% of these patients died (Agrawal et al., 2017).

In Africa, motorcycle-related crashes contribute 21-71% to the burden of head injuries among road crashes victims (Kamulegeya, Kizito, Nassali, Bagayana, & Elobu, 2015; Chih-wei, Yi-chu, Hsiao-yu, & Ping-ling, 2017; Thomas, Bernice, & Kuria, 2018; Ngunu, 2015; Yusuf, Odebode, & Adeniran, 2014). Mukuria et al (2018) conducted a cross-sectional study to estimate the prevalence of motorcycle injuries in Nakuru County Referral Hospital in Kenya. They documented 27.1% of the respondents had had motorcycle-related injuries and 42.3% of the victims suffered from head/face injuries. Similarly, motorcycle-related injuries account for 51.4% of all injuries in Rwanda, and 55.8% of these patients suffered from head injuries (Mbanjumucyo et al., 2016). Mortuary-based injury surveillance data in Ghana revealed that head injuries account for 51.7% of 795 injury-related deaths in the Central Region (Morna et al., 2019), and 91.2% of traumatic brain injury occurred among motorcycles and tricycles riders/passengers in the Northern Region (Adam et al., 2016).

Table 2.1: Comparison of proportion of motorcycle and head injuries from reviewed studies

Author (year)	Total subject	Proportion of motorcycle injuries	Proportion of head injuries	Country/city
Adam, et al., (2016)	671	91.2%	100%	Tamale, Ghana
Morna, et al., (2019)	795	11%	51.7%	Cape Coast, Ghana
Hassan, (2016)	1620 (PhaseI)	18.8%	35.7%	Nairobi, kenya
Mukuria, et al., (2018)	96	27.1%	42.3%	Nakuru County, Kenya
Solagberu,et al., (2006)	412	27.2%	63.5%	Nigeria
Bhatti, et al., (2018)	109210	109 210	34.3%	Pakistan
Agrawal, et al., (2017)	337	100%	60.5%	India

2.6 Factors associated with head injuries

Motorcycle users are confronted with several risk factors that may not affect other motorized vehicle users like the driver and passengers. Table 2.2 presents a summary of findings on risk factors of head injuries among motorcycle users from selected literature.

A systematic review from Uganda reported that risk factors of road traffic injuries like motorcycle crashes are mainly extroverted and introverted road use culture; reckless driving; inappropriate driving experience; lack of respect to road traffic laws and vehicle roadworthiness. Others are road infrastructure deficiencies and inappropriate usage, alcohol, and drug impairment, not wearing appropriate safety gear (such as helmet, seat belts, and child restraints), speeding and overloading vehicles (Balikuddembe, Ardalan, Nejati, & Munanura, 2017).

A hospital-based matched case-control study conducted in Kampala City of Uganda also documented age, marital status, Muslim, income per week, alcohol consumption, experience of riding, engine capacity, time of starting of riding before 6 am, not having received rider training, riding duration, shares motorcycle, and non-helmeted as factors associated with injuries among commercial motorcyclists (Tumwesigye et al., 2016).

Other studies have identified several factors including lack of certified driver training and valid licensing, lower engine capacity, riding experience of fewer than 3 years, speed and reckless driving, poor regulation and law enforcement, non-helmet use by riders and their passenger, drink driving which increases the risk of motorcycle crashes, injuries and fatalities (Adam et al., 2016; Chang & Yeh, 2007; Mabula et al., 2010; Musah, Marfo, & Akpade, 2018; Ngunu, 2015; Sanyang et al., 2017).

Table 2.2: Summary of findings on risk factors of head injuries among motorcycle users

Author, year	Title	City/ Country	Design	Findings
Balikuddembe et al., 2017	Road traffic incidents in Uganda: a systematic review of a five-year trend	Uganda	Systematic review	Reckless driving, inappropriate driving experience, lack of respect to road traffic laws and vehicle roadworthiness, alcohol and drug impairment, and not wearing helmet, speeding
Tumwesigye et al., 2016	Factors Associated with Injuries among Commercial Motorcyclists: Evidence from a Matched Case-Control Study	Kampala City, Uganda	Hospital-based matched case-control study	Age, marital status, Muslim, income per week, alcohol consumption, experience of riding, engine capacity, time of starting of riding before 6 am, not having received rider training, riding duration, shares motorcycle, and non-helmeted
Chih-Wei et al., 2017	A population-based case-control study of hospitalization due to head injuries among bicyclists and motorcyclists	Taiwan	Population-based case-control study	Age, sex, urban or rural area, drink driving, non-helmet use, curved road, poor visibility (dusk or dawn), multiple vehicle crash,
Parambil et al., 2019	Epidemiologic Characteristics of Patients Presenting with Head Injury due to Road Traffic Accident and Factors Associated with Outcome: Experience of a Tertiary Care Center	Northern Kerala	Population-based descriptive study	Motorcycle-use, non-helmet use, alcohol intake common findings related to head Injury

2.6.1 Socio-demographic factors linked to motorcycle head injuries

Socio-demographic factors such as young adults, males, marital status, religion, occupation/profession, and socioeconomic status have been linked to crashes (Tumwesigye et al., 2016), and subsequent head injuries.

Sex (Male) and head injuries in motorcycle crash victims

Head injuries among motorcycle crash victims are common presentation among males (Macleod, Digiacomo, & Tinkoff, 2010a, 2010b; Ogbonna, Nnadi, Bankole, & Fente, 2015; Parambil et al., 2019). Ogbonna et al., (2015), reported 90.3% of patients with traumatic head injuries among males compared with 9.7% among females. Similarly, Parambil et al., (2019), indicated that 615 two-wheeler drivers were males who were involved in road traffic accidents (RTAs) as against 13 females who reported with head injuries. Yusuf et al. (2014) also documented 93.3% of patients with motorcycle-related head injuries among males while females only contributed 6.7%. Though these studies did not make any statistical inferences, their findings suggested that being a male is a risk factor for motorcycle associated head injuries.

Age (Young adult) and head injuries in motorcycle crash victims

Age of motorcycle users is a strong determinant of motorcycle crash injuries (Balikuddembe et al., 2017; Chih-wei et al., 2017; Sanyang et al., 2017; Tumwesigye et al., 2016). Yusuf et al., (2014), reported that 76.0% of motorcycle-related head injuries are among young adults of ages 14-44 years. The youthfulness of the motorcyclists is among the major factors responsible for motorcycle accidents due to inexperience (Nyatundo, 2014). Young age has been associated with motorcycle injuries (Chih-wei et al., 2017; Lin & Kraus, 2009; Sanyang et al., 2017; Tumwesigye et al., 2016). Other findings from Uganda showed that advanced ages above 25 years are much less likely to suffer from motorcycle injuries in both unadjusted and adjusted models (Tumwesigye et al., 2016). On the other hand, Sanyang et al. (2017), reported that motorcycle injuries are 86% less likely to occur among young people aged less than 25 years. The risk of head injuries among young motorcyclists in developing countries may be higher than those reported in developed countries since the majority (54-57%) of motorcyclists in developing countries are among young adults of ages 20 to 29 years (Nyatundo, 2014; Sowa, 2013).

Marital status and head injuries in motorcycle crash victims

Marriage is highly valued in most African societies and in Ghana married couples are highly respected due to their boldness to embrace the responsibility of raising children(Ahonsi et al., 2019). Although the influence of marital status on motorcycle injuries has not been studied intensively, one may expect a married person to behave better compared to an unmarried person. This is because marriage comes with responsibilities that the married motorcyclist may have his family in mind and this is likely to influence his or her driving behavior(Ahonsi et al., 2019; Antov et al., 2010; Tunnicliff, 2006). Therefore, risk-taking behaviors among unmarried motorcycle users may be much higher. For instance, an unmarried young male (<40 years) may engage in more risky driving behaviors compared to a married man with children.

A test of association between marital status in a matched case-control study showed that married motorcycle crash victims are less likely to suffer from injuries as compared to Single/separate/widow (OR=0.43, 95%CI=0.29–0.64) (Tumwesigye et al., 2016). Another study by Adejugbagbe, Fatiregun, Rukewe, and Alonge (2015) indicated that unmarried drivers are 2.3 times more likely to be involved in road traffic accidents compared to married drivers (OR=2.3, 95%CI: 0.5, 10.0).

Whitlock et al., (2004) conducted a cohort study to assess the impact of marital status on motor vehicle driver injury. Their findings after adjustment for age, sex, and study cohort indicated that participants without marriage history had twice the risk of driver injury (hazard ratio [HR] 2.06, 95% confidence interval [CI] 1.35 to 3.16) as married participants (HR 1.00). The relative risk for never married participants was slightly higher (HR 2.29), though less precise (95% CI 1.39 to 3.76), after further adjustment for alcohol intake, driving exposure, area of residence, body mass index, and occupational status (Whitlock, Norton, Clark, Jackson, & Macmahon, 2004). This evidence is in line with the researcher's assertion that marital status is likely to influence the occurrence of head injuries in motorcycle crash victims in the Northern region.

Level of education and training and head injuries in motorcycle crash victims

Education and training are important factors of one's knowledge of traffic rules as well as the skills and expertise required to ride (Nyatundo, 2014). Through education, one is made aware and could make informed choices to pursue safe driving compared to less educated ones. For instance, motorcyclists' knowledge of the benefit of helmet use (as a protective factor of head injuries) is likely to promote helmet use among such motorcyclists. A study in developing countries showed that riders learn how to ride through friends and family members, other than certified bodies(Nyatundo, 2014).

To determine significant factors contributing to motorcycle injury severity in Pakistan, Waseem et al. (2019) performed a random parameters logit model with heterogeneity in means and variances with motorcycle crash data. With education, they fitted the model that involved crash severity, the month of the year, day of the week, weather conditions, the season of the year, time of the day, roadway type, rider details, gender, motorcycle registration status, brand Japanese, engine capacity (cc), and crash characteristics. Their results showed that majority of the crash victims were middle school (24.8%) and high school (45.4%) leavers and crashes involving victims with no education were more likely to result in a fatal outcome. Although, they reported that the probability of sustaining severe, minor, and no injury decreases by 0.0011, 0.0044, and 0.0002 respectively for a rider with no education, but the probability of sustaining fatal injury increases by 0.0057. To explain this, with the increase in the education level, the motorcyclists tended to be more cautious about their safety. It could be inferred that educated road users often wear helmets and follow traffic regulations, therefore are less to be involved in fatal traffic crashes (Waseem et al., 2019).

Similarly, Tumwesigye et al. (2016), reported a greater proportion of their study participants had obtained primary (39.5%) and secondary (33.9%) education, and the odds of injury severity decreases with an increasing level of education. Patients with a higher level of education have been found to have a reduced risk of motorcycle injuries by 0.31 folds as compared to patients with no education. Their results also showed that victims with no formal rider training had 4.04 folds odds of severe injuries as opposed to those with some form of training (95%CI: 2.65–6.15). Also, the odds of severe injuries were 11folds among victims with inadequate knowledge of road safety rules as compared to those with high knowledge (95%CI:5.8-22.5). All these were statistically significant at a p-value less than 0.050. (Tumwesigye et al., 2016).

In a spatial analysis to examine the influence of socioeconomic status on traumatic brain injury amongst pediatric populations in Greater Vancouver, Amram et al., (2015) fitted a final model which included the percentage of Aboriginal, percentage of Lone Families, percentage of the population 15 and over with no high school diploma, percentage of no Detached Housing, median income and average income, unemployment rate Within30min of BC Children Hospital, and composite SES Index. Their study identified that a low level of education was the main predictor of a high rate of injury (OR = 1.13, 95% CI = 1.03–1.23, p= 0.009). This, they further interpreted that for each 10% increase in the proportion of people with no high school diploma the rate of injury increased by 13% (Amram et al., 2015).

Religion and head injuries in motorcycle crash victims

Religion, according to Merriam-Webster, is a social-cultural system of designated behaviors and practices, morals, worldviews, texts, sanctified places, prophecies, ethics, or organizations, that relates humanity to supernatural, transcendental, or spiritual elements. Religions have sacred histories and narratives, which may be preserved in sacred scriptures, and symbols, and holy places, that aim mostly to give meaning to life. In Africa, religion is highly respected and beheld by the masses. It has the potential to influence the behaviors of those who believe and practice its teachings. Previous studies have tried to link religion with the occurrence of road traffic injuries (Adejugbagbe et al., 2015; Woldu, Desta, & Woldearegay, 2020), and specifically, only focused on how religion influences motorcycle injuries (Tumwesigye et al., 2016).

Woldu, Desta, and Woldearegay (2020) investigated the magnitude and determinants of road traffic accidents in Northern Ethiopia using a cross-sectional study that captured religion as well under the sociodemographic characteristics of drivers studied. Their findings revealed that drivers of orthodox origin are much affected (Christians; 54.39%) as compared to those of Muslim religion (29.82%). Although the Chi-square test indicated a significant association between religion and the occurrence of injuries (p=0.031), the authors did not explain the observed association because it was not significant in the adjusted regression model (AOR=0.24, 95%CI:0.05 to 1.26) (Woldu et al., 2020). The Northern Ethiopia is predominately Orthodox worshipers and one would expect that majority of the injured would be people of Orthodox origin.

Similarly, a hospital-based matched case-control study conducted by Tumwesigye et al., (2016), also suggested that Muslims were 0.52 times less likely to suffer from motorcycle injuries compared to Catholics when adjusted for other confounders like age, education, marital status, and weekly income. Meanwhile, in the general population Catholics (42%) were much higher than Muslims (12%) in Uganda (Uganda Bureau of Statistics, 2006). Furthermore, a cross-sectional study conducted to assess road traffic crashes (RTC) among long-distance drivers in Ibadan, Nigeria reported a higher proportion of RTCs among Muslims than Christians (17.1% vs 14.9%). But their study found no significant association between religion and occurrence of RTCs (p=0.40) (Adejugbagbe et al., 2015). In Nigeria, the population of Muslims (52%) is slightly higher than Christians (46%) respectively(Pew Forum, 2009).

Both studies from Uganda and Nigeria suggest that Muslims are most likely to sustain motorcycle head injuries compared to Christians counterpart irrespective of their representation in the general population of the country. Although, the influence of religion on the occurrence of motorcycle injuries is generally not significant it may still have some influence on the victim's behavior.

The influence of religion on people's behavior (that augment or reduce risk of motorcycle-related head injuries) is multi-dimensional. For instance, early marriages are frequently seen among Muslims than Christians which ensure that they assume responsibilities at youthful ages. To live long and continue to feed their families, may influence Muslim road users to be more careful when riding to reduce the risk of road crashes. In another fashion, life-style in terms of dressing code for Muclims (veils for women and garment for both sexes) might inconvenience or impede them from using protective gears such as helmets and protective coats compared to Christians who freely wear any type of clothing. Also, motorcycle is a preffered mode of transport among the masses. In most Sub-Saharan African countries, motorcycling has been the most preffered mode of transport in Muslim predominated communities. Hence, the frequent use of motorcycle coupled with not wearing protective gears may have exacerbated motorcycle crashes and head injuries among Muslims.

Socioeconomic status and head injuries of motorcycle crash victims

Socioeconomic status has been long thought to be associated with health status (Rutstein, 2004). In line with this statement, previous studies have revealed that lower socioeconomic status influences the occurrence of motorcycle injuries which includes head injury (Hurt, Ouellet & Thom, 2015; Lin & Kraus, 2009; Tumwesigye et al., 2016). The findings from a spatial analysis on the association between socioeconomic status (SES) and traumatic brain injury amongst pediatric populations showed that the socioeconomic composite Index (which composed of annual family income, social resources, and maternal education) is a predictor of traumatic brain injury in children (OR=1.089, 95%CI:1.031–1.151, p= 0.002) (Amram et al., 2015).

Benavente-fernández et al. (2019) conducted a prospective cohort study of preterm neonates to explore the association of socioeconomic status (SES) and brain injury with neurodevelopmental outcomes of very preterm children. Their findings indicated that SES is associated with modified cognitive outcomes of both groups of children. In the absence of brain injury, the higher SES group achieved a predicted full-scale intelligence quotient (FSIQ) that is 7.4 points higher (95% CI, 6.99-8.83; P < .001) than the lower SES group. In the presence of brain injury, the association with SES increased, with the higher SES group having a mean increase of 13.7 points (95% CI, 13.34-14.25; P < .001) relative to the lower SES group (Benavente-fernández et al., 2019). Findings, as stated in previous literature (Amram et al., 2015; Benavente-fernández et al., 2019; Hurt,Ouellet & Thom, 2015; Tumwesigye et al., 2016), suggest that low SES does not only influence the occurrence of but also the treatment outcomes of head injuries.

In this study, items from the wealth index were used to estimate the socioeconomic status of motorcycle crash victims (apart from education, occupation, and monthly income). The wealth index based on the Demographic and Health Surveys (DHS) allows for the estimation of the socioeconomic status of the population and relates the difference to their health status (Rutstein et al, 2004; Smits, 2013). Rutstein et al. (2004) have identified several categories of indicators to estimate wealth status which include equitable distribution of social resources, household income, household consumption expenditure, assets, and services. This study focused items on assets and services since respondents may found it easy to reply to questions on them. Assets and possessions included consumer durables (television, refrigerator, phone, motorcycle, expensive and cheap utensils), and housing characteristics (water supply, electricity, floor material, toilet facility, and the number of rooms)(Rutstein et al, 2004; Smits, 2013). The overall score of the wealth index was graded as poorest, poor, moderate wealth, rich, and richest, and the association between the patients' SES and motorcycle-related head injuries was determined.

2.6.2 Mechanism of injury and head injuries of motorcycle crash victims

The mechanism of motorcycle crashes has been linked to the occurrence of head injuries (Hurt, Ouellet & Thom, 2015). Motorcycle crashes may occur in several ways; hit the back of a vehicle, hit by a vehicle, pedestrian or animal knockdown, hit the pavement, hit by another motorcycle, and fell when making a U-turn (Ayuekanbey, 2016). These mechanisms can be broadly classified into the following; single motorcycle crash, multiple motorcycles collision, motorcycle versus vehicle, and motorcycle versus pedestrian or animal.

Ayuekanbey (2016) conducted a cross-sectional study to determine the level of motorcycle registration and accidents in the Bolgatanga Municipality and found that most of the victims of motorcycle accidents had their injuries through being hit by a vehicle. This made motorcycle versus vehicle the leading mechanism of injury in motorcycle crashes in the Bolgatanga Municipality, Ghana. A multicenter assessment of motorcycle accident cause factors and identification of countermeasures in California, USA, documented 25.6% and 74.1% of motorcycle crashes resulting from single vehicle collision and multiple vehicle collision respectively. Most of the objects were struck by motorcycle were passenger cars (65.3%) and roadway (19.1%) (Hurt et al., 2015).

In a population-based case-control study of hospitalization due to head injuries among motorcyclists in Taiwan, it also revealed that the type of crash was associated with head injuries ($p<0.001$). But the risk of head injury is higher among motorcyclists involved in single-vehicle crashes (Chih-wei et al., 2017). This could be attributed to the speed at which the crash occurs in single vehicles (Chih-wei et al., 2017). Additionally, a systematic review conducted by Lin and Kraus (2009) in the United State of America (USA) documented that head injuries among motorcycle crashes are common in single-motorcycle crashes and head-on collisions. Furthermore, a descriptive study in Nigeria indicated that half (50%) of the patients presenting with head injuries were involved in collision between motorcycle and other vehicles collisions but most of the mortality recorded occurred among patients involved in single motorcycle crashes (Yusuf et al., 2014). These studies revealed that the type of motorcycle crashes, pattern (mostly head-on), and the object struck by the motorcycle play a significant role in the occurrence of head injuries during motorcycle crashes

2.6.3 Safety and behavioral factors associated with head injuries among motorcyclists

Numerous human attributes, about safety and behavioral factors, have been identified to influence head injuries among motorcyclists (Chih-wei et al., 2017; Lin & Kraus, 2009; Sanyang et al., 2017; Tumwesigye et al., 2016). In a systematic analysis of risk factors of motorcycle crash injuries, Lin and Kraus (2009) reported these factors under the human component and two out of the three phases (pre-event, event, and post-event) according to the Haddon's matrix. At the pre-event phase, they included inexperience, crash history, no driving license, traffic violation history, high risk-taking behavior, alcohol and other drug use, motorcycle ownership, excessive and slow speeds, and riders conspicuity. Also, the second phase (event phase), which is the last to be considered in this study, focused on riding distance and time, excessive speed, no safety devices such as helmet wearing (Lin & Kraus, 2009).

Another hospital-based matched case-control study by Tumwesigye et al. (2016) found an association between motorcycle injuries and having a current history of alcohol consumption (2folds), lack of ownership of the motorcycle (3 folds), lower engine capacity (5 folds), short time of riding experience (<2 years)(4 folds), lack of training on riding (4 folds), sharing motorcycle (5 folds), and inconsistent/non-use of helmet (2 folds)(Tumwesigye et al., 2016). In this review, it focused much on non-helmet use, over speeding, drink-driving and drugs use, shared motorcycle, drivers fatigue, long duration riding, driving inexperience, and ownership of motorcycle as safety and behavioral factors of head injuries in motorcycle crashes.

Non-helmet use and head injuries in motorcycle crash victims

Despite the evidence that motorcycle helmets provide the best protection from head injury for motorcyclists involved in traffic crashes (Ngunu, 2015; Peltzer & Pengpid, 2014), the world continues to report significant proportions of motorcyclist not using helmets (Bao et al., 2017; Ogbonna et al., 2015; Peltzer & Pengpid, 2014; Turkson et al., 2013). Ghana is one of the three African countries with a comprehensive helmet law and standard (WHO, 2015b), but enforcement has been a major challenge. The rate of helmet use among motorcycle riders in Ghana ranges from 33-54% (Turkson et al., 2013), against 34.2% of helmet use in Tamale (Ackaah & Afukaar, 2010). Low knowledge of traffic rules, age, sex, the discomfort of wearing a helmet, among others are possible reasons for the lower rate of helmet use in developing countries (Musah, Marfo, & Akpade, 2018; Taylor, 2010; Turkson et al., 2013)

Evidence from a matched case-control study among commercial motorcyclists indicated that the odds of head injuries among non-helmeted patients is 2.21folds the odds of helmeted patients (Tumwesigye et al., 2016). Further, a retrospective study among motorcyclists comparing the level of head injuries among unhelmeted patients against patients with a full-face helmet (FFH), open face helmet (OFH), and half-coverage helmet (HCH). This study documented the characteristics of helmet use among 738 patients and found that 27.8% were not in a helmet, 33.5% with FFH, 17.6% with OFH, and 13.0% with HCH. The inferential analysis showed that patient with full-face helmet ($\beta=-0.368$, 95% CI: −0.559, −0.177) and open face helmet($\beta=-0.235$, 95% CI: −0.459, −0.010) have a lower head maximum Abbreviated Injury Severity (AIS) than those not wearing a helmet, but patients with only FFHs experiencing a significant reduction in the effect of severe and minor head injury (Sung et al., 2016). These findings suggest that motorcycle crash victims without a helmet have a higher risk of severe head injury compared to patients with any type of helmet.

Over speeding and head injuries in motorcycle crash victims

Excessive speed has been linked to single vehicle accidents, and it accounts for more than one-third of the accidents that result in death or serious injury (Mccarthy et al., 2007). A study reported that more than half (53.2%) of the RTIs victims were traveling on motorcycles and 53.2% were speeding while riding (Nuwematsiko et al., 2018). In a retrospective analysis of motorcycle crash data in Pakistan, Waseem et al. (2019) reported 50.9% of the victims were riding at a speed of 70Km/h beyond the normal speed limit. In a random parameters logit model with heterogeneity in means and variances motorcycle crash data performed by Waseem et al. (2019), it was revealed that the average marginal effects show that the probability of severe injury increases by 0.0128 and minor injury decreases by 0.0121 for roads with posted speed limits of 70-km per hour or higher. This indicates that speeding increases the likelihood of severe and fatal injury crashes, and crashes on roads with posted speed limits below 50-km per hour are more likely to result in no injuries.

In a systematic review, Lin and Kraus (2009) reported that when crash speeds exceeded ≥50mph, there was a reduction in helmet effectiveness in preventing motorcycle deaths from head injuries. They further indicated at high speeds, the fixed and non-fixed parts of the body such as the skull and brain move differentially, and brain injuries due to deceleration may occur. According to NHTSA as cited by Lin et al. (2009), it is estimated that persons driving on highways with a speed limit of ≥55mph were 3.7-

times more likely to be killed in crashes than those driving at lower speed limits for all types of vehicles in the United State of America. They also noted in addition to excessive speed, inappropriate speed for traffic conditions and slow speeds are positively linked with a high risk of initiating two-vehicle collisions (Lin & Kraus, 2009).

Although several reports have linked speeding to motorcycle injuries, a prospective cross-sectional study found a greater proportion (76.9%) of the motorcycle crash victims were speeding, but later found that victims speeding were less likely to suffer motorcycle-related injuries (OR=0.85, 95%CI: 0.4-1.74) (Sanyang et al., 2017).

Alcohol and other drugs use and head injuries in motorcycle crash victims

Alcohol and drug use have been linked to motorcycle crashes which results in head injuries (Chih-wei et al., 2017; Hurt et al., 1981; Lin & Kraus, 2009; Tumwesigye et al., 2016; WHO, 2015a). Alcohol consumption impairs the rider's performance and is implicated often in fatal crashes than non-fatal crashes (Siskind, 2011). Though evidence supports the influence of alcohol and drug use on the occurrence of head injuries in motorcycle crashes, statistics from developed countries indicate low alcohol and drug consumption among riders and may contribute insignificantly to the burden of motorcycle-related head injuries (Hurt, Ouellet & Thom, 2015). Different observations can be made in developing countries where road safety laws are often violated and not enforced effectively (WHO, 2015a).

Ngunu (2015) conducted a cross-sectional study to determine the factors determining the level of severity of motorcycle injuries among patients in Kiambu County, Nairobi, Kenya. Although the blood alcohol level and toxicology screen were not carried ascertain the actual levels, self-reported alcohol use among motorcycle crash victims was relatively low. The study reported an overall use of alcohol of 11% and 7% reported use of other drugs six hours before the accident. Stratification by type of victims showed that 31% of the motorcycle riders reported use of alcohol or drugs six hours before the accident while 15% and 7% of the passengers and pedestrians respectively reported use of alcohol or drugs six hours before the accident (Ngunu, 2015).

On the other hand, a slightly higher proportion of victims in 29.8% cases and 18% controls were reported to have been involved in drink-driving in a hospital-based matched control study conducted in Uganda (Tumwesigye et al., 2016). The findings further revealed that alcohol consumption while riding increases the likelihood of motorcycle injuries (OR=1.97, 95%CI: 1.31–2.96) and this was found to be statistically significant at $p<0.010$.

Lin et al. (2009) also noted in their systematic review that as alcohol is the drug-associated most frequently with all kinds of motor vehicle crashes, motorcycle drivers are more likely to have consumed alcohol than are other motor-vehicle drivers in fatal and non-fatal crashes. These suggest that drinking motorcycle riders involved in a crash are more likely than nondrinking riders to have lost control of their vehicle, and have lower rates of helmet use, more-severe head injuries, and higher ISS levels (Lin et al., 2009). Also, since motorcycle drivers are more vulnerable than other motor-vehicle drivers to alcohol's effects on balance, motor coordination, and judgment and more-basic skills are needed to operate the inherently unstable vehicle, a lower legal limit of BAC for motorcycle drivers has been suggested (Lin et al., 2009).

Multiple occupants and head injuries of motorcycle crash victims

Multiple occupants can be explained as when there is another person [known as pillion rider (s)] on the motorcycle aside from the rider. Often, two-wheeled motorcycles have a single occupant (the rider) while three-wheeled motorcycles may carry multiple passengers. In several Sub-Saharan Africa countries, three-wheeled motorcycles are commonly used for commercial purposes in transporting people and goods as alternative vehicles due to the increasing transport demands (World Bank Group, 2015). The use of motorcycles for commercial purposes is commonly known in West Africa as "Okada", and it constitutes 8% of all modes of public transportation in Ghana as of the year 2015 (Frimpong & Nurudeen, 2013). The frequency and severity of motorcycle injuries are higher among multiple occupants than a single motorcycle (Hurt et al., 2015).

Drivers' fatigue, and long duration riding and head injuries in motorcycle crash victims

Driver fatigue and hunger are the common rider temporary physiological impairment that influence motorcycle crashes (Hurt et al., 2015). Longer duration of riding, hunger, and thirst are potential determinants of stress, and stress causes motorcycle riders not to be attentive during the pre-crash time. The matched case-control study conducted by Tumwesigye et al. (2016) assessed the influence of hours of riding on injury severity among motorcycle crash victims. Their findings showed that the level of injuries among motorcycle crash victims' increases with increasing hours of riding in both cases and controls. For example, the proportion who suffered severe injuries was highest among victims who were riding between 14 hours and 19 hours (50.9% in cases vs 28% in controls) as compared to those who rode for less than 12 hours (17% in cases vs 23.2% in controls). Since it was a matched case-control study, they further performed bivariate and multivariable conditional logistic regression analyses to establish factors associated with injury among both groups. The unadjusted OR of injuries was significantly higher for victims who shared motorcycle (uOR=2.53, 95%CI: 1.55–4.11, p<0.001). The influence of hours of riding on motorcycle crash injuries increased almost three times after adjusting for the effects of age, drinking, engine capacity, having a driving license, riding experience, changed motorcycle within past 1 year, and shared motorcycle (aOR=6.25, 95%CI: 2.62–25.9, p<0.001) (Tumwesigye et al., 2016).

Driving inexperience and head injuries of motorcycle crash victims

An increase in driving experiences is a protective factor for motorcycle injuries (Tumwesigye et al., 2016; Nyatundo, 2014). National Transportation Safety Board (NTSB) in 2018 published Safety Report from Washington, D.C in the United States. The NTSB identified four motorcycle safety issue areas in this report: (1) crash warning and prevention, (2) braking and stability, (3) alcohol and other drug use, and (4) licensing procedures. This report analyzes factors associated with motorcycle crash causation and prevention; therefore, many well-established injury prevention factors, such as helmet use, are not included (NTSB, 2018). In assessing rider-related factors, a case-control study was adopted and findings on the driving experience of crash victims (case vs controls) revealed that a greater proportion of the victims had higher riding experience [less than 2 years (18.2% vs 8.1%), 2-4 years (21.2% vs 19.2%), and 5 years and above (60.6% vs 72.7%)]. The report further showed that victims with less than 2 years riding experience are 2.72 times more likely to suffer crash injuries as compared to those with 5years and above riding experience (95%CI: (2.36, 8.55) (NTSB, 2018).

A study conducted by Tumwesigye et al. (2016) in Uganda, found a better riding experience among controls than in cases. The majority of the controls (37.4%) had

8years and above riding experience as compared to 11.1% among cases. The study further found that the unadjusted OR of injuries was significantly lower for victims who had 8years and above riding experience (uOR=0.10, 95%CI: 0.05–0.19, p<0.001). Victims with better riding experiences are less likely to experience motorcycle crash injuries even after adjusting for the effects of age, alcohol consumption, engine capacity, have a driving permit, changed motorcycle in past 1 year, hours of riding, and shared motorcycle (aOR=0.08, 95%CI: 0.03–0.20) (Tumwesigye et al., 2016).

A descriptive study in Ghana has indicated that riders with many years of experience rarely get involved in accidents (Nyatundo, 2014). This study provided evidence based on participants' views on whether riding experience rarely influenced motorcycle accidents and not on a statistical basis. Hence, findings from this study may be subjective since the statistical analysis was lacking and only based on respondents' perceptions.

Ownership or shared motorcycle and head injuries in motorcycle crash victims

A systematic review revealed that motorcycle drivers who crashed and who did not own the motorcycle were more likely to be unlicensed than those owning the motorcycle, and owners involved in a crash were less likely to have a license than those not in a crash (Lin & Kraus, 2009). The study's findings associated with road traffic injury(RTI) with shared motorcycles, and not owning a motorcycle have also been established in several studies (Lin & Kraus, 2009; Tumwesigye et al., 2016).

Findings from a previous study in Uganda showed a relatively small proportion of shared motorcycle, 14.9% in cases, and 4.2% in controls. The unadjusted OR of injuries was significantly higher for victims who shared motorcycle (uOR=4.88, 95%CI: 2.28–10.43, p<0.001). The influence of shared motorcycle on motorcycle crash injuries increased twice after adjusting for the effects of age, drinking alcohol, engine capacity, having a driving license, years' of riding experience, changed motorcycle in past 1 year, and hours of riding (aOR=8.25, 95%CI:2.62– 25.9) (Tumwesigye et al., 2016).

The observed relationship between shared motorcycle and injury was explained as lack of commitment to maintain the motorcycle, inexperience in riding, and the use of a particular motorcycle (Tumwesigye et al., 2016). In addition, shared motorcycles could be linked to situations when regular riders get exhausted after a day's work and relatives or close friends take over the motorcycles to make extra income. These riders may be inexperienced in riding or a learner.

2.6.4 Environmental and Road condition factors associated with motorcycle crashes

The combined effect of poor environmental and road conditions increases the risk of motorcyclists involving in a crash and the severity of the injury sustained (New Zealand Motorcycle Crash Fact Sheet, 2014). Most often, the nature of the road coupled with prevailing weather conditions predetermines the speed and alertness level of the motorcycle rider which is a key determinant of an accident. The condition of the road, such as poor visibility or obstructions, unclean road, **s**lippery road, or raining, poor road condition underline crashes (Haworth, 1999).

Poor visibility and head injuries in a motorcycle crash

A population-based case-control study of hospitalization among motorcyclists with head injuries in Taiwan revealed that dusk or dawn was associated with a higher risk of hospitalization for head injuries among motorcyclists(Chih-wei et al., 2017). Existing literature on motorcycle road safety showed that diminished light conditions are associated with accident occurrence and also with head injury(Chih-wei et al., 2017;

Hurt et al., 2015; Lin & Kraus, 2009; Nyatundo et al., 2014). These findings indicate that enhancing conspicuity in diminished light conditions can be a countermeasure to reduce both the risk of an accident and its consequences.

Road and weather conditions are considered to greatly influence the rider behavior on the road. The poor weather condition in the case of this study focused on whether the crash occurred in raining or dry season. This can impede riding visibility and slippery road, especially in the wet period. In rare instances, the status of the road compounded with prevailing weather conditions determines the speed and alertness of the rider which are key in accident susceptibility (Nyatundo, 2014). Although motorcycle crashes are bound to occur on slippery roads, the slippery roads during the raining season destabilize motorcycles and influence riders to fall off the road. In a cross-sectional study that was carried out among long-distance drivers within selected parks in Ibadan, it was observed that the majority (42.6%)of the RTCs among long-distance drivers occurred in raining season with a 95% confidence interval of 33% to 52.7% (Adejugbagbe et al., 2015).

Location of road and head injuries in a motorcycle crash

The use of location is extremely important to determine the type of road crashes that occurred either urban or rural, highway or street. National Transportation Safety Board (NTSB) in 2018 reported that crashes occurred more often in an urban environment (65%) than in suburban (29%) and rural (6%) environments. Also, motorcycle crashes occurred most on arterial roadways (79%) than non-arterial (17%) in Washington, D.C in the United States of America (NTSB, 2018). It can be deduced from the above report that roads located in the urban environment are likely to be busy and experience rampant crashes compared to rural areas. This phenomenon is more likely to be observed in well-developed nations while a reversal in developing or underdeveloped nations where bad roads affect most rural communities. For example, in a hospital-based study to describe the characteristics of head injuries among 337 patients in India, it was revealed that 62.9% of motorcycle-related head injuries occurred on urban roads and 81.3% in rural locations (Agrawal et al., 2017).

A cross-sectional study to examine the factors determining the level of injury severity among motorcycle crash victims in Kiambu county, Kenya reported several factors such as type of motorcycle users, helmet use, head-light on, weekend, highway, foggy/wet weather, suspected alcohol use, among others. It found out that relatively lower proportions of the injuries among the motorcycle crash victims occurred on highways (28% of moderate /severe injury and 20% mild injury). This finding points to the fact that most injuries in developing countries are likely to occur on roads located in a rural environment (Ngunu, 2015). As it has been inferred that road conditions such as muddy road surface, roads with loose chips, mainly “lack of visibility or obstructions, unclean road or loose material, poor road condition or road markings all potentially contribute to accidents (Nyatundo, 2014). Perception-based findings from a cross-sectional study on whether road conditions influence accident involvement indicated that 66.5% of respondents believe that the condition of the road has a great influence on motorcycle accident rates, 17.5% were of a different opinion and 16.0% were neutral (Nyatundo, 2014). This implies that there is a strong relationship between the road condition and the motorcycle accident and associated injuries. This finding though relevant but maybe subjective since the statistical analysis was lacking and only based on respondents' perception.

Days of the week and head injuries of motorcycle crash victims

There is no limitation in motorcycle use on days of the week. Previous studies have reported that most presentations of motorcycle injuries occur on weekends (Friday, Saturdays, and Sundays) (Hurt et al., 2015; Yusuf et al., 2014). Yusuf et al. (2014), reported that more than half (51%) of the crashes documented in their study occurred on Fridays, Saturdays, and Sundays. Similarly, the National Transportation Safety Board (NTSB) in 2018 reported that 51% of motorcycle crashes in Washington D.C., the United State of America (USA) occurred from Friday to Sunday.

On the other, a cross-sectional study by Ngunu (2015) found that the majority (73%) of the motorcycle crash victims in Kenya were involved in a motorcycle crash between Monday and Friday with the days recording the highest number of crashes being Monday (18%) and Friday (16%). However, he noted that involvement in a motorcycle crash during the weekend was not found to be significantly associated with the level of injury severity (cOR=1.48 P=0.09). Consistent with this study's findings Sanyang et al. (2017) found 71.2% of the motorcycle crash injuries to have occurred on weekdays. The study further noted that involvement in a motorcycle crash on a weekday was not found to be significantly associated with motorcycle crash injuries (cOR= 1.21, 95%CI:0.61–2.39) (Sanyang et al., 2017). Days of the week are a distal factor that facilitates the occurrence of motorcycle injuries including head injury among motorcycle crash victims.

Defects in road design and head injuries of motorcycle crash victims

Road designed with multiple curves/blind spots facilitates motorcycle crashes. Most single motorcycle accidents have been associated with curves that lead to roadside accidents. About 26% of motorcycle crashes in Europe are mainly "single motorcycle collision" and 75% of these crashes occurred by roadway or roadside as a result of curve/blind spots on roads (Hurt, Ouellet & Thom, 1981). The majority of these victims will end up with severe head injuries if there are not wearing a helmet.

Ngunu (2015) reported that more than half (52%) of the motorcycle crash victims in his study subjects were involved in a crash on a straight and flat section of the road, 23% on curve roads with 17% crashes occurring at a corner junction. And 33% of the crashes occurred on a damaged or potholed section of the road. In as much as curve roads contribute significantly to motorcycle injuries, findings from Nguna's study have indicated that straight and flat sections of the road are emerging potential threats to motorcycle users. This is because straight roads may facilitate over speeding among riders which renders helmet useless in protecting crash victims from a head injury.

2.6.5 Modeling the risk factors of head injuries using the Haddon matrix approach

In an attempt to model the risk factors of head injury among motorcycle crash victims, the concept in the Haddon matrix is appropriate. The Haddon matrix was developed by William Haddon to identify risk factors before the crash, during the crash, and after the crash, regarding the human, vehicle, and environment domain. The Haddon matrix has become an analytical tool used in identifying potential factors associated with a motorcycle crash (WHO, 2010). When multiple factors associated with motorcycle crash are identified and analyzed, countermeasures can be developed and prioritized for implementation over short-term and long-term periods (WHO, 2010). As illustrated in Table 2, risk factors for motorcycle crash-related head injuries are classified according to the Haddon matrix.

For this study, regression models will focus on pre-event and event factors under human, environmental factor, and mechanism of crash under vehicle. The human dimension includes the sociodemographic characteristics (young age, male, low economic status, marital status, the experience of the motorcyclist, motorcycle ownership, etc), behavioral and/ or safety factors (including not wearing a helmet, high risk-taking behavior, alcohol use, and recreational drug use, excessive speeds, long driving distance) that exposed and increased the severity of motorcycle crashes. The mechanism of crash has been documented as single or multiple collisions, and the struck of a motorcycle by other objects (Hurt et al., 2015). The last category of factors included in the model is the environmental factors which include light condition, road surface condition, season/ period, time of the day, day of the week, and type of road-rural/urban.

Table 2.3: Risk factors for motorcycle crash-related head injuries according to the Haddon matrix

	Human	Vehicle	Environment/road
Pre-event	Younger age, low economic status, inexperience in riding, crash history, not having a driving license, traffic violation history, alcohol, and other drug use, owning motorcycle, excessive and slow speeds, and rider;'s inconspicuity	Motorcycle inconspicuity (e.g without daytime headlight use)	Nighttime, poor light condition, poor road condition, summer period, rural/urban area
Event	Long driving distance and duration, no safety gears(e.g. helmet wearing)	Motorcycle make, mechanism of crash	Collision with a heavy object (e.g. moving car)
Post-event	Elderly person, pre-existing medical condition		Slow emergency response, poor rehabilitation programs

Source: Lin & Kraus (2009)

2.8 Summary of the literature review

In line with the study's objectives, the reviewed literature examined the trend of registered motorcycle, motorcycle use, the burden of motorcycle crashes, burden of head injuries, and factors associated with head injuries in motorcycle crash victims which had been captured as sociodemographics factors, mechanisms of injury, safety or behavioral factors, and environmental factors.

From the literature, it was observed that the number of registered motorcycles and related injuries is on ascendency both locally and worldwide. For example, motorcycle registrations in Tamale, Ghana had increased to over 8000 motorbikes annually.

The literature also emphasized non-helmet use as a key determinant of head injuries in motorcycles crashes. Also, this review identified a number of factors which are significantly associated with motorcycle injuries: young age, marital status, Muslim, low socioeconomic status; reckless driving; inappropriate driving experience; lack of respect for road traffic laws; vehicle roadworthiness; road infrastructure deficiencies and inappropriate usage, alcohol and drug impairment; over-speeding and over-loading vehicles among others. However, these are evidence from Asia, Europe, and other western countries with limited information from Sub-Saharan Africa countries like Ghana. Motorcycle related studies in Ghana have focused extensively only on the prevalence of helmet use through observational designs, economic and social burden of motorcycle injuries. Despite the reported increase in motorcycle population and accidents in the Northern region of Ghana, little or no studies have comprehensively assessed the underlying factors of motorcycle injuries on the whole and specifically the traumatic head injuries among this population.

This study aims to bridge this gap through an unmatched case-control study to examine in the Northern region context, the socio-demographic factors, environmental and road factors, safety or behavioral factors, and the type of mechanism of injury that has characterized the occurrences of head injuries among motorcycle crash victims reporting to the Tamale Teaching Hospital.

CHAPTER THREE

METHODS

3.0 Introduction

The chapter presents the study design, description of the study area, variables of interest, study population, inclusion and exclusion criteria, sampling size and sampling technique, data collection technique, quality control, data management and analysis, ethical consideration, and pre-testing of study instrument.

3.1 Study design

This study employed an unmatched case-control study design to assess the factors contributing to head injuries in motorcycle crash victims of age 16 years and above reporting to the Tamale Teaching Hospital. This took place from December 2019 to May 2020.

3.2 Study Area

The study site was the Tamale Teaching Hospital located in the Northern region of Ghana. The Northern Region is the largest in Ghana in terms of landmark, which occupies an area of about 70,384 square kilometers. It shares boundaries with the Upper East and the Upper West regions to the north, the Brong Ahafo and the Volta regions to the south, Togo to the east, and Côte d'Ivoire to the west. The Northern region has a total population of 2,479,461 in 2010 with an annual population growth rate above 3.2% (GSS, 2015).

The Tamale Teaching Hospital (TTH) is an 800-bed capacity hospital which is the only Tertiary referral hospital in the whole of the savanna ecological zone of Ghana. This zone includes the Northern Region, Upper East, Upper West, and some parts of northern Volta and Brong Ahafo regions of Ghana. The hospital also receives cases from neighboring countries like Burkina Faso, Mali, and the Northern part of Togo (Adam et al., 2016). The teaching hospital has an Accident and Emergency (A&E) department, and Department of Surgery including trauma and orthopedics unit, neurology, plastics, ear nose and throat (ENT) unit, and general surgery. These two departments are responsible for the treatment and management of motorcycle crash victims at TTH. These departments operate on 24hours each day and more often than not, both departments receive motorcycle crash victims from communities or facilities within the region and beyond. Currently, there is no official documentation on motorcycle injuries at TTH. However, anecdotal evidence from the accident and emergency department revealed that TTH received an average of 60 motorcycle crash victims per month.

3.3 Study variables

Table 3.1: Dependent Variables of the study.

Variable	**Operational definition**	**Scale of measurement**	**Type of variable**
Dependent variable			
Cases	Motorcycle crash victims of age 16 years above with moderate or severe head injuries (GCS<13 and AIS-head >1) reporting at THH	Categorical	Nominal
Control	Motorcycle crash victims of age 16 years above with no or mild head injury (GCS ≥13 and AIS-head ≤1) reporting at THH	Categorical	Nominal

Table 3.2. Independent Variables

Variable	Operational definition	Scale of measurement	Type of variable
Socio-demographic characteristics			
Age	Date of birth or age at last birthday	Continuous categorical	Ratio Ordinal
Sex	Sex of participant	Categorical	Nominal
Residence status	The residential status of where the participants stay	Categorical	Nominal
Education status	The highest education status of participants	Categorical	Ordinal
Marital status	Marital status of participants	Categorical	Nominal
Religion	The type of religion practiced by participants	Categorical	Nominal
Socioeconomic status			
Employment status	Whether a participant is currently employed by self or someone else	Categorical	Nominal
Occupation	The source of income or the work a participant does.	Categorical	Nominal
Average monthly income	On average the among of income a participant earn in a month	Continuous categorical	Ordinal
Socioeconomic class	The number of assets a participant possesses using the wealth index items: motorcycles, fridge, phone, television, utensils, floor materials, number of sleeping rooms own, and toilet facility.	Categorical	Ordinal
Mechanism of injury as a factor			
Type of road user	The road user involved in a motorcycle accident	Categorical	Nominal
Type of collision	How the accident occurred (e.g. head-on-collision) and the object involved in the crash	Categorical	Nominal
Number of vehicles	The number of vehicles involved in the accidents (e.g. single motorcycle accident)	Continuous categorical	Ratio Ordinal
Vehicles/objects	The type of object or vehicle collided with the motorcycle used by participants (e.g. moving vehicle)	Categorical	Nominal

Table 3.2. Independent Variables (*continue*)

Variable	Operational definition	Scale of measurement	Type of variable
Safety and behavioral factors			
Excessive speed	Motorcycle traveling at a speed unsuitable for the existing road and traffic conditions, usually above 50km/hr on the urban road and 60km/hr on a rural road	Continuous	Ratio
Non-use of helmet	Motorcycle rider or passenger who did not use a helmet while the cyclist is in motion	Categorical	Nominal
Alcohol/drug use	A motorcycle crashed victim who had a history of alcohol or drug intake within 24 hours before the accident	Categorical	Nominal
Use mobile phones	A motorcycle crashed victim who used cell phone: received or made a phone call, messaging, etc. while riding the motorcycle	Categorical	Nominal
Multiple occupants/ overloading	Whether the motorcycle involved in the crashed had more occupants than specified	Categorical	Nominal
Environmental factors:			
Poor visibility	Whether the road was visible for the rider to see ahead	Categorical	Nominal
Time of the day	Time at which injury occurred, whether the crash occurred in the morning, afternoon, evening or night.	Continuous	Ordinal
Weather condition	Whether it rained when the injury occurred	Categorical	Nominal
Type of road	The residential status of the road on which the accident occurred, whether an urban or rural road	Categorical	Nominal
Nature of road	The nature of the road on which the accident occurred, whether concrete or rural road	Categorical	Nominal

3.4 Study population

The study population included motorcycle crashed victims of age 16 years and above reporting to the TTH for treatment from November 2019 to May 2020.

3.5 Inclusion/Exclusion criteria (Restriction)

3.5.1 Cases

Inclusion criteria

Motorcycle crash victim of age 16 years and above, and diagnosed with a head injury at the Tamale Teaching Hospital within the study period were included.

Exclusion criteria

Motorcycle crash victims of age 16 years and above who diagnosed with a head injury at the Tamale Teaching Hospital but incapacitated to recount incidents were excluded

3.5.2 Control

Inclusion criteria

Motorcycle crash victim of age 16 years and above confirmed to have no head injury at the Tamale Teaching Hospital within the study period were included

Exclusion criteria

Motorcycle crash victim of age 16 years and above confirmed to have no head injury at the Tamale Teaching Hospital but incapacitated to recount incidents were excluded.

3.6 Sampling technique and sample size determination

3.6.1 Sample size determination

The sample size for assessing the risk factors of head injury among motorcycle crashed victims in this unmatched case-control study was calculated assuming a power of 80% to detect an odds ratio of 2.21 with the proportion of control not wearing a helmet as 18% (Tumwesigye et al., 2016) at 5% level of significance. OpenEpi Version 3 was used in the sample size determination using the formula below (Kelsey et al., 1996):

$N_1 = (r + 1)/r * \bar{p}(1-\bar{p})(Z_\beta - Z_{\alpha/2})^2 / (p1-p2)^2$ $N_2 = rN1$

Where N1= number of cases

N2= number of controls

Z_β = desired power, 0.84 for a power of 80%

$Z_{\alpha/2}$= confidence level (95%)= 1.96

p1= proportion of cases with exposure= 32.7%

p2 = proportion of controls with exposure= 18%

r = ratio of controls to cases and

$\bar{p}$ = (p1+rp2)/(r+1)

Minimum sample size calculated from the above N1 (cases) = 139 N2 (controls) = 139;

Total = 278. From a similar case-control study in Uganda, it showed that about 11.1% of motorcycle crash victims reported at the TTH may not consent or were incapacitated to participate in the study (Tumwesigye et al., 2016). To account for this, a 10% non-response rate was estimated; total minimum sample size = 278+27.8 = 306. This was adjusted to 306 to give a total of 153 cases: 153 controls.

3.6.2 Sampling technique

Consecutive sampling was employed to recruit subjects from the Tamale Teaching Hospitals. All patients presenting with motorcycle-related injury as a rider, passenger, or pedestrian who visited the TTH was selected and the selection ratio of cases to controls was 1:1.

3.6.3 Selection of Cases and Controls

In this study, head injury was defined as a person with Glasgow Coma Scale (GCS) less than 13 [moderate (GCS 9–12) to severe (GCS 8 or less)] and Abbreviated injury score (AIS) of 2 to 6 [moderate (2) to unsurvivable (6)]. Hence, any participant whose head injury met the above criteria was classified as a case and vice versa. As shown in Figure 3.1, out of the total 469 MCVs recruited 265 met the case definition as cases and 204 as controls which exceed the minimum sample size estimated (306).

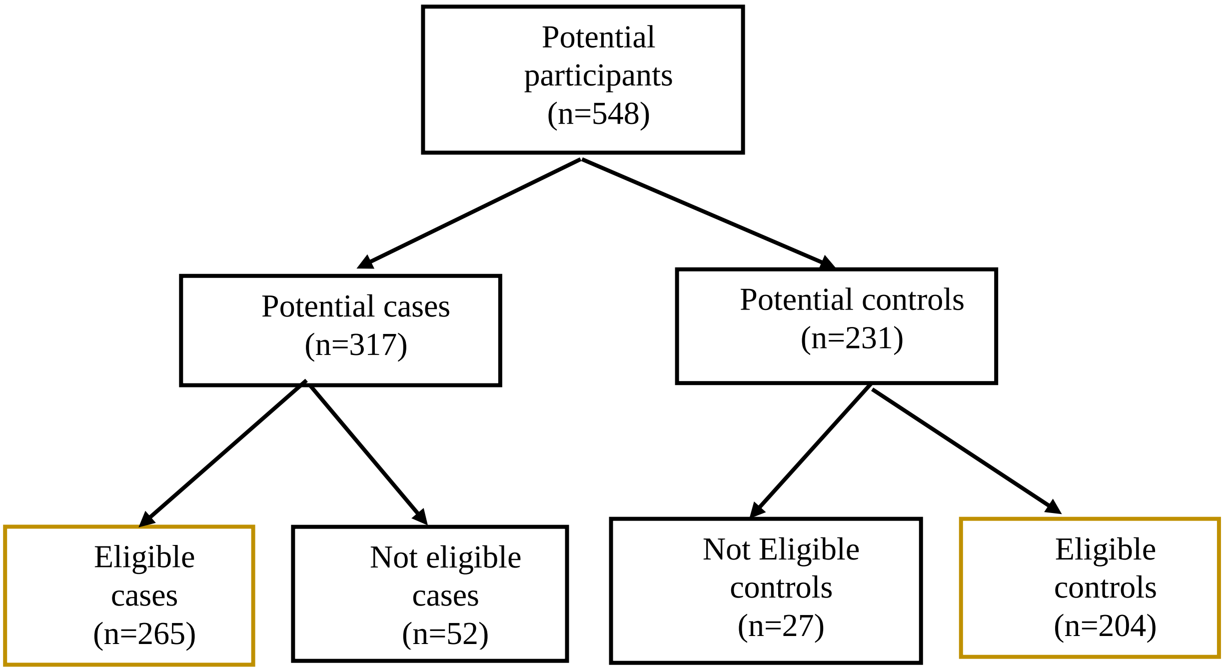


Figure 3.1: Shows the distribution of participants based on criteria for cases and controls.

3.7 Data collection instruments

A semi-structured questionnaire was used to collect information from patients who met the case definition as cases or controls, and it contained both open and closed-ended questions. The questionnaire was structured into three parts. **Part one:** Patient sociodemographic characteristics included age, sex, highest level of education, occupation/profession, income status, marital status, place of stay, type of settlement (rural/urban), ethnicity, religious affiliation, driving experiences, and ownership of the motorcycle, and other wealth index items. **Part two**: Injury and diagnosis history that included the mechanism of injury, the anatomic region affected, type of injury, and severity of injury scores. **Part three:** Safety/behavioral factors such as non-helmeted use, speed level, drink-driving or use of medicinal or recreational drugs, drivers fatigue, duration of work per day, driving time, etc.; environmental and road condition factors such as day of the incident, time of the day, type and nature of the road, weather condition, visibility, etc.

3.8 Pre-testing of data collection instruments

To improve on the validity and reliability of the study outcome, the research instrument was pre-tested among 10 motorcycle crash victims (MCVs) at the Tamale teaching hospital (TTH) during a site tour. The researcher was aware that conducting the pre-test at the same study site could lead to response bias. Hence, aside from the Research Assistants, the MCVs and other hospital staff involved during the pre-testing were not engaged during the actual data collection. The pre-testing helped the researcher to rephrase and re-structure unclear and ambiguous questions. Some of the questions were rearranged to ensure the logical ordering of questions and the deletion of repeated ones.

3.9 Quality control

Several mechanisms were put in place to ensure and guarantee data accuracy and quality devoid of biases. These included orientation for research assistants, pre-testing of questionnaires, and supervised data entry and processing. Completed questionnaires were validated before entry daily after which data was cleaned.

3.10 Orientation for Research Assistants

Three research assistants with three-years of experience in the trauma registry at the TTH were consulted and recruited to collect the data for the study. A two-day orientation was organized to make them conversant with the study instrument, participants' exclusion and inclusion criteria, ethical issues, and how to seek informed consent from participants for this study.

3.11 Data collection techniques

Data collection was done by administering a semi-structured questionnaire and medical records review to obtain a diagnosis.

3.11.1 Questionnaire administration

Firstly, inform consent was obtained from all participants who met the inclusion criteria, and a brief description of the purpose and benefits and the potential risk of the study was explained to participants. Afterward, the research assistants at the site administered the semi-structured questionnaire to respondents. Respondents who were unstable or unconscious were given time to recover before the interview was completed.

3.11.2 Record review

Also, together with the research assistants, the medical records of each patient were reviewed to complete the study instruments. Data captured in record review included diagnosed injuries, radiologic imaging requested (x-ray, head CT, and IMR), Abbreviated Injury Score (AIS), and Glasgow Coma Scale (GCS). The review lasted over the four (4) months period of data collection. The researcher found that information on patient diagnosis was routinely updated during admission and so the researcher had to wait until some patients are discharged to complete the questionnaire.

3.11.3 Assessment of head injuries

Assigning Injury Severity Score (ISS) to head injuries

Firstly, the Abbreviated Injury Score (AIS) was used to describe the severity of head injury. The following injuries were scaled: brain contusions, intracerebral hematomas, skull fractures, depressed injury, laceration and bruises/abrasions, and others (Yusuf et al., 2014). These injuries were confirmed by the attending Medical Officer using a head Computer Topography (CT) scan (or skull x-ray). Persons diagnosed with brain contusions, intracerebral hematomas, skull fractures, depressed injury, were considered to have a head injury (Yusuf et al., 2014). The injuries were scored based on the six-point ordinal scale of the Abbreviated Injury Scale (AIS). The scale included minor (1), moderate(2), serious(3), severe (4), critical(5), and untreatable (6).

Assigning Glasgow Coma Scale (GCS) score to head injuries

Secondly, the Glasgow Coma Scale (GCS) score, this neurological scale aims to give a reliable and objective recording of the state of a person's consciousness for initial as well as subsequent assessment. Each patient's GCS was assessed and recorded in the folder by the attending Medical Officer. The GCS was categorized into three groups in line with the National Institute for Health and Care Excellence (NIHCE, 2018): normal or minimally impaired conscious level (Glasgow Coma Scale [GCS] greater than 12); moderate (GCS 9–12); or severe (GCS 8 or less).

3.11.4 Wealth Index Score

The socioeconomic status of the respondent was estimated by adopting the DHS wealth quintile approach for measuring household wealth, a proxy for measuring wealth status: poorest, poorer, middle, rich, and richest (GHS, GSS, 2014). This study chose items such as assets and services since respondents may find it easier to respond to questions on them. Asset and services items included consumer durables (television, refrigerator, phone, motorcycle, expensive and cheap utensils), and housing characteristics (water supply, electricity, floor material, toilet facility, and the number of rooms)(Rutstein et al, 2004; Smits, 2013). The overall score was graded as the poorest, poor, moderate wealth, rich, and richest.

3.12 Data Processing and Analysis

The completed questionnaires were kept with the Principal Investigator with only access given to the principal supervisor. The completed questionnaires were scrutinized for completion and for any mistakes. The data were coded and entered into a statistical package for social sciences (IBM SPSS, version 21) software. The data were imported into STATA IC version 15 (StataCorp. College Station, TX, USA) for further management by relabeling, and recoding variables to suit the type of analysis to be performed.

A descriptive statistic such as mean, standard deviation, proportions (frequencies and percentages) was used to describe a patient's socio-demographic, characteristics, economic status, levels of head injuries, and exposures variables under the mechanism of injury, behavioral and safety, and environmental and road features. Categorical variables were compared using the Chi-square test and Fisher's exact test while continuous variables were compared using the Student t-test. Each exposure variable for the dependent variable (case or control group) was constructed as a binary outcome and was analyzed with logistic regression analysis. Binary logistic regression is a robust regression option that does not necessarily require independent variables to be normally distributed, or have equal variance in each group. Likewise, the dependent variable need not be normally distributed. Also, it does not assume a linear relationship between the exposure and outcome variables. A bivariate logistic regression was performed for each of the exposure variables and subsequently, multivariate regression models were built to explore the association between exposure variables while adjusting for the effects of covariates (socio-demographic and economic status). The multivariate regression analysis included independent variables from the univariate model with p values <0.2. The results were presented as crude odds ratio (COR), and adjusted odds ratio (AOR) respectively with their 95% confidence interval (CIs). Pearson goodness-of-fit test for the final multivariable model was determined. All statistical analyses were considered significant at p-value ≤ 0.05. The results of these analyses were presented as tables and charts.

3.13 Ethical consideration

3.13.1 Institutional and ethical approval

The ethical approval for this study was obtained from the Ethics Review Committee of the Ghana Health Service (Ref: GHS-ERC024/12/19). The consent of the management and Ethics Committee of the Tamale Teaching Hospital was sought.

3.13.2 Description of subjects in the study

The population for this study was motorcycle crash victims with or without head injury who were seeking care at the TTH from December 2019 to April 2020.

3.13.3 Description of study's procedure

The principal investigator and the two research assistants recruited participants and interviewed them during the period of data collection (12th December 2019 to 12th April 2020) each day until the sample size of 306 (153 cases and 153 controls) was attained. The participants were recruited using consecutive sampling of motorcycle crash victims for each day. The recruited patients consented and were interviewed using semi-structured questionnaires. Participants had the right at any point in the study to withdraw if so desired.

3.13.4 Confidentiality and privacy

Data collected from participants interviewed were kept private and confidential. The interviewer only used identification numbers to represent each participant instead of their names to ensure anonymity. Also, they were assured that the information obtained during the interview will not be shared with a third party.

3.13.5 Voluntary Participation/ withdraw

Both written and oral informed consent was sought from study participants before data was collected. Participation in the study was solely voluntary and participants had the option to opt-out at any desired time.

3.13.6 Data Access and storage

The completed questionnaires were collected each day and stored in a locked locker with only the principal investigator having access. The answered questionnaires were scrutinized for completion and for any mistakes. The data were coded and entered into a statistical package for social sciences (IBM SPSS, version 21) software with access given to the principal investigator. Soft copies were stored on an external drive. After the use of data, all soft copies will be cleaned and hard copies destroyed after five years.

CHAPTER FOUR

RESULTS

4. 1 General characteristics of study participants

A total of 548 MCVs reported to the facility between 12th December 2019 and 12th April 2020. Of 548 MCVs, 317 were identified as potential cases and 231 were potential controls. Using their age 16 years and above as inclusion criteria, 469 of the MCVs met the selection criteria and recruited as participants in this study. The general socio-demographic characteristics of the study participants are presented in Table 4.1. The motorcycle crash victims' age ranged from 16 to 89 years with a mean age of 34.2 (±13.5) years. A significant proportion of the respondents 287(61.2%) were found within the age range of 21-40 years while 66 (14.1%) were below 21 years. The majority of crashed victims from this study were males 352(75.1%) and were residing in peri-urban communities in the five Northern regions. Generally, most of the victims whose records were reviewed were married 307(65.5%) and were Muslims 339(72.3%) with 121 (25.8%) of them being Christians. A significant proportion of the victims had no formal education 188(40.1%) and 107 (22.8%) had attained at least primary education (Table 4.1).

Table 4.1 Socio-demographic characteristics of study participants, Tamale Teaching Hospital, 2020

Characteristics	Study participants	
	Number of MCVs (n)	Proportion (%)
Age, years		
Mean (SD), range	34.23 (13.53)	16-89
Group		
<21	66	14.1
21-40	287	61.2
41-60	91	19.4
60+	25	5.3
Total	469	100.0
Sex		
Male	352	75.1
Female	117	24.9
Total	469	100.0
Residential status		
Urban	124	26.4
Peri-urban	253	53.9
Rural	92	19.6
Total	469	100.0
Marital status		
Single	160	34.1
Married	309	65.9
Total	469	100.0
Religion		
Christian	121	25.8
Muslim	339	72.3
Others	9	1.9
Total	469	100.0
Education		
None	188	40.1
Primary	107	22.8
JSS/JHS	40	8.5
SSS/SHS/vocational	102	21.7
Tertiary	32	6.8
Total	469	100.0

JHS-Junior high school, JSS-Junior secondary school, SHS-Senior high school, SSS-Senior secondary school

Table 4.2 summarizes the socioeconomic characteristics of the study participants. The largest proportion 338 (72.1%) of the study participants was employed with the majority as farmers 182(38.8%) while only 37(7.9%) were salary workers on the government payroll. One-fourth 120(25.6%) of the victims engaged in extra income-generating businesses. In terms of household wealth status, most of the victims 230(49%) were in the middle quantile while a significant number 143(30.5%) were financially disadvantaged.

Table 4.2 Socioeconomic status of study participants, Tamale Teaching Hospital, 2020

Characteristics	Study participants	
	Number of MCVs (n)	Proportion (%)
Employment status		
Unemployed	131	27.9
Employed	338	72.1
Total	469	100.0
Occupation		
Salary worker	37	7.9
Farmer	182	38.8
Artisan	22	4.7
Trade	78	16.6
Others	55	11.7
Unemployed	95	20.3
Total	469	100.0
Extra sources of income		
No	349	74.4
Yes	120	25.6
Total	469	100.0
Wealth Status		
Poorest	23	4.9
Poor	120	25.6
Middle	230	49.0
Rich	73	15.6
Richest	23	4.9
Total	469	100.0
Motorcycle		
No ownership	100	21.3
Ownership	369	78.7
Total	469	100.0

As shown in Figure 4.1 below, the majority of the victims were riders 347(74%) while 122 (26%) of them suffered injuries as passengers (pillions riders).

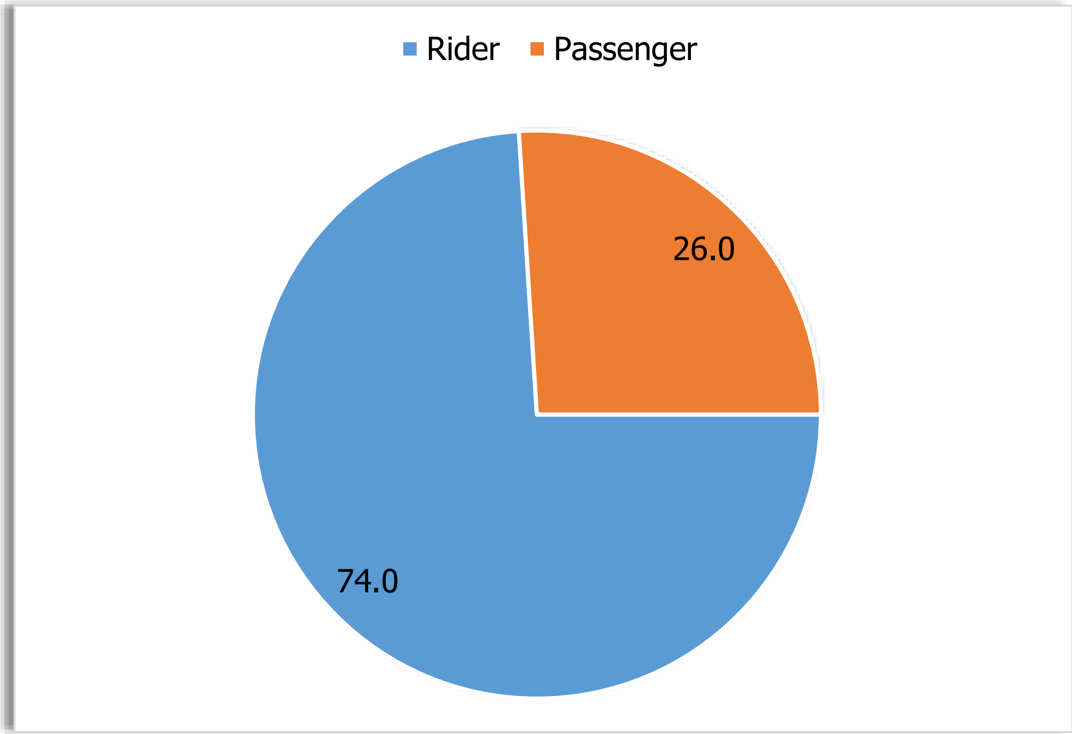


Figure 4.1 Motorcycle user category of crash victims, Tamale Teaching Hospital, 2020

The type of motorcycle and number of occupancy among crash victims are as shown in Figure 4.2. A total of 402 (85.7%) of crashes were among two-wheeled motorcycles. Of these, the majority were single occupants 220(54.7%) while a significant proportion 180(44.8%) of the victims shared motorcycles. A total of 67 (143%) of the crashes were among three-wheeled motorcycles and 63(94%) had occupancy of 3 and above.

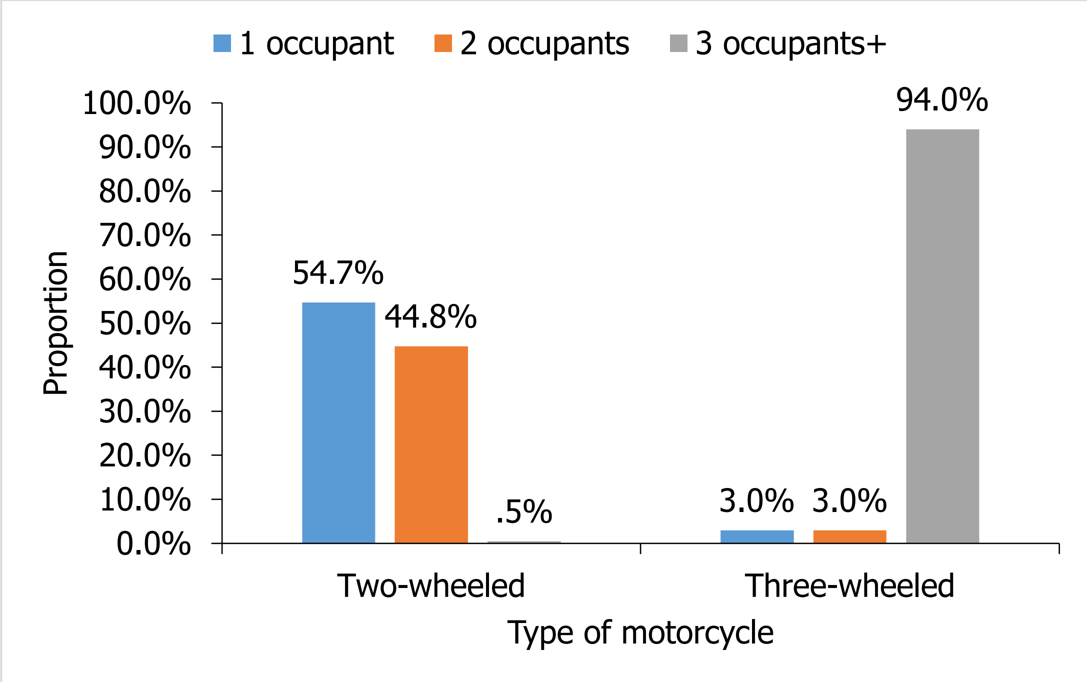


Figure 4.2 Type of motorcycle and number of occupancy among crash victims, Tamale Teaching Hospital, 2020

4.3 Assessment of head injury and participants' classification in medical records reviewed

The summary of head injuries suffered by participants is presented in Table 4.1. Out of the 469 MCVs, 445(94.9%) suffered either lacerations or abrasions, 230 (49%) had Skull fractures and Subdural/subarachnoid hematoma was seen in 140 (29.9%) of MCVs.

Table 4.3: Medical Record review of Head injuries suffered by motorcycle crash victims, Tamale Teaching Hospital, 2020

Injuries	Number of MCV	Proportion (%)
Skull fractures	230	49.0
Brain contusions	71	15.1
Subdural/subarachnoid hematoma	140	29.9
Lacerations/abrasions	445	94.9
Other (cerebral bleeding)	2	0.4

Using the Glasgow Coma Scale (GCS) as a measure of head injury from the medical records of patients as shown in Figure 4.3, 319 (68%) of the victims had a normal (13-15) GCS, while only 35 (7.5%) scored GCS of less than 8, representing severe head injury.

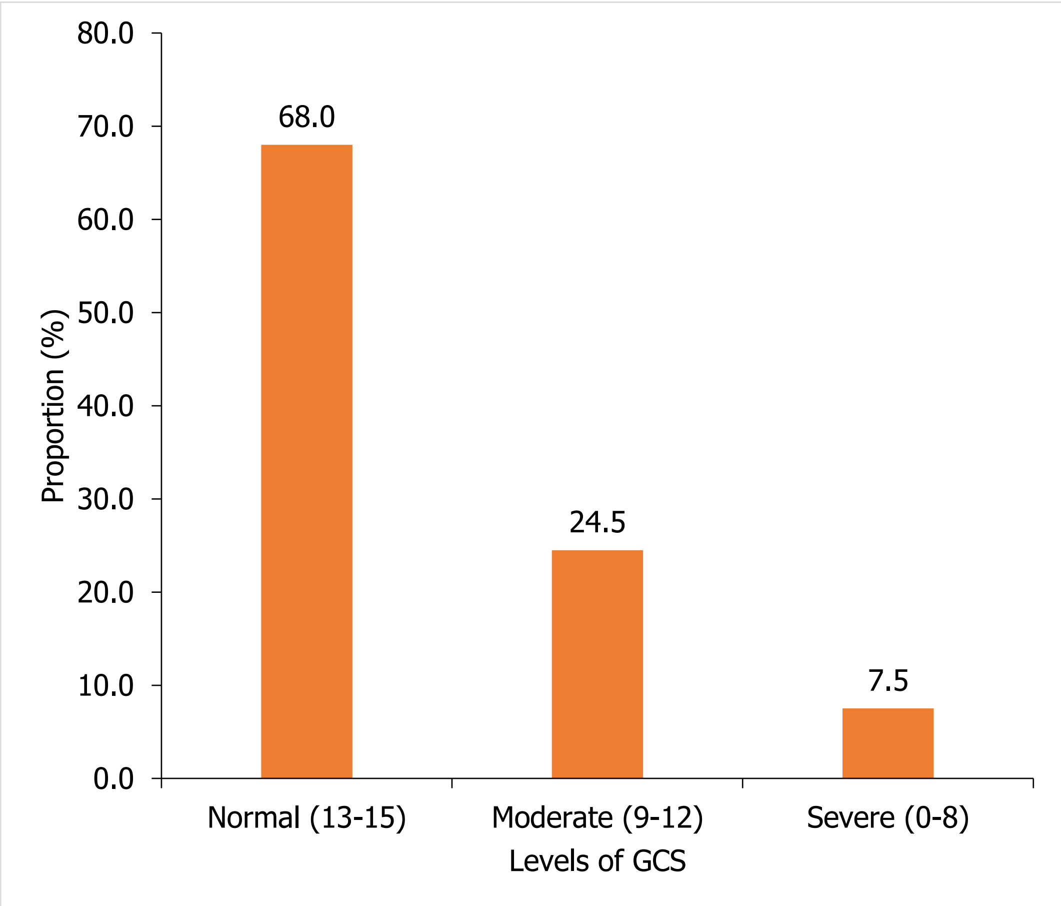


Figure 4.3: Level of head injury using the Glasgow Coma Scale (GCS), Tamale Teaching Hospital, 2020

The Abbreviated Injury Score (AIS) was used as a measure of head injury and the findings are shown in Figure 4.4. Most of the victims (182(38.8%)) of MCVs suffered a mild injury while a significant proportion of them suffered moderate (135(28.8%)) to severe (10(10.5%)) injuries. Only 2(0.4%) suffered critical forms of head injuries.

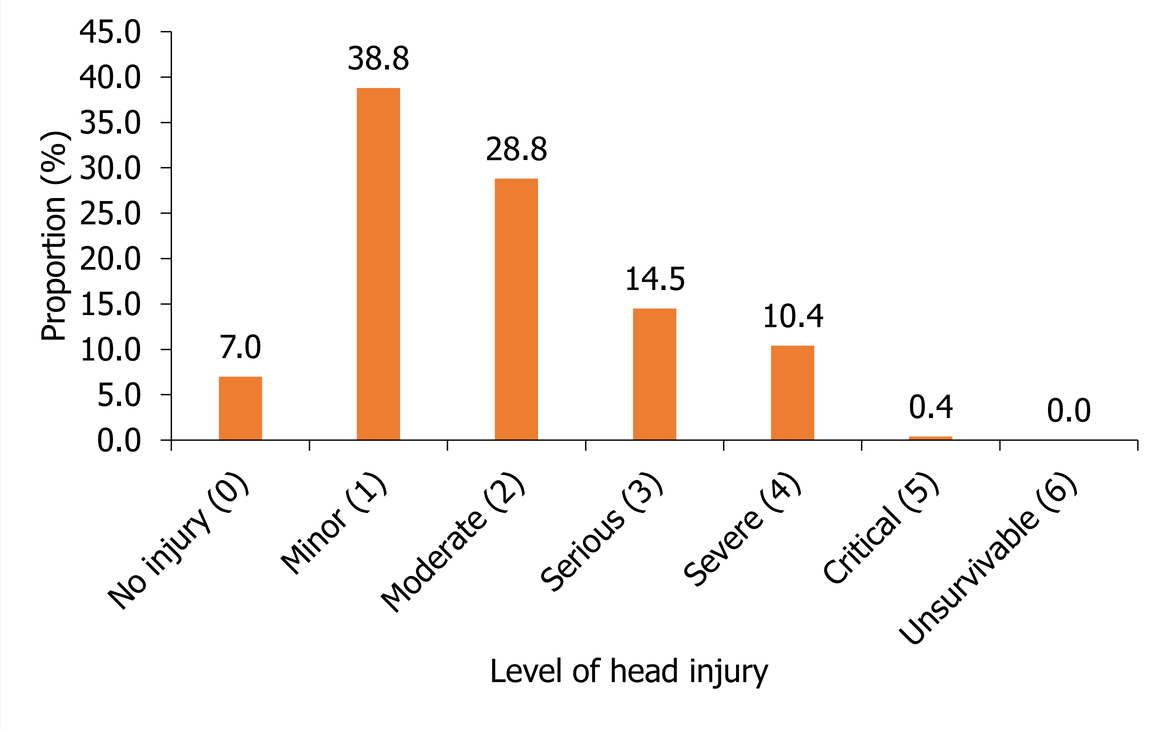


Figure 4.4: Level of head injury from medical records reviewed using Abbreviated Injury Score (AIS), Tamale Teaching Hospital, 2020

4.4 Participants' characteristics and occurrence of head injury

This section presents the socio-demographic and socioeconomic characteristics of cases and controls.

4.4.1 Socio-demographic characteristics of participants and the occurrence of head injury

The socio-demographic characteristics of cases and controls are shown in Table 4.3. Most of the cases (152(57.4%)) and controls (135(66.2%)) were 21–40 years while (223(84.2%)) of cases and (129(63.2%)) of controls were males. A greater proportion (125 (47.2%)) of cases and (128 (62.7%)) controls resided in peri-urban communities while (165(62.3%)) of cases and (142 (69.6%)) of controls were married. A greater proportion of both cases (180(67.9%)) and controls (159(77.9%)) were Muslims. Majority of the victims both cases (107(40.4%)) and controls (81(39.7%)) had no formal education while only 32(6.8%) [16(6.0%) of cases and 16(7.8%) of controls] had attained tertiary education. The occurrence of head injury was significantly associated with the sex of the victim (p<0.001) and residential status (p=0.004).

Table 4:3 Socio-demographic characteristics and head injury in motorcycle crash victims, Tamale Teaching Hospital, 2020

Categories	Cases (n=264)		Controls (n=204)		Chi-sqaure p-value
	N	%	n	%	
Overall MCVs	265	56.5	204	43.5	-
Age, years					
Mean (SD)	40.0 (±13.6)		34.5 (±13.5)		
Range					0.147
<21	45	17.0	21	10.3	
21-40	152	57.4	135	66.2	
41-60	53	20.0	38	18.6	
60+	15	5.7	10	4.9	
Sex					
Male	223	84.2	129	63.2	<0.001**
Female	42	15.8	75	36.8	
Residential status					0.004*
Urban	80	30.2	44	21.6	
Peri-urban	125	47.2	128	62.7	
Rural	60	22.6	32	15.7	
Marital status					0.117
Single	100	37.7	60	29.4	
Married	165	62.3	142	69.6	
Widowed	0	0.0	1	0.5	
Divorced	0	0.0	1	0.5	
Religion					0.108
Christian	79	29.8	42	20.6	
Muslim	180	67.9	159	77.9	
Traditionalist	5	1.9	2	1.0	
Others	1	0.4	1	0.5	
Education					0.428
None	107	40.4	81	39.7	
Primary	68	25.7	39	19.1	
JSS/JHS	21	7.9	19	9.3	
SSS/SHS/vocational	53	20.0	49	24.0	
Tertiary	16	6.0	16	7.8	

**Significant at p<0.001, * Significant at p<0.05

4.4.2 Socioeconomic status of participants and occurrence of head injury

Table 4.4 summarizes the participants' socioeconomic characteristics and the occurrence of head injury. There was an even but a higher proportion of study participants who were employed among cases (192(72.5%)) and controls (146(71.6%)), and most of these participants were farmers in both cases (112(42.3%)) and controls (70(34.3%)). Less than one-third of both cases (56(21.1%)) and controls 64(31.1%) had extra sources of income. Majority of the victims had a household wealth status at the middle quantile, this was higher in controls (116(56.9%)) than in cases (114(43%)).

A significant association was found between the occurrence of head injuries and extra sources of income (p=0.012), and economic class of victim (p=0.021) (Table 4.4).

Table 4.4: Socioeconomic characteristics and head injury in motorcycle crash victims, Tamale Teaching Hospital, 2020

Variables	Cases (n=264)		Controls (n=204)		*Chi-square p-value*
	n	**%**	**N**	**%**	
Employment status					0.832
Unemployed	73	27.5	58	28.4	
Employed	192	72.5	146	71.6	
Occupation					0.059
Salary worker	20	7.5	17	8.3	
Farmer	112	42.3	70	34.3	
Artisan	14	5.3	8	3.9	
Trade	35	13.2	43	21.1	
Others	25	9.4	30	14.7	
Unemployed	59	22.3	36	17.6	
Extra sources of income					0.012*
No extra income	209	78.9	140	68.6	
Had extra income	56	21.1	64	31.4	
Economic class (from wealth index items)					0.021*
Poorest	5	6.8	5	2.5	
Poor	48	27.2	48	23.5	
Middle	116	43.0	116	56.9	
Rich	27	17.4	27	13.2	
Richest	8	5.7	8	3.9	

* Significant at p<0.05

4. 5 Mechanism of injury and occurrence of head injury

Tables 4.5 summarizes the mechanism of head injuries among motorcycle crash victims (MCVs). One-fourth of the victims among cases (195(26.4%)) and controls (151(26%)) had a history of motorcycles injuries. The proportion of two-wheeled MCVs of cases (166(89.1%)) was higher than that of controls (236(81.4%)). A greater proportion of MCVs were riders, with a relatively higher proportion in cases (204(77.4%)) than controls (142(69.6%)). Generally, there was nearly an even distribution of injuries among single and double occupants motorcyclists, in both cases [131(49.4%) versus 107(40.4%)] and controls [91(44.6%) versus 75(36.8%)], but this was relatively higher in cases than in controls.

The proportion of injuries from a single motorcycle accident [cases (53(20%)) as against controls (25(12.3%))] and motorcycle vs other vehicles [cases (77(29.1%)) as against control (42(20.6%))] was found to be higher in cases than controls, and vice versa for multiple motorcycle collision [cases (77(29.1%)) as against controls (87(42.6%))] and motorcycle vs pedestrian [cases (58(21.9%)) as against controls (50(24.5%))]. A greater proportion of the accidents were through *head-on-collision with other motorcycles* but twice lower in cases (74(27.9%)) than controls (85(41.7%)). On other hand, cases were more involved in *head-on-collision with other vehicles* in cases (62(23.4%)) than controls (37(18.1%)).

The occurrence of head injuries were significantly associated with the type of motorcycle (p=0.018), number of occupants (p=0.032), the type of collision (p=0.003) and the circumstance in which the injury occurred (p=0.047).

Table 4.5: Mechanism of injury and occurrence of head injury among MCVs, Tamale Teaching Hospital, 2020

Variable	Cases (n=264)		Controls (n=204)		P-value
	n	%	N	%	
History of motorcycle injury					0.916
No history	195	73.6	151	74.0	
Has history	70	26.4	53	26.0	
Type of motorcycle					0.018*
Two-wheeled	236	89.1	166	81.4	
Three-wheeled	29	10.9	38	18.6	
State of involvement					0.058
Rider	204	77.4	142	69.6	
Passenger	60	22.6	62	30.4	
Shared motorcycle					0.299
Rider only	131	49.4	91	44.6	
Shared	134	50.6	113	55.4	
Number of occupants					0.032*
1 occupant	131	49.4	91	44.6	
2 occupants	107	40.4	75	36.8	
3 occupants+	27	10.2	38	18.6	
Type of collision					0.003*
Single motorcycle accident	53	20.0	25	12.3	
Multiple motorcycle collision	77	29.1	87	42.6	
Motorcycle vs other vehicle	77	29.1	42	20.6	
Motorcycle vs pedestrian	58	21.9	50	24.5	
Description of mechanism					0.047*
Run-off roadway	39	14.7	20	9.8	
Fell making a U-turn	13	4.9	7	3.4	
Head-on collision with another motorcycle	74	27.9	85	41.7	
Head-on collision other vehicle	62	23.4	37	18.1	
Fell avoiding incoming vehicle	16	6.0	10	4.9	
Fell avoiding with pedestrian/animal	56	21.1	44	21.6	
Motorcycle run into preceding motorcycle	5	1.9	1	0.5	

* Significant at $p<0.05$

4.5 Behavioral and safety factors and the occurrence of head injury

The distribution of motorcycle crash victims (MCVs) by riding experience is summarized in Figure 4.6. The overall average riding experience of victims was 10.2 (±6.7) years (range: 1 to 40 years) with 10.7 (±6.9) years in cases and 9.5 (±6.2) years in controls. Most of the respondents, 101(38.1%) and 98(48%) had 6 to 10 years of riding experience for cases and controls respectively. There was a significant association between the riding experience of victims and head injury occurrence (P=0.008).

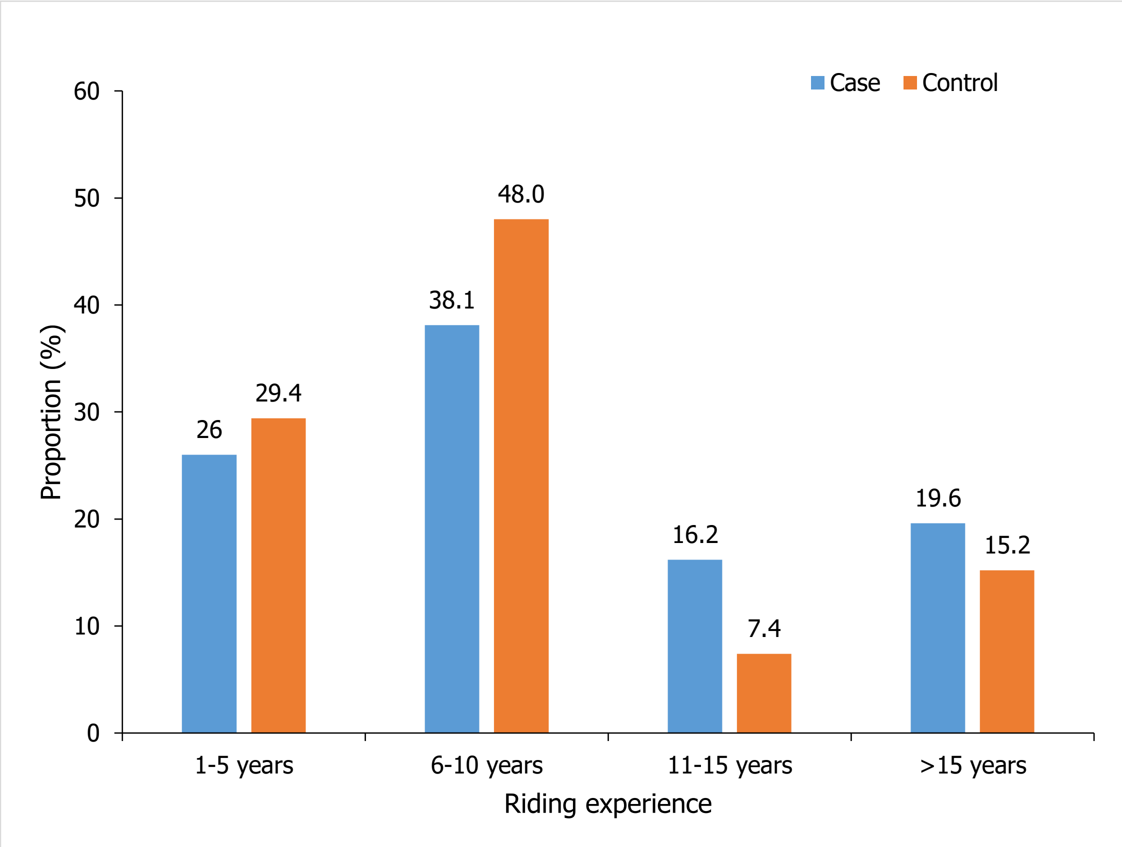


Figure 4.5: The distribution of MCVs by riding experience, Tamale Teaching Hospital, 2020 Tamale Teaching Hospital, 2020

The behavioral and safety factors (human attributes) of head injury among motorcycle users are presented in Table 4.6. The proportion of participants who owned a motorcycle was higher in controls (171(84.3%)) than in cases (197(74.3%)). A greater proportion of the cases (225(84.9%)) were not wearing a helmet as compared to (88(43.1%)) of the controls. Among those in helmet, most of the controls (68(33.3%)) were using an *open face helmet* against (15(5.7%)) of cases.

More than half of both cases (167(63%)) and controls (115(56.4%)) were speeding (>50km/h) while a significant proportion of cases (104(39.2%)) and controls (72(35.3%)) were carelessly overtaking. Relatively few victims were under influence of alcohol [cases: 4(1.5%) versus controls:4(2%)]. None of the cases used mobile phones while only 3(1.5%) of the controls used mobile phones while riding. Most of the cases (129(48.7%)) had the accident within 30mins of riding while 104(51%) of the controls had the accident between 30mins and 60mins of riding. Experience of riding fatigue was found to be higher in cases (30(11.3%)) and in controls (7(3.4%)).

A significant association was found between the occurrence of head injuries and ownership of motorcycle (p=0.004), helmet use (p<0.001), type of helmet used (p<0.001), mobile phones use (p=0.048), and tiredness while riding (p=0.002).

Table 4.6: Behavioral and safety factors (human attributes) of head injury among motorcycle users

Variable	Cases (n=264)		Controls (n=204)		P value
	N	%	N	%	
Ownership of motorcycle					0.009*
Owns none	68	25.7	32	15.7	
Owns one	197	74.3	171	84.3	
Helmet use					<0.001**
No helmet	225	84.9	88	43.1	
With helmet	40	15.1	116	56.9	
(if used) Type of helmet used					<0.001**
Full face helmet	14	5.3	39	19.1	
Open face helmet	15	5.7	68	33.3	
Partial helmet	12	4.5	10	4.9	
Not helmeted	224	84.5	87	42.6	
Over speeding					0.145
Under speed limit (<50km/h)	98	37.0	89	43.6	
Over speed limit(>50km/h)	167	63.0	115	56.4	
Careless overtaking					0.381
Not careless	161	60.8	132	64.7	
Careless	104	39.2	72	35.3	
Riding under influence of alcohol					0.708
Non-alcohol	261	98.5	200	98.0	
Alcohol influence	4	1.5	4	2.0	
Recreational drug					
No drug	265	100.0	204	100.0	-
use drug	0	0.0	0	0.0	
Using mobile phones while riding					0.048*
No phone use	265	100.0	201	98.5	
Phone use	0	0.0	3	1.5	
Riding duration					0.118
<30 mins	129	48.7	93	45.6	
30-60 mins	117	44.1	104	51.0	
>60 mins	19	7.2	7	3.4	
Tiredness while riding					0.002*
Not tired	235	88.7	197	96.6	
Tired	30	11.3	7	3.4	

**Significant at p<0.001, * Significant at p<0.05

4.7 Environmental and road factors and the occurrence of head injury

The majority of the motorcycle crash victims were involved in a motorcycle crash between Monday and Friday with the days recording the highest number of crashes being Wednesday [cases: 53(20%) and controls: 37(18.1%)] and Thursdays [cases: 43(16.2%) and controls: 35(17.2%)] (Figure 4.7). Involvement in a motorcycle crash by day was not found to be significantly associated with occurrence of head injury (P=0.940).

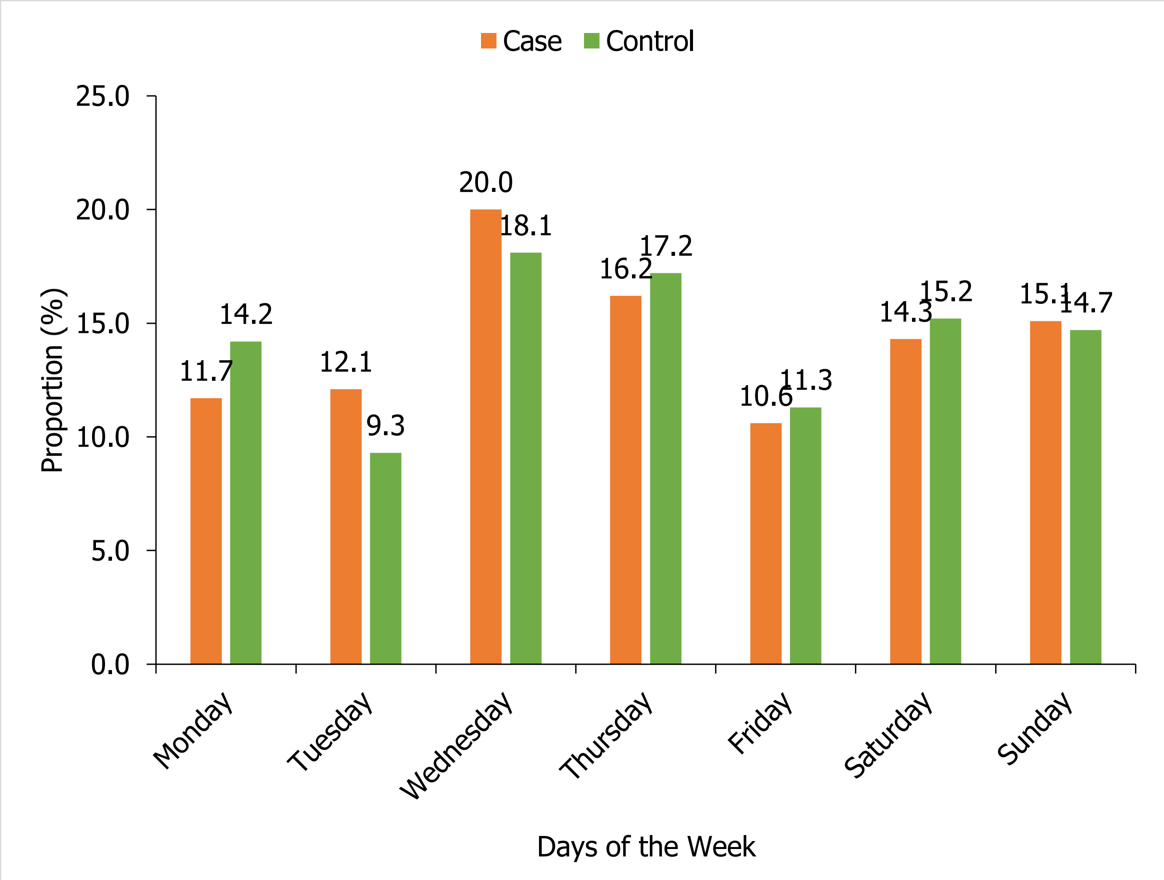


Figure 4.6: The distribution of MCVs by day of the week, Tamale Teaching Hospital, 2020

Table 4.7 summarizes the environmental and road factors of head injury among motorcycle crash victims. On the time of involvement in a crash, most of the crashes occurred in the afternoon [cases: 120(45.3%) and controls: 88(43.1%)] and evening [cases: 102(38.5%) and controls: 78(38.2%)] of the day. As expected, the largest proportion of the crashes among both cases (187(70.6%)) and controls (143(70.1%)) took place on weekdays as compared to the weekend [cases: 78(29.4%) and controls: 61(29.9%)]. However, there is no significant association between the occurrence of head injury and time of the day (p=0.618) and period (p=0.912) of crashes.

On weather conditions focusing on raining season, the majority of the crashes in both cases (260(98.1%)) and controls (192(94.1%)) occurred in the dry season. Crashes among cases (5(1.9%)) were less likely to occur in the raining season compared to controls (12(5.9%)). The difference in the proportion of exposure between cases and control was significant at p=0.002 (Table 4.7).

Apart from the time of the day in which the accident occurred, the street light condition was used to assess road visibility; a greater proportion of the accidents in cases (146(55.1%)) and controls (130(63.7%)) occurred during the daylight. The occurrence of motorcycle crashes in the darkness was relatively higher in cases (54(20.4%)) than in controls (26(12.7%)), but the difference in proportion was not significant (p=0.066).

Generally, most of the crashes occurred on urban roads. However, crashes in cases (116(43.8%)) were highest on urban-roads while (92(45.1%)) of the controls urban-highway. A greater proportion of crashes occurred on concrete with potholes for both cases (164(61.9%)) and controls (129(63.2%)). There was no significant association between the occurrence of head injury and road type (P=0.225), and road surface condition (P=0.069).

Crashes that occurred in the presence of curves was much higher in controls (104(51%)) than cases (86(32.5%)), likewise crashes that occurred in presence of speed limit [cases: 168(63.4%) and controls: 148(72.5%)], and presence of road sign [cases: 160(60.4%) and controls: 147(72.1%)]. A significant association was found between the occurrence of head injury and presence of curves (p<0.001), presence of speed limit (p=0.036), and presence of road sign (p=0.008).

Table 4.7: Environmental and road factors of head injury among motorcycle crash victims

Variable	Cases (n=264)		Controls (n=204)		P-value
	n	%	N	%	
Time of the day					0.618
Morning	23	8.7	25	12.3	
Afternoon	120	45.3	88	43.1	
Evening	102	38.5	78	38.2	
Night	20	7.5	13	6.4	
Weekday/ weekend					0.912
Weekdays	187	70.6	143	70.1	
Weekends	78	29.4	61	29.9	
Weather condition					0.022*
Raining	5	1.9	12	5.9	
Not raining	260	98.1	192	94.1	
Street light condition					0.066
Daylight	146	55.1	130	63.7	
Reduced light	65	24.5	48	23.5	
No light	54	20.4	26	12.7	
Road type					0.225
Urban-street	116	43.8	76	37.3	
Rural	50	18.9	36	17.6	
Urban-highway	99	37.4	92	45.1	
Road surface condition					0.069
Untarred/earthen road	54	20.4	27	13.2	
Concrete with potholes	164	61.9	129	63.2	
Asphalt	47	17.7	48	23.5	
Presence of curves					<0.001**
No curve	179	67.5	100	49.0	
curve	86	32.5	104	51.0	
Presence of speed limit					0.036*
No speed limit	97	36.6	56	27.5	
Speed limit	168	63.4	148	72.5	
Presence of road sign					0.008*
No road sign	105	39.6	57	27.9	
Road sign	160	60.4	147	72.1	

**Significant at p<0.001, * Significant at p<0.05

4.8 Logistic regression analysis of factors associated with head injury in motorcycle crash victims

This section presents the results from the bivariate and multivariate logistic regression analysis involving the outcome variable (cases or controls) and the categories of factors (socio-demographics, safety/behavioral, mechanism of injury, and environmental factors). The results are presented as crude odds ratio (COR), and adjusted odds ratio (AOR) respectively with their confidence interval (CIs). Each category of factors has been presented in separate sub-sections.

4.8.1 Sociodemographic predictors of head injury among motorcycle crash victims

Table 4.8 presents the bivariate and multivariate analysis of Socio-demographic factors of head injuries in motorcycle crash victims. At the bivariate level, Motorcyclists of age group 21-40 years were less likely to sustain head injuries (cOR = 0.53, 95%CI: 0.30, 0.93). Males were 3.09 times more likely to sustain head injuries (95%CI:1.99, 4.77) whilst peri-urban residents (cOR = 0.54, 95% CI: 0.34, 0.84), Muslims (cOR = 0.60, 95%CI: 0.39, 0.93), and extra income earners (cOR = 0.59, 95%CI: 0.39, 0.89) were less likely to suffer head injuries. None of these factors remained significant in the multivariable model.

Table 4.8: Bivariate and multivariate analysis of Socio-demographic factors of head injuries in motorcycle crash victims

Categories	Crude		Adjusted	
	OR (95%CI)	p-value	OR (95%CI)	p-value
Age, years				
<21	1(ref.)		1(ref.)	
21-40	0.53 (0.30, 0.93)	0.026*	0.65 (0.26, 1.64)	0.366
41-60	0.65 (0.33, 1.27)	0.205	1.24 (0.37, 4.03)	0.726
60+	0.70 (0.27, 1.82)	0.463	1.57 (0.33, 7.65)	0.572
Sex				
Female	1(ref.)		1(ref.)	
Male	3.09 (1.99, 4.77)	<0.001**	1.90 (0.97, 3.72)	0.061
Residential status				
Urban	1(ref.)		1(ref.)	
Peri-urban	0.54 (0.34, 0.84)	0.006*	0.83 (0.32, 2.16)	0.229
Rural	1.03 (0.59, 1.81)	0.915	0.68(0.36, 1.28)	0.709
Marital status				
Single	1(ref.)		1(ref.)	
Married	0.70 (0.47, 1.03)	0.070	0.73 (0.33, 1.62)	0.443
Religion				
Christian	1(ref.)		1(ref.)	
Muslim	0.60 (0.39, 0.93)	0.021*	0.81 (0.4, 1.49)	0.498
traditionalist	1.33 (0.25, 7.15)	0.740	5.34 (0.62, 46.07)	0.128
others	0.53 (0.03, 8.72)	0.658	0.92 (0.02, 37.22)	0.964
Occupation				
Salary worker	1(ref.)		1(ref.)	
Farmer	1.36 (0.67, 2.77)	0.397	1.87 (0.63, 5.52)	0.258
Artisan	1.49 (0.50, 4.39)	0.472	3.30 (0.65, 16.83)	0.150
Trade	0.69 (0.31, 1.52)	0.358	2.05 (0.48, 8.67)	0.329
Others	0.71 (0.31, 1.64)	0.419	1.07 (0.29, 3.8)	0.917
Unemployed	1.39 (0.65, 3.00)	0.398	0.83 (0.24, 2.86)	0.774
Extra sources of income				
No extra income	1(ref.)		1(ref.)	
Had extra income	0.59 (0.39, 0.89)	0.012*	0.56 (0.24, 1.30)	0.175
Economic class (from wealth index items)				
Poorest	1(ref.)		1(ref.)	
Poor	0.42 (0.14, 1.20)	0.104	0.55 (0.14, 2.10)	0.378
Middle	0.27 (0.10, 0.76)	0.013*	0.75 (0.18, 3.14)	0.697
Rich	0.47 (0.16, 1.42)	0.182	1.05 (0.21, 5.15)	0.950
Richest	0.52 (0.14, 1.93)	0.329	1.18 (0.18, 7.92)	0.864

**Significant at p<0.001, * Significant at p<0.05

4.8.2 Mechanism of injury as a predictor of head injuries in motorcycle crash victims

Results from the bivariate and multivariate analysis of the mechanism of injuries of head injuries in motorcycle crash victims are summarized in Table 4.9. None of these factors remained significant in the multivariable model.

Table 4.9: Bivariate and multivariate analysis of the mechanism of injuries of head injuries in motorcycle crash victims

Variable	Crude		Adjusted	
	OR (95%CI)	p-value	OR (95%CI)	p-value
Type of motorcycle				
Two-wheeled	1(ref.)		1(ref.)	
Three-wheeled	0.54 (0.32, 0.91)	0.020*	1.21 (0.14, 10.25)	0.862
State of involvement				
Passenger	1(ref.)		1(ref.)	
Rider	1.49 (0.99, 2.26)	0.059	0.84 (0.34, 2.09)	0.707
Number of occupants				
1 occupant	1(ref.)		1(ref.)	
2 occupants	0.99 (0.67, 1.48)	0.965	0.91 (0.49, 1.70)	0.763
3 occupants+	0.49 (0.28, 0.87)	0.014*	0.21 (0.02, 2.19)	0.193
Type of collision				
Single motorcycle accident	1(ref.)		1(ref.)	
Multiple motorcycle collision	0.42 (0.24, 0.74)	0.002*	0.59 (0.10, 3.39)	0.555
Motorcycle vs other vehicle	0.86 (0.47, 1.59)	0.639	0.62 (0.10, 3.69)	0.599
Motorcycle vs pedestrian	0.55 (0.29, 1.00)	0.052	0.28 (0.04, 1.93)	0.200
Description of mechanism				
Run-off roadway	1(ref.)		1(ref.)	
Fell making a U-turn	0.95 (0.33, 2.76)	0.928	3.08 (0.63, 14.99)	0.163
Head-on collision with another motorcycle	0.45 (0.24, 0.83)	0.011*	1.37 (0.21, 9.19)	0.743
Head-on collision other vehicle	0.86 (0.44, 1.69)	0.660	1.68 (0.24, 11.83)	0.605
Fell avoiding incoming vehicle	0.82 (0.32, 2.14)	0.685	2.11 (0.26, 17,15)	0.486
Fell avoiding with pedestrian/animal	065 (0.33, 1.37)	0.211	3.56 (0.49, 26.06)	0.212
Motorcycle run into preceding motorcycle	2.56 (0.28, 23.46)	0.404	4.58 (0.17, 125.03)	0.367

* Significant at $p<0.05$

4.8.3 Behavioral and safety factors of head injuries in motorcycle crash victims

Table 4.10 summarizes the results from bivariate and multivariate analysis of behavioral and safety factors of head injuries in motorcycle crash victims. The crude odds ratios of getting head injury was significantly higher for victims with 11-15 years riding experience (cOR = 2.49, 95%CI: 1.26, 4.93), for non-helmet users (cOR = 7.41, 95%CI: 4.80, 11.46), partial helmet users (cOR = 3.34, 95%CI: 1.18, 9.44), who were tiredness while riding (cOR= 3.59, 95%CI: 1.54, 8.36) but was lower for victims who owned motorcycle (cOR = 0.54, 95%CI: 0.34, 0.86).

Also in the adjusted model, the odds of suffering from head injury was significantly higher for victims with 11-15 years riding experience (aOR = 2.91, 95%CI: 1.01, 8.39), and wearing a partial helmet (aOR = 4.78, 95%CI: 1.38, 16.55).

Table 4.10: Bivariate and multivariate analysis of behavioral and safety factors of head injuries in motorcycle crash victims

Variable	Crude		Adjusted	
	OR (95%CI)	p-value	OR (95%CI)	p-value
Riding experience				
<5years	1(ref.)		1(ref.)	
6-10 years	0.89 (0.58, 1.40)	0.628	1.64 (0.75, 3.62)	0.217
11-15 years	2.49 (1.26, 4.93)	0.009*	2.91 (1.01, 8.39)	0.049*
>15years	1.46 (0.83, 2.56)	0.189	1.16 (0.41, 3.30)	0.783
Ownership of motorcycle				
Owns none	1(ref.)		1(ref.)	
Owns one	0.54 (0.34, 0.86)	0.010*	0.47 (0.19, 1.12)	0.088
Helmet use				
No helmet	7.41 (4.80, 11.46)	<0.001**	3.47 (0.58, 20.92)	0.174
With helmet	1(ref.)		1(ref.)	
(if used) Type of helmet used				
Full face helmet	1(ref.)		1(ref.)	
Open face helmet	0.61 (0.27, 1.41)	0.249	0.84 (0.31, 2.25)	0.722
Partial helmet	3.34 (1.18, 9.44)	0.023*	4.78 (1.38, 16.55)	0.013*
Not helmeted	7.17 (3.71, 13.86)	<0.001**	4.22 (0.59, 30,03)	0.151
Over speeding				
Under speed limit (<50km/h)	1(ref.)		1(ref.)	
Over speed limit(>50km/h)	1.32 (0.91, 1.91)	0.145	1.51 (0.83, 2.77)	0.173
Riding duration				
<30 mins	1(ref.)		1(ref.)	
30-60 mins	0.81 (0.56, 1.18)	0.274	1.40 (0.81, 2.41)	0.223
>60 mins	1.96 (0.79, 4.85)	0.147	1.01 (0.30. 3.41)	0.983
Tiredness while riding				
Not tired	1(ref.)		1(ref.)	
Tired	3.59 (1.54, 8.36)	0.003*	2.36 (0.79, 7.07)	0.125

**Significant at p<0.001, * Significant at p<0.05

4.8.4 Environmental factors of head injuries in motorcycle crash victims

Table 4.11 presents the outcome from bivariate and multivariate analysis of environmental factors of head injuries in motorcycle crash victims. The unadjusted model showed that the odds of head injury was significantly higher when riding in dry season (cOR=3.25, 95%CI: 1.12, 9.38), in darkness (cOR=1.85, 95%CI: 1.09, 3.12) but lower on asphalt roads (cOR= 0.49, 95%CI: 0.27, 0.90), on roads with curves (cOR= 0.46, 95%CI: 0.32, 0.67), on roads with speed limits (cOR= 0.66, 95%CI: 0.44, 0.97) and on roads with road signs (cOR= 0.59, 95%CI: 0.39, 0.87).

In the adjusted model as shown in Table 4:11, riding in darkness was found to be statistically significant with the occurrence of head injury (aOR= 2.69, 95%CI: 1.28, 5.67, p=0.009).

Table 4.11: Bivariate and multivariate analysis of environmental factors of head injuries in motorcycle crash victims

Variable	Crude		Adjusted	
	OR (95%CI)	p-value	OR (95%CI)	p-value
Weather condition				
Raining	1(ref.)		1(ref.)	
Not raining	3.25 (1.12, 9.38)	0.029*	1.37 (0.34, 5.44)	0.659
Street light condition				
Daylight	1(ref.)		1(ref.)	
Reduced light	1.21 (0.78, 1.88)	0.406	1.37 (0.74, 2.54)	0.323
No light	1.85 (1.09, 3.12)	0.022*	2.69 (1.28, 5.67)	0.009*
Road surface condition				
Untarred/earthen road	1(ref.)		1(ref.)	
Concrete with potholes	0.64 (0.38, 1.01)	0.085	1.21 (0.49, 3.03)	0.677
Asphalt	0.49 (0.27, 0.90)	0.022*	1.99 (0.65, 6.09)	0.227
Presence of curves				
No curve	1(ref.)		1(ref.)	
curve	0.46 (0.32, 0.67)	<0.001**	0.56 (0.30, 1.05)	0.071
Presence of speed limit				
No speed limit	1(ref.)		1(ref.)	
Speed limit	0.66 (0.44, 0.97)	0.037*	2.28 (0.38, 14.13)	0.377
Presence of road sign				
No road sign	1(ref.)		1(ref.)	
Road sign	0.59 (0.39, 0.87)	0.009*	0.38 (0.007, 2.18)	0.277

**Significant at p<0.001, * Significant at p<0.05

The Pearson goodness-of-fit test for the final multivariable model (including variables with p<0.2) showed a significant model with a p= 0.0006 and chi2(d.f:411)=510.84. In summary, only riding experience of 11 to 15 years (aOR = 2.91, 95%CI: 1.01, 8.39), partial helmet use (aOR = 4.78, 95%CI: 1.38, 16.55) and riding in darkness (aOR= 2.69, 95%CI: 1.28, 5.67) remained significant with head injury after controlling for confounders.

CHAPTER FIVE

DISCUSSION

5.1 Related socio-demographic background characteristics and head injury

Findings from the study show that the proportion of motorcycle crashes are much higher in younger riders, males, married, Muslims, less educated patient, and among the moderate wealth group. Over 74% of study participants in this study were below 41 years [21-40years (61.2%) and below 21 years (14.1%)], 75% were male occupants, 65.6% were married and 72.3% were Muslims. These findings are consistent with the findings of Tumwesigye et al. (2016), who reported that injured motorcyclists were significantly younger. However, their findings indicated a higher proportion of head injuries among unmarried and higher-income earners, unlike married and moderate-income earners reported in this study. Kamulegeya et al. also reported a mean age of 29.01 (9.15) years among their study participants who were all males, and had primary or no education (56.7%)(Kamulegeya et al., 2015).

The high proportion of younger ages reported in this study explains why Nyatundo (2014) asserted that the youthfulness of the motorcyclists is among the major factors responsible for motorcycle accidents as this is due to inexperience. This implies if the current patterns of demographic distribution among victims continue, what will happen is that more younger adult males in the economically active age group will continue to get injured and perhaps die as a result of motorcycle crashes, thus reducing productivity in the Northern regions and the country at large. The high proportion of married MCVs could be attributed to the predominant Islamic worshipers in the Northern Regions of Ghana which encourages early marriages and polygamy. Consistent with findings from Uganda(Nuwematsiko et al., 2018), the majority of the MCVs in the Northern region were in middle wealth status.

5.2 Proportion of head injury among motorcycle crash victims

The primary outcome of this study is head injury. The study adopted an internationally accepted standard to determine the level of head injuries among motorcycle crash victims. In this study, the proportion of motorcycle crash victims who suffered significant head injury was 256, representing 56.5%. The study's finding is consistent with 55.8% of motorcycle accident victims who suffered head injuries in Rwanda (Mbanjumucyo et al., 2016). A much higher proportion (71%) was reported in Uganda by Kamulegeya et al (Kamulegeya et al., 2015). A similar study also found a lower proportion of head injuries (29.3%) in Taiwan (Chih-wei et al., 2017). The high incidence of head injuries could be partly explained by a combination of non-adherence to safety measures, increasing demand for motorcycles for transport due to the growing population, a growing middle class, and the availability of cheaper motorcycles (Iaccarino, Carretta, & Morselli, 2018). These findings suggest that targeted interventions to reduce motorcycle-related head injuries in developing countries must essentially address these underlying causes that have the potential to impose huge socioeconomic burden on families and economic loss to the nation.

Previous studies on motorcycle crash victims have reported a high prevalence of head injury among male motorcyclists (Macleod et al., 2010a, 2010b; Ogbonna et al., 2015; Parambil et al., 2019). Consistent with these findings, the current study found that nearly 85% of the motorcycle crashes in males resulted in head injuries. Although higher, Ogbonna et al. (2015) reported a much higher proportion of 90.32% of patients with traumatic head injuries among males while Yusuf et al. (2014), also documented 93.3% of patients with motorcycle-related head injuries in male victims. The observed higher proportion of head injury in male motorcycle crash victims in the Northern region, could be attributed to a number of reasons. First, most of the motorcycle users are males who are likely to engage in risky behaviors such as over speeding, drinking among others. Secondly, as found in this study, most of the male motorcyclists do not use the helmet, a protective factor of traumatic brain injury (TBI). In the context of previous studies, the higher incidence of head injuries in male motorcyclists have been linked with higher risky behaviors such as alcohol consumers, excessive speeding, not wearing a helmet, use of cell phone, cigarette smoking among others (NTSB, 2018; Sanyang et al., 2017; Tumwesigye et al., 2016; Waseem et al., 2019).

Similar to previous studies, the majority of patients who sustained head injury were young, and between 21 and 40 years. These were young men in their prime age working to make ends meet. The data from this current study did not show the reasons for riding a motorcycle, whether for commercial or private purposes. However, a greater proportion (72.1%) of the victims were employed in the informal sector and are self-employed of which a significant proportion of them may engage in extra sources of income that might include commercial motorcycle activities. Also in the Northern region where commercial vehicles are limited, many commuters use motorcycles as a means of transport to their homes and workplaces. The patronage encourages many young ones to join commercial motorcycle riding as a source of living.

In line with reported evidence, the findings of this study reveal that the proportion of victims with head injury is high among victims without helmet (84.9%) than victims in helmet (15.1%). Previous study also found that the majority of the victims with severe head injury without protective gear (92%) were statistically significantly higher than those with mild head injury who also were not in safety gear (77.1%) (Kamulegeya et al., 2015). Although the data from this study did not measure attitude of motorcyclists, finding from this current study might suggests that victims who sustained head injury had poor attitudes towards the use of quality of helmets. Full face helmet is the most durable and protective helmet against motorcycle-related head injury, however, only 5.3% of the cases who wore helmet had a full-face helmet to protect their heads. As highlighted in Vietnam, the observed difference in helmet use from these studies could be due to a variety of reasons including different enforcement levels of helmet legislation, economic conditions, knowledge of the law, and benefits of correctly wearing standard helmets (Bao et al., 2017). Failure to wear a helmet is a major clinical problem because head injury from such behavior is associated with high morbidity and mortality, prolonged hospital stay and disability in victims(Adeloye et al., 2016; Chih-wei et al., 2017; Kamulegeya et al., 2015; Sung et al., 2016; Tumwesigye et al., 2016). It is also evident that the use of helmet does not only prevent head injury but it also reduces the severity of head injury among victims (Kamulegeya et al., 2015).

5.3 Sociodemographic factors of head injury among motorcycle crash victims

The difference in sociodemographic factors between the cases and controls in the study is consistent with results from several studies. Like previous studies (Chih-wei et al., 2017; Plancikova, 2017; Tumwesigye et al., 2016), adolescents (<21 years) were at a higher risk of head injuries than young adults of age 21-40 years. However, the findings of this study further show that compared to motorcycle crash victims (MCVs) of age below 21 years, those of ages above 40years had a much higher risk of head injuries. Younger drivers have higher crash risks than older drivers, with research indicating that the youngest group of drivers have the highest risk (Agrawal, Munivenkatappa, Rustagi, Mohan, & Subrahmanyan, 2017; Plancikova, 2017; Tumwesigye et al., 2016). This higher crash risk could be due to a lack of experience, and a propensity to drive in high- risk situations, lack of driving skill, immaturity, lack of risk perception ability, and overestimation of their driving skills (Bates, Davey, Watson, King, & Armstrong, 2014; Nyatundo, 2014; Ogbonna et al., 2015; WHO, 2010). Evidence from Uganda showed that advanced ages above 25 years are much less likely to suffer from motorcycle injuries in both unadjusted and adjusted models (Tumwesigye et al., 2016). On other hand, Sanyang et al. (2017), reported that motorcycle injuries were much (Adjusted OR=0.24) less likely to occur among young people (95% CI: 0.1–0.52). The risk of head injuries in young motorcyclists in developing countries may be higher than those reported in developed countries since the majority (54-57%) of motorcyclists in developing countries are among young adults of ages 20 to 29 years (Nyatundo, 2014; Sowa, 2013).

Previous studies have highlighted that lower socioeconomic status influences the occurrence of motorcycle injuries which includes head injury (Hurt, Ouellet & Thom, 2015; Lin & Kraus, 2009; Tumwesigye et al., 2016). These findings depict a negative linear correlation. The difference in measuring the wealth status, sampling approach and sampled population used by these studies might explain the observed variation in findings. Similar study by Tumwesigye et al. (2016) also found a higher odds of motorcycle injury among high income earners (OR = 12.9, 95%CI: 5.95–28.08). The finding of current study and that of Tumwesigye et al., (2016) on the relationship between SES and head injury somewhat show a positive correlation between the SES of motorcyclist and the head injury, a reverse of what is literally known. Although these findings are reported in developing countries with similar socioeconomic distribution, these are some level of internal variations contributing to the differences in findings observed. These could be due to the approach the studies used in estimating wealth status, sampling procedure, inclusion and exclusion criteria used and the context these studies were conducted.

5.4 Mechanism of injury as a predictor of head injury in motorcycle crash victims

The mechanism of motorcycle crashes contributes significantly to the kind of injury suffered by the motorcyclist (Hurt, Ouellet & Thom, 2015). The severity of the crash in motorcyclists might render helmet less effective to protect the head as suggested by previous studies, which could be attributed to the speed at which the crash occurs (Chih-wei et al., 2017). A greater proportion of head injuries sustained by motorcyclists in this study were due to multiple motorcycle collisions, and those between motorcycle and other vehicles. And most of the head injuries occurred through head-on collisions either by two motorcycles or other vehicles.

Consistently, Yusuf et al. (2014) found that motorcycle versus other vehicle collisions resulted in more patients with severe head injury followed by lone motorcycle crash though the relationship between collision type and head injury severity was not statistically significant (Yusuf et al., 2014). Again, Ayuekanbey (2016) found that most of the victims of motorcycle accidents had their injuries through being hit by vehicle on the other hand, the risk of head injury is higher among motorcyclists involved in single-vehicle crashes (Chih-wei et al., 2017). A study conducted by Hurt et al. (2015) in California, United States of America (USA), documented 25.6% and 74.1% of motorcycle crashes resulting from single vehicle collision and multiple vehicle collisions respectively.

Irrespective of the type of motorcycle, the contribution of risky rider behavior like not wearing a helmet, speeding, etc., and the nature of road to head injuries during motorcycle crashes cannot be disregarded. As seen in the unadjusted model, it is expected that the risk of head injuries among the motorcyclists of two-wheeled to be much higher than their counterparts, because of their poor stability or balance on road compared to the three-wheeled motorcycle. In explaining the role of balance in the mechanism of motorcycle-related head injuries, the finding from this study indicates that the odds ratios of head injury for motorcycle crash victims who fell when making a U-turn (AOR=3.08), fell avoiding with pedestrian or animal (AOR=3.56), and run into preceding motorcycle (AOR=4.58), are much higher than those involved in a head-on collision with another motorcycle (AOR=1.37) and with other vehicles (AOR=1.37).

Further on, the data revealed that most of these patients who suffered through a fall either when making a U-turn or avoiding pedestrian or animal were mainly two-wheeled motorcyclists. Hurt et al. (2015) in California attributed the falling of motorcycle to the loss of control problems in which they related it to excess speed entering a U-turn and under-cornering in that turn rather than sliding out. They further observed that most cases of running wide on a turn were single motorcycle accidents where the motorcycle ran off the road then collided with some parts of that environment. It is therefore surprising that the risk of head injury was higher in crashes involving three-wheeled than two-wheeled when adjusted for confounders like speeding, helmet use, and others in this study. In the Northern region where transportation of human and goods are limited to motorcycles, the majority of three-wheeled (94%) had to carry three or more passengers. Also, many passengers on a three-wheeled motorcycle in the region perceive to be protected and do not wear protective gear like helmets. These might have accounted for the increased risk of head injury among three-wheeled compared to two-wheeled.

5.5 Behavioral and safety factors of head injury in motorcycle crash victims

Multiple risk factors of motorcycle injury have been documented by World Health Organization (WHO, 2010), these factors were reviewed according to the concepts of the Haddon Matrix which stratified them into three phases including human, vehicle, and environment. Most of the safety and behavioral factors studied in this study are placed in the pre-event and event domains. The pre-event focuses on inexperience, crash history, high risk-taking behavior, alcohol and other drug use, motorcycle ownership, excessive speeds, and rider's inconspicuity; while the event includes long driving distance and time, no safety devices e.g. helmet wearing (WHO, 2010). In the present study, the occurrence of head injury among crash victims is significantly linked with riding experience, ownership of the motorcycle, non-helmet use, mobile phones use, and tiredness while riding.

On non-helmet use, this study reports that a greater proportion of victims were not wearing a helmet and this is significantly higher among cases as compared to the controls (84.9% vs 43.1%). The crude model in the study finds that non-helmet users are 7.4 times more likely to sustain a head injury within a 95% CI of 4.80 to 11.46. The influence of not wearing a helmet on motorcycle crash head injuries decreases by twice after adjusting for the effect of confounders (aOR=3.47; 95%CI: 0.58, 20.92). This finding is consistent but with higher odds than what was reported from a matched case-control study among commercial motorcyclists in Uganda (Tumwesigye et al., 2016). The study reported that patients without helmet were 2.21times more likely to suffer head injuries than patients wearing helmets (95%CI:1.47–3.30).

Further analysis from the present study among those in helmet showed that majority of the motorcyclists were using open face helmets. The 2017 report of the USA Governors

Highway Safety Association revealed that helmets reduce the risk of head injury from motorcycle crashes by 69 percent and deaths by 37 percent (Governors Highway Safety Association, 2017). An open face helmet (OFH) is less protective against head injury as compared to the full face helmet (FFH). The study also found that participants wearing a partial helmet are 4.78times more likely to sustain head injuries compared to those wearing the full-face helmet (95%CI: 1.38, 16.55).

Inferential analysis from a retrospective observational study in the Republic of Korea showed that patient with FFH and OFH have a lower head abbreviated injury severity (AIS) than victims without helmet and those with half-coverage helmet. Sung et al. (2016), further indicated that patients with full-face helmet experienced a significant reduction in the effect of severe and minor head injury. In line with previous studies, the findings of this study suggest that motorcycle crash victims without a helmet have a higher risk of severe head injury compared to patients with any type of helmet. This finding supports the evidence that motorcycle helmets provide the best protection from head injury for motorcyclists involved in traffic crashes (Ngunu, 2015; Peltzer & Pengpid, 2014). Although we have a comprehensive helmet law, low knowledge of traffic rules, younger age, male sex, and discomfort of wearing a helmet has been the reported reasons for the lower rate of helmet use in developing countries (Musah, Marfo, & Akpade, 2018; Taylor, 2010; Turkson et al., 2013).

The findings of this study show that cases (10.7years) had better riding experience than in controls (9.5 years) with most of these victims having ride motorcycle for more than 6 years. However, victims with 11-15 years riding experience are 2.9 times more likely to suffer head injury as compared to those with 5 years and below (95% CI: 1.01, 8.39). On the contrary, the United States National Transportation Safety Board (NTSB) reported that victims with less than 2 years of riding experience are 2.72 times more likely to suffer crash injuries as compared to those with 5 years and above riding experience (95% CI: 2.36, 8.55) (NTSB, 2018). Previous studies have revealed that an increase in driving experiences is a protective factor for motorcycle injuries (Tumwesigye et al., 2016). Similarly, Nyatundo, (2014) indicated that riders with many years of experience rarely get involved in accidents (Nyatundo, 2014). This could be explained by the fact that experienced riders know how to maneuver on all kinds of roads and at different times.

Impairment associated with alcohol is an important factor influencing both the risk of a road crash as well as the severity of the injuries that result from crashes (WHO, 2010). Although alcohol use has been linked to motorcycle injuries (Tumwesigye et al., 2016), this study found no significant association between alcohol use and head injuries as only eight victims' self-reported alcohol use while riding. This might not reflect the true alcohol use among the study participants since the study could not measure blood alcohol concentration (BAC) and only had to depend on self-reported use. It has been indicated that alcohol consumption can work as a proxy for addictive conduct including smoking, a strongly correlates of motorcycle injuries (Tumwesigye et al., 2016).

5.6 Environmental factors of head injury in motorcycle crash victims

According to the New Zealand Motorcycle Crash Fact Sheet (2014), the combined effect of poor environmental and road conditions increase the risk of motorcyclists being involved in a crash and there is a potential increase of injury severity. In this study, the influence of days of the week, time, weather condition, street light condition, the status of the road, road surface condition, presence of curves, presence of speed limit, and presence of road safety signs on motorcycle-related head injuries were assessed.

Weather is a known underlying risk factor of road traffic accidents, hence, weather forecast informs drivers to take cautions in bad weather (Liu et al., 2018). The finding of this present study shows that a significant proportion of the motorcycle crashes occurred in the dry season, however, crashes that occurred in the raining season were much lower among cases than in controls (1.9% vs 5.9%). The pattern of head injuries in the dry season could be explained in different ways. Foremost, the Northern regions are savannah zones that experience a long duration of dry season, hence, is likely that most of the crashes which could result in head injuries may occur in that season. Secondly, there could be a potentially high-risk perception among motorcycle riders regarding the nature of road networks in the regions during the raining season. Most often than not, the untarred roads in the north may become very slippery, coupled with poor visibility become life-threatening in the wet season, which influences riders to be cautious to avoid the risk of crashes.

The study's findings on days and time of crash involvement reveal that majority of the motorcycle crashes occurred on weekdays, and predominately Mondays and Thursdays. Most of the crashes occurred in the afternoon and evening of the day. Involvement in a motorcycle crash by day and time was not significantly associated with motorcycle injuries and the occurrence of head injury. In a developing country like Ghana, Mondays and other weekdays are busy days where businesses resume in full operation after the weekend break, hence there is an increased in road patronage, and the influence of additional risky behaviors including over speeding, improper overtaking, and many others. The possible explanations given for the afternoon time association with head injuries occurrence could be due to fatigue and speeding to catch up with time. Similarly, Sanyang et al. (2017) found 71.2% of the motorcycle crash injuries among their study population occurred on weekdays. The study further noted that involvement in a motorcycle crash on a weekday was not found to be significantly associated with motorcycle crash injuries in the Gambia (Sanyang et al., 2017). The findings on days of the week that crashes occur in this study were also consistent with the findings of Ngunu (2015), who reported the majority of motorcycle crashes in Kenya occurred between Monday and Friday with the days recording the highest number of crashes being Monday. He also noted that involvement in a motorcycle crash during the weekend was not significantly associated with the level of injury severity.

On the contrary, several studies have reported that most presentations of motorcycle injuries occur on weekends in the United States of America and Nigeria (Hurt et al., 2015; Yusuf et al., 2014). Although these studies did not report on the trend of motorcycle use by days or week, it could be that the distribution of motorcycle use by day in these countries differs which might account for the differences in findings. The difference in findings could be the level of enforcement and adherence to road safety regulations (being protective factor against motorcycle injuries) that exist in these countries.

Apart from the season and time of the day in which motorcycle accidents occur, the street light condition was also used to assess road visibility and it was observed that a greater proportion of the crashes occur during the day (cases: 55.1% and controls: 63.7%). However, the involvement of motorcycle crashes at night was relatively higher in cases than in controls. The adjusted model also shows that victims who crashed in the dark have significantly higher likelihood to sustain head injury as compared to those who crashed at daytime (aOR= 2.69, 95%CI: 1.28, 5.67). As enumerated by Motuma (2017) from Swaziland, it is obvious that street lighting may improve a rider's visual capabilities and ability to detect roadway hazards, particularly among older drivers, thus decreasing the severity of motorcycle associated head injuries that occur at night.

Consistently, Matheka et al. (2015) study among commercial motorcycle users in Kenya revealed that most crashes (32.0%) occurred during the daytime, but people injured in the night were 5 times more likely to sustain a bodily injury compared to daytime. Motuma (2017) study found that most of the road traffic injuries (69%) occurred during the day, however, the bivariate analysis found no association between severity of the road traffic injuries and night or daylight conditions in Swaziland (Motuma, 2017). Similar to the findings of this present study, a systematic review of the effects of street lighting on fatalities and injuries from road traffic crashes revealed that street lighting conditions significantly affect the severity of the road traffic injuries (Beyer & Ker, 2009).

Other environmental factors in this study included road type, road surface condition, and road design. This study further recorded relatively higher proportion of motorcycle crashes on urban roads concrete with potholes, and road with curves, and with the speed limit. Although most of the participants of this present study assert the presence of road safety signs, the findings suggest that motorcyclists in the Northern region were not obeying these road signs. This might be that they do not understand the true meaning and importance of these signs or they have over familiarized with them. In this study, inferences from these findings cannot be linked to the aspect of knowledge and attitude of motorcyclists on road safety signs and road safety regulation since this study gather no evidence of knowledge, attitude, and practice (KAP) of motorcyclists regarding road safety signs and road safety regulation.

In a similar analogy, Motuma (2017) reported that most serious or fatal injuries occurred on concrete or asphalt roads and in the bivariate analysis, the surface condition of the roads had no significant association with the severity of injuries. Like the present study, he associated his findings with the higher traffic flow rate and the higher number of vehicles present on the major roads and highways (which were concrete or asphalt) at the same time. Also, on low-quality road surface types, drivers tend to drive at a lower speed which tends to minimize the risk of head injuries in crashes involving motorcyclists. As seen in the adjusted model for this study, high impact crashes on asphalt roads are likely to result in head injuries due to excessive speeding among motorcycle riders which may render helmet less effective (Lin et al., 2009), that is if the rider uses helmet while non-helmet riders sustain most severe or fatal injuries.

5.7 Limitation of the study

This was an unmatched case-control study conducted at a single teaching hospital and therefore the results may not be generalizable to the rest of the country. Data collected was self-reported hence the results may have been biased since the accuracy of respondents' description of circumstances of the injury could not be independently verified. As some participants may have reported injury events that may have occurred outside the study period, there is a possibility that some details of the injury event may have been missed, hence introducing recall bias to the study. Also, there could be selection bias as a result of misclassification of cases and controls. This might have affected the true representation of cases and controls in the sampled population thereby influencing the findings of this study.

This study included only motorcycles crash victims (MCVs) who sustained an injury within three weeks prior to presentation at the hospital within the study period,12th December 2019 to 12th April 2020, could minimize this recall bias, It is also acknowledged that the short period for data collection that focused on motorcycle injuries within the preceding 4 months, did not take into consideration the seasonality patterns that might influence head injuries in motorcycle crashes throughout the year.

In order to reduce the number of questions to be answered by a motorcycle crash victims, this study could not adopt all the items listed in the demorgraphic health survery (2014) for the socioeconomic status (wealth index estimation). This might have led to underestimation of the wealth index status of the population studied.

Despite these limitations, this study being the first case-control study on motorcycles injuries in the Northern region highlights common head injuries sustained among crash victims as well as context-based factors contributing to the high proportion of head injury among motorcycle crash victims. These findings will probably provide direction for restructuring road safety policy, enforcement of road safety regulations, and preliminary data for further studies.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

This study confirmed that motorcycle crash victims in the Northern region are highly susceptible to head injury (56.5%) especially without helmet. It highlighted riding experience of eleven years or more, partial helmet use, and riding in darkness predisposes motorcycle crash victims to head injury. Even in this environment where a greater proportion of helmets are likely to be sub-standard, the available helmets provide significant protection against head injury. This study has provided preliminary data to inform stakeholders involved in injury prevention in the Northern region, Ghana, and beyond. Specifically, the officials of the Police Motor Traffic and Transport Department (MTTD) and National Road Safety Commission (NRSC) to respectively increase the tempo of enforcing the helmet regulation and road safety education to improve the use of standard helmet as a precursor to reducing head injuries from motorcycle crashes in the Northern region.

6.2 Recommendation

Implementers of road safety laws

1. The Police Motor Traffic and Transport Department (MTTD) should enhance the enforcement of road safety laws and fine riders who are reckless, exhibit risk-taking behavior, and are not using helmets. In particular, enforcement should be stringent on weekdays and between the afternoon and late evenings, as there are frequent head injury occurrences during these periods.
2. National Road Safety Commission (NRSC), the Driver and Vehicle License Authority (DVLA), and the National Commission for Civic Education (NCCE) should organize routine education programs on road safety laws and the benefits

of using a “full-face helmet”, particularly for young riders. This sensitization programs should include commercial motorcycle riders and owners of both private and commercial motorcycles.

3. The Regional Coordinating Council and the Mayor of Tamale Metropolitan Assembly should post city guards to assist the officials of MTTD of the Ghana Police Service to arrest and prosecute offenders to serve as a deterrent to others.
4. A stakeholder’s consultative meeting should be held among the officials of NRSA, MTTD of the Ghana Police Service, NCCE, and Ghana Highway Authority on the motorcycle injury prevention focusing on the above-listed concerns. This meeting should be geared towards a further discourse on motorcyclists safety
5. The researcher should design a policy brief and a press release on the prevalence of motorcycle–related head injuries and consequences, risk of not wearing helmets, and benefits of observing helmet legislation, etc. and share with media houses and members commercial motorcycle riders association in the Northern region. Also, to inform a wilder population of listeners and viewers, the researcher should arrange with media houses for open discussion on press release on study findings.

Future researchers

1. It is recommended that a study at different levels of health facilities and also assessing outcomes including length of hospitalization, the outcome of admissions, and presence of disabilities among risk groups like pediatrics and young adults be conducted.

2. In this study, Blood Alcohol Concentration (BAC) and victims' knowledge of road safety laws were not determined. A study should explore these areas on their influence on motorcycle crashes and head injuries.

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APPENDICES

APPENDIX I: INSTITUTIONAL AND ETHICAL APPROVAL

GHANA HEALTH SERVICE ETHICS REVIEW COMMITTEE

In case of reply the number and date of this Letter should be quoted

Research & Development Division
Ghana Health Service
P. O. Box MB 190
Accra
GPS Address: GA-050-3303
Tel: +233-302-681109
Fax + 233-302-685424
Mob + 233- 050-3539896
Email: ethics.research@ghsmail.org

MyRef. GHS/RDD/ERC/Admin/App /19/703
Your Ref. No.

13th December, 2019

Anthony Baffour Appiah
Department of Epidemiology and Disease Control
School of Public Health
University of Ghana
Legon

The Ghana Health Service Ethics Review Committee has reviewed and given approval for the implementation of your Study Protocol.

GHS-ERC Number	**GHS-ERC024/12/19**
Project Title	Factors Associated with Head Injuries among Motorcycle Crash Victims Reporting to the Tamale Teaching Hospital
Approval Date	13th December, 2019
Expiry Date	12th December, 2020
GHS-ERC Decision	**Approved**

This approval requires the following from the Principal Investigator

- Submission of yearly progress report of the study to the Ethics Review Committee (ERC)
- Renewal of ethical approval if the study lasts for more than 12 months,
- Reporting of all serious adverse events related to this study to the ERC within three days verbally and seven days in writing.
- Submission of a final report **after completion** of the study
- Informing ERC if study cannot be implemented or is discontinued and reasons why
- Informing the ERC and your sponsor (where applicable) before any publication of the research findings.

Please note that any modification of the study without ERC approval of the amendment is invalid.

The ERC may observe or cause to be observed procedures and records of the study during and after implementation.

Kindly quote the protocol identification number in all future correspondence in relation to this approved protocol

SIGNED...
Dr. Cynthia Bannerman
(GHS-ERC Chairperson)

Cc: The Director, Research & Development Division, Ghana Health Service, Accra

Department of Research &Development
Tamale Teaching Hospital

TTH/R&D/SR/154
05/12/2019

TO WHOM IT MAY CONCERN

CERTIFICATE OF AUTHORIZATION TO CONDUCT RESEARCH IN TAMALE TEACHING HOSPITAL

I hereby introduce to you **Mr. Anthony Baffour Appiah,** an Mphil candidate in the School of Public Health, College of Health Sciences, University of Ghana, Legon. The candidate has been duly authorized to conduct a study titled **"Factors Associated with Head Injuries among Motorcycle Crash Victims, Tamale, Northern Region, Ghana."**

Please accord the candidate the necessary assistance to enable him completes the study. If in doubt, kindly contact the Research Unit on the second floor of the administration block or on Telephone 0209281020. In addition, kindly report any misconduct of the Researcher to the Research Unit for necessary action.

The candidate is required to furnish the hospital a copy of the dissertation/Study upon completion.

Please note that this approval is given for a period of six months, beginning from 5th of December, 2019 to 4th of June, 2020.

Thank You.

ALHASSAN MOHAMMED SHAMUDEEN.
(HEAD, RESEARCH & DEVELOPMENT)

APPENDIX II: PARTICIPANT INFORMATION SHEET

Title: Factors associated with head injuries among motorcycle crash victims reporting to the Tamale Teaching Hospital

Principal Investigator: Anthony Baffour Appiah

Address: Department of Epidemiology and Disease Control, School of Public Health, University of Ghana, Legon, Email: anthonybaffourappiah@yahoo.com, Tel.: (+233)549676149/556759656

General Information about Research

This study seeks to assess the factors associated with head injuries among motorcycle crash victims attending to Tamale Teaching Hospital in Ghana. In this study, I expect to estimate the proportion of motorcycle associated head injuries and determine the socio-demographic factors, environmental and road factors, Safety factors, and the type of mechanism of injury influencing the occurrences of head injuries. The study findings will add to existing data on factors contributing to the increasing prevalence of motorcycle crashes and associated head injuries in Tamale and the Northern region, and perhaps the whole country. The findings of this study will provide vital information, contribute to knowledge and guide key stakeholders in policymaking, road safety law enforcement, and injury prevention and control.

Recruitment and sampling procedures

This is a case-control study that will involve 320 motorcycle crash victims reporting to the Tamale Teaching Hospital in the Northern Region. Consecutive sampling will be used to select participants. The patient diagnosed with head injury by attending medical doctor will be recruited as a case, and the patient without head injury will be recruited as control, though both cases and controls may have multiple injuries. We invite you to take part in this research project. If you accept, you will be required to sign or give oral consent to this study. Afterward, you will be assisted by the Research Assistant to fill the questionnaire. The questionnaire contains questions on sociodemographic characteristics, epidemiology and clinical information, mechanism of injury and factors such as safety or behavioral issues, environment and road conditions where and when accidents occurred. Your participation in this study is expected to last for a maximum of 20 minutes.

Possible Risks and Discomforts

You will not be required to go through a separate diagnosis, clinical information on your condition will be obtained from attending medical doctor, hence you may not incur physical or economic distress. However, some questions on the incidence may arouse emotions but the probability is low, the magnitude of the risk is low, and the risk would include the duration of the interview. To minimize the potential risk identified above, interviews will be made short and attending medical doctor will be consulted prior to the interview to help address if it occurs.

Possible Benefits

You may not get any direct benefit but the findings of this study will be made available to Trauma and Orthopaedics surgeons, Public health practitioners and other key stakeholders in health delivery to inform their management practices. This will promote dialogues between key stakeholders to facilitate efforts to prevent and control the incidence of head injuries, and also in risk communication to patients to inform their choice. Also, results will be presented at conferences and peer-review journals to inform practice in a broader sense.

Confidentiality

We will protect information about you to the best of our ability. The interviewer will only use the identification numbers to represent you instead of your name to ensure confidentiality. Information obtained during your interview will not be shared with a third party other than my supervisors who may access my records.

Compensation

There are no compensation packages whether in cash or kind available for participation

Voluntary Participation and Right to Leave the Research

This study is strictly voluntary. Should you, at any point during the study, decide that you do not wish to participate any further, you are free to terminate your participation, effective immediately.

Termination of Participation by the Researcher

There is no circumstance which may cause your termination in this study, except you do not have an x-ray and you wish not to take any.

Contacts for Additional Information

You may contact my supervisor if you need further explanation of pertinent questions about this research. Dr. Patricia Akweongo, 0243138376

Your rights as a Participant

This research has been reviewed and approved by the Ethical Review Committee of Ghana Health Service (GHS-ERC). If you have any questions about your rights as a research participant you can contact the GHS-ERC Administrator, Nana Abena Apatu, between the hours of 8 am-5 pm through the landline or 0503539896 or email addresses: ethics.research@ghsmail.org

APPENDIX III: CONSENT FORM FOR RESPONDENTS

Title: Factors associated with head injuries among motorcycle crash victims reporting at the Tamale Teaching Hospital

Participant's statement

I confirm that I have been informed by the researcher about the nature, conduct, benefits, and risks of the study. I have read/it was read to me in a language I understand (English [ ], Dagbani [ ] or Akan [ ] language), and I have had the opportunity to ask questions. I also understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my medical care and legal rights being affected. I also understand that copies of the information sheet and signed consent form will be given to me for my personal records before filling the questionnaire.

I agree to take part in the above-mentioned study.

------------------------------ ------------------------------------- -----------------------

Name and Surname Signature/ Thumb Print Date

Interpreters' Statement

I interpreted the purpose and contents of the participants' Information Sheet to the aforenamed participant to the best of my ability in the Dagbani [ ] Akan[ ] language to his proper understanding.

All questions, appropriate clarifications sort by the participant and answers were also duly interpreted to his/her satisfaction.

Name of Interpreter……………………………………

Signature of Interpreter………………………………..

Date…………………

Statement of Witness

I was present when the purpose and contents of the participation Information Sheet was read and explained satisfactorily to the participant in the language he/she understood

(Dagbani [ ] Akan[ ] language). I confirm that he/she was given the opportunity to ask questions/ seek clarifications and the same were duly answered to his/her satisfaction before voluntarily agreeing to be part of the research.

Name……………………………………… Signature…………………………

OR Thumb Print Date……………………………….

Investigator statement and Signature

I certify that the participant has been given ample time to read and learn about the study. All questions and clarifications raised by the participant have been addressed.

------------------------------ --------------------------------------- ---------------------

Name and Surname Signature Date

Should you wish to contact me at any stage regarding consent you can contact me at Cell +233 549676149 or Email: anthonybaffourappiah@yahoo.com

APPENDIX IV: QUESTIONNAIRE

SCHOOL OF PUBLIC HEALTH
UNIVERSITY OF GHANA, LEGON

Title of Project: Factors associated with head injuries among motorcycle crash victims reporting at the Tamale Teaching Hospital

Date of Interview: __ __ / __ __ / 2019

Consent Form

Hello Sir/ Madam, my name is **Anthony Baffour Appiah**, a master of philosophy student at the School of Public Health, University of Ghana, Legon. I am conducting this study on the f**actors associated with head injuries among motorcycle crash victims reporting at the Tamale Teaching Hospital**. The purpose of this research is to estimate the proportion of motorcycle associated head injuries and determine the socio-demographic factors, environmental and road factors, Safety factors, and the type of mechanism of injury influencing the occurrences of head injuries. There is no risk associated with this study. However, some questions may make you uncomfortable or you may not know the answer to a particular question. I would like to assure you that any information you provide will be strictly confidential; and will be used only for the purposes of this research and never be used against you.
Your participation is voluntary, and you may stop the interview at any time.

Do I have your permission to continue? Yes [ ] No[ ]

PART I: SOCIO-DEMOGRAPHIC FACTORS

No.	Question	*Please, tick the appropriate option (√)*
A1	What is your age at last birthday?	Date of birth………………. Age …………
A2	What is your gender?	1-Male [ ] 2- Female [ ]
A3	Where do you stay/live?	…………………………………..
A4	What is your residence status?	1-Rural [ ] 2-Peri-urban[ ] 3-Urban [ ]
A5	What is your highest level Education?	1-None[ ] 2-Primary[ ] 3-Secondary[ ] 4-ertiary[ ]

A6	What is your religious affiliation?	1-Christian[ ] 2-Muslim[ ] 3-Traditionalist[ ] 4-Others[ ]	
A7	Whatg is your marital status?	1-Single[ ] 2-Married [ ] 3-Widowed[ ] 4-Divorced[ ] 5-Others[ ] ……………………	
A8	How many years of riding experience (all motorcycles)?	………………………………	
A9	Assessing socioeconomic status		
A9a	Are you employed?	0- No[ ] 1- Yes[ ]	
A9b	If employed, what is your occupation?	1-Public/civil servant [ ] 2-Farmer[ ] 3-Artisan[ ] 5-Trade 6-Others [ ] (Specify)…………………	
A10	Do you own your business?	0- No[ ] 1- Yes[ ]	
A11	Average monthly income	Amount ……………………………	
	Wealth index items		
A12a	Which of the following do you own?	Items you have	Response
		Motorcycle	0- No[ ] 1- Yes[ ]
		Television	0- No[ ] 1- Yes[ ]
		Refrigerator	0- No[ ] 1- Yes[ ]
		Phone	0- No[ ] 1- Yes[ ]
		Expensive utensil	0- No[ ] 1- Yes[ ]
		Cheap utensil	0- No[ ] 1- Yes[ ]
A12b	Are you satisfy with their durability and state?	Items you have	Response
		Motorcycle	0- No[ ] 1- Yes[ ]
		Television	0- No[ ] 1- Yes[ ]
		Refrigerator	0- No[ ] 1- Yes[ ]
		Phone	0- No[ ] 1- Yes[ ]
		Expensive utensil	0- No[ ] 1- Yes[ ]
		Cheap utensil	0- No[ ] 1- Yes[ ]
A12b	House floor materials	1-Tiles [ ] 2-Concreate [ ] 3-Earth or dung [ ]	
A12	Toilet facility	1-have no toilet facility [ ] 2-have low-quality toilet facility [ ] 3-have quality toilet facility [ ]	
A12d	Number of persons per rooms	1 person per room [ ] 2 persons per room [ ] 3 persons per room [ ]	

		4-More than 3 persons per room [ ]

PART II: EPIDEMIOLOGY AND CLINICAL INFORMATION

B	Question	*Please, tick the appropriate option (√)*
B1	Have you had any motorcycle accidents before?	0- No[ ] 1- Yes[ ]
B2	If yes, how many times have you had motorcycle accident?	…………………………………………………
B3	What type of motorcycle involved in the most recent/current injury?	1-Two-wheeled[ ] 2-Three-wheeled[ ]
B4	Type of motorcycle user	1-Rider[ ] 2-Passenger [ ]
B5	How many people were on the motorcycle?	……………………………………….
B6	What type of user collision?	1- Single motorcycle accident [ ] 2- Multiple motorcycle collision [ ] 3- Motorcycle vs other vehicle[ ] 4- Motorcycle vs pedestrian [ ]
B7	Does the patient have multiple injuries?	0- No[ ] 1- Yes[ ]
B8	Does the patient have a head injury?	0- No[ ] 1- Yes[ ]
B9	Other principal region with injuries	1-Neck[ ] 2-Spine[ ] 3-Abdomen[ ] 4-Extremities (including Pelvis) [ ] 5-External [ ] 6-thers (specify) [ ] ……………..
B10	What investigation(s) was used to diagnose for a head injury?	1-Head CT [ ] 2-Head X-ray [ ]
B11	Findings on head injuries	1-Skull fracture [ ] 2-Brain contusions[ ] 3-Haematomas[ ] 4-Lacerations[ ] 5-Bruises/abrasions 6-Others (specify) [ ] ……………..
B12	Glasgow Coma Scale (GCS)	Eye Opening Motor ……………./4 Spontaneous Movement………../6 Comprehension ………………../5 Total Score ……………………/15

PART III: INJURY PATTERNS (PLEASE TICK AS APPROPRIATE)

	Injury description	minor	moderate	serious	severe	Critical	unsurvivable	Square top 3
Head & neck								
Face								
Chest								
Abdomen								
Extremities (including pelvis)								
external								

PART IV: MECHANISM OF INJURY, SAFETY, AND ENVIRONMENTAL FACTORS

C	Variable	*Please, tick the appropriate option (√)*
C1	Mechanism of injury	1-Single motorcycle accident [ ] 2-Multiple motorcycle collision [ ] 3-Motorcycle vs other vehicle[ ] 4-motorcycle vs pedestrian [ ]
C2	How did the accident occur?	1-Run-off roadway [ ] 2-Fell making a U-turn [ ] 3-Head-on collision with another motorcycle[ ] 4-Head-on collision with another vehicle [ ] 5-Fell avoiding incoming vehicle[ ] 6-Fell avoiding with pedestrian/animal [ ] 7-Motorcycle run into preceding vehicle[ ] 8-Others (specify) [ ] …………………...
	Safety and behavioral factors	
C3	Were you wearing a helmet?	0- No[ ] 1- Yes[ ]
C4	Were you speeding when the recent accident occurred?	0- No[ ] 1- Yes[ ]
C5	To the best of your knowledge at what speed were you going when the accident occurred?	………………………Km/hour
C6	Were you overtaking when the accident?	0- No[ ] 1- Yes[ ]
C7	If yes, at what instance do you overtake?	1-Overtaking on the same side and direction of traffic[ ] 2-When there was a car or motorcycle ahead of you overtaking [ ] 3-On a single lane roadway [ ] 4-Along a curved road [ ] 5-When visibility was poor [ ] 6-When was raining[ ] 7-When riding in the night [ ]

C8	Have you used alcohol in the past 24 hours ?	0- No[ ] 1- Yes[ ]
C9	Have you used any recreational drug in the past 24 hours?	0- No[ ] 1- Yes[ ]
C10	Were you using mobile phones whiles riding?	0- No[ ] 1- Yes[ ]
C11	How long were you driving time/duration?	…………….hours
C12	How many hours of sleep did you have in the past 24 hours?	…………….hours
C13	Were you tired while riding (fatigue)?	0- No[ ] 1- Yes[ ]
C14	Were you feeling sleeping when the accident occurred?	0- No[ ] 1- Yes[ ]
	Environmental factors	
C15	What time of the day of the collision occurred?	1-Morning [ ] 2-Afternoon[ ] 3-Evening[ ] 5-Night[ ]
C16	What day of the week collision occurred?	--
C17	Weather condition	1-Raining [ ] 2-Not raining[ ]
C18	Street light condition	1-Reduced light[ ] 2-Daylight [ ] 3-No light [ ]
C19	Where is the road accident occurred located?	……………………………………………
C20	Is it a busy road?	0- No[ ] 1- Yes[ ]
C21	What is the nature of the road	1-Untiled / earthen road 2-Concrete with potholes 3-Asphalt[ ]
C22	Were they many road curves	0- No[ ] 1- Yes[ ]
C23	Were they speed limits on the road accident occured	0- No[ ] 1- Yes[ ]
C24	If yes, were they a visible signs/signboard to communicate their limit?	0- No[ ] 1- Yes[ ]

THANK YOU VERY MUCH