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KNOWLEDGE IN ACTION

School of Transportation Sciences

Master of Transportation Sciences

Master's thesis

Factors influencing motorcycle taxi crashes in the city of Kigali, Rwanda

Esthelyne Dusabe

Thesis presented in fulfillment of the requirements for the degree of Master of Transportation Sciences, specialization Traffic Safety

SUPERVISOR :
Prof. dr. Elke HERMANS

CO-SUPERVISOR :
Prof. dr. Yongjun SHEN

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Preface

The increase in the number of road crashes is one of the major health problems nowadays, especially for vulnerable road users, including motorcyclists, cyclists and pedestrians. Therefore, as a student at the University of Hasselt, I gained a lot of knowledge and techniques that improved my abilities as a transport researcher. This work focuses on the factors influencing the involvement of motorcycle taxis in crashes in the City of Kigali, Rwanda.

In Rwanda, I usually use a motorcycle taxi as a mode of transport for several reasons: speed, access, time saving, etc., which is extremely convenient for me. But motorcyclists are a little intimidating because of the way they drive, which could lead to road crashes. I became interested in this because of the strong involvement of the motorcycle taxis in collisions in the City of Kigali, Rwanda, which cost the lives of people. That's why I found this topic very interesting because it will help us to better plan effectively to improve the safety of motorcycle drivers and users.

Acknowledgment

First of all, I would like to thank the almighty God for being always on my side, keeping me healthy and strong to carry out the research.

This study would not have been reached at this stage without the support of some people. My sincere appreciation go to my promoter, Professor. Dr. Elke Hermans, who has always guided me to carry out this research, I will be eternally grateful for her support. I would also like to thank my Co-Promoter, Professor Dr. Yongjun Shen, for his support throughout this study.

I would like to express my gratitude to all the IMOB staff members who gave me knowledge drive throughout my studies. This recognition also applies to all those concerned who have awarded me this VLIR-UOS Scholarship.

Finally, my thanks also go to my classmates, family and especially to all the respondents for their willingness to contribute to the success of the thesis by giving their precious time and valuable information during the fieldwork.

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List of Abbreviations

CoK	City of Kigali
FERWACOTAMO	Federation Rwandaise des Convoyeurs du Taxi-Moto
LMIC	Low and Middle Income Countries
MININFRA	Ministry of Infrastructure
NCST	National Council for Sciences and Technology
NISR	National Institute of Statistics Rwanda
ODK	Open Data Kit
PM	Particulate Matter
RNP	Rwanda National Police
RoSPA	Royal Society for Prevention of Accidents
RTDA	Rwanda Transport Development Agency
RTIs	Road Traffic Injuries
RURA	Rwanda Utilities Regulatory Authorities
SPSS	Statistical Package for the Social Sciences
SYTRAMORWA	Syndicate of Taxi-Motos of Rwanda
VRUs	Vulnerable Road Users
WHO	World Health Organization

Abstract

Motorcycles are becoming one of the main means of public transportation of both people and goods all over the world particularly in Low and Middle-Income Countries (LMIC). However, this mode of transport constitutes a large proportion of road deaths globally. This number is very high in developing countries including Rwanda. Motorcycle taxis are an important public transport mode in the City of Kigali due to its benefits such as providing door-to-door service, fast, easy to access, time saving, etc. However, motorcycle crashes and the associated unpleasant consequences are on the rise in Rwanda.

Motorcyclists are among the highest risk road user group and the group that requires the most attention in the City of Kigali, where the number of motorcycle taxis is increasing. This research was conducted with the aim of identifying the causes that influence the motorcycle taxis crashes in the City of Kigali and propose preventive measures improving the safety of motorcycle taxi drivers and users. The study used questionnaires; In particular, field surveys were conducted randomly in face-to-face interviews with 124 motorcyclists-taxi drivers, 57 motorcycle passengers and 8 stakeholders.

The results of the survey were analysed statistically. ANOVA and Chi-Square tests were performed to visualize the mean difference and to test independence between identified factors. A Logistic Binary Regression Model was performed. From the results, speeding, fatigue, misbehaviors, poor road condition and overtaking were identified as the factors that influence motorcycle taxi crashes in the city of Kigali. The study found that age was a key factor that influences many risky behaviors such as speeding, alcohol and phone usage while driving. The ownership of the motorcycle has also been identified as having any influence on speed.

Setting regular and specific campaigns, installing speed governors in motorcycle taxis to limit exceeding speed and improving road conditions were proposed as the main countermeasures toward motorcycle taxi safety. And to efficiently manage and improve the safety of motorcycle taxis as a formal mode of transport, the study recommends to the Ministry of Infrastructure jointly with its stakeholders to reorganize motorcycle cooperatives and assign specific road safety responsibilities to each institution. The responsibility should be defined based on 5 E'S of road safety improvement (Engineering, Education, Encouragement/ Engagement, Enforcements, and Evaluation).

Keywords: Motorcycle Taxis, Crashes, Speeding, Factors, Safety, and Countermeasures

Chapter 1. INTRODUCTION

This thesis deals with identifying the factors influencing motorcycle taxi crashes. The problem statement gives an outline of the problems being faced in motorcycle safety. It provides the basis for the development of the research questions and objectives. The methodology used is briefly introduced. Moreover, the practical and theoretical relevance will be clarified.

1.1. Background

The motorcycle is a motorized two-wheeled vehicle that can transport one or two riders (Aderamo and Olatujoye, 2013). Commercial motorcycles are becoming an important means of transport in most low- and middle-income countries (Naqvi & Tiwari (2017) and Rollason (2012)). The motorcycle is faster than other modes of transportation on very congested roads and can offer more flexibility in traffic; therefore, it can provide door-to-door service and can stop anywhere (Aderamo and Olatujoye (2013), Rollason (2012), Dinye (2013), Aderamo (2013) and Diaz Olvera et al. (2016)). Motorcycle taxi is also the main source of income for the urban poor by employing and supporting a very large number of people, especially young people (Diaz Olvera et al, 2016). On the other hand, the motorcycle taxis negatives impacts on the society are also increasing in developing countries in particular (Aderamo, 2013).

Globally, motorcycle and moped vehicles accounted for more than 286,000 deaths in 2013, or about 23% of all road casualties (WHO, 2015). South-East Asian countries and the Western Pacific countries account the highest share of motorcycle fatalities, approximately 34% worldwide, whereas African countries account around 7% (only data from 15 out of 43 countries reported).

This increase of fatalities is associated with rapid growth in the number of motorcycles and moped vehicles all over the world, particularly in Low- and Middle-Income Countries. The commercial use of motorcycles has increased considerably in recent years in Sub-Saharan Africa in particular (Olivera et al., 2016). Tanzania for instance, has seen a motorcycle increase from 46% to 54% of its registered number of motorcycles in the last three years together with a rise of motorcycle fatalities from 13% to 22% of the total amount of its causalities (WHO, 2015). Hence, motorcyclists are among the group of road users with the highest risk and the group, which needs most attention when it comes to safety improvement.

1.2. Study Area

Rwanda is a country situated in East Africa; it is sometimes called the "Land of Thousands Hills" as it includes many hills (Wikipedia, 2018). Rwanda has a surface of 26,338 km2 and is the most densely inhabited country in the world with about 12 million inhabitants, or 230 inhabitants per km2 (Patel et al., (2016); Rollason (2012) and Wikipedia (2018)). According to (Patel et al., 2016), Rwanda has achieved enormous economic development that increased its gross domestic product from $ 753 million in 1994 to $ 7.89 billion in 2014; thus, Rwanda's goal is to achieve middle-income status in the year 2020.

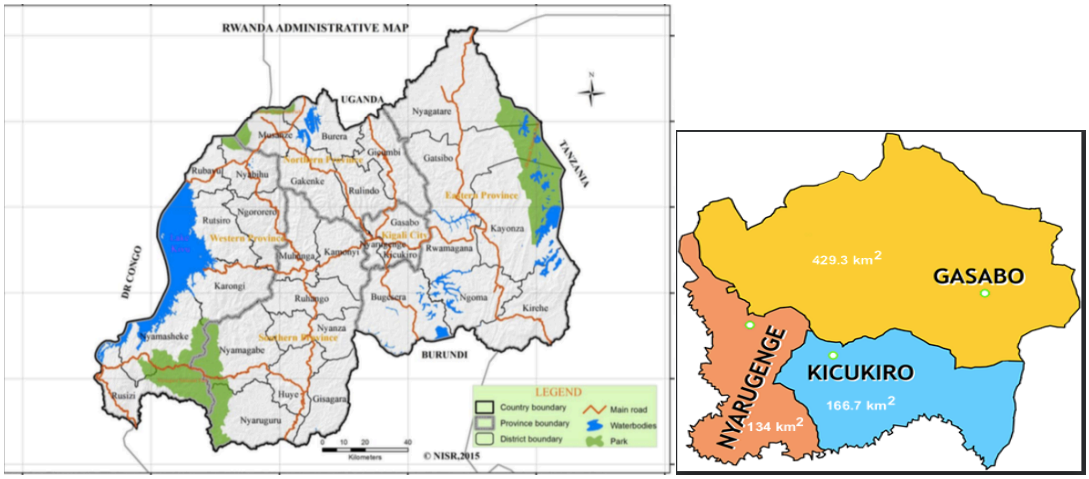


Figure 1 Map of Rwanda on the left and Kigali City on the right (study area), Source: Statistical Year Book, 2017

Kigali-City (study area) is the capital city of Rwanda; Kigali-City accounts approximately 1.13 million inhabitants with an average population density of 1552 people/km^2 (NISR, 2017). Kigali is made up of three districts, Gasabo, Kicukiro and Nyarugenge, with a combined average road density of 0.093 km/km2 and unpaved average road density of 0.12 km/km^2 (Ncube et al., 2013).

Motorcycle taxis are an important mode of public transport in Kigali City, the use of motorcycle taxis as means of transport has grown very rapidly in recent years in Rwanda (Rollason, 2012). Currently, Rwanda counts 142 licensed motorcycle cooperatives with over 30,000 commercial motorcyclists recorded in the official database and about 15,000 motorcycles operating in Kigali City (RURA database, 2018). Motorcyclists are almost exclusively men and most of them are young (under 35years) (Rollason, 2012).

Motorcycle taxis are popular for many reasons such as they are fast, capable of negotiating standing traffic, and while they are certainly the most dangerous form of public transport available in Kigali, they run at

night after bus services have stopped and on roads impassable to other vehicles. Of the many motorcyclists working in Kigali, approximately 50% are migrants or commuters to the urban area (Rollason, 2013). Motorcyclists are organized into two competing organizations, "Federation Rwandaise des Convoyeurs du Taxi-Moto" (FERWACOTAMO) with approximately 6,882 members in Kigali City and the smaller "Syndicate of Taxi-Motos of Rwanda" (SYTRAMORWA) with around 3,604 members, which provide security and management functions as well as being tasked with the development of their members (D. W. Rollason, n.d.). The motorcycle taxis are often also the main source of income. They can employ and support a very large number of people and many people depend on motorcyclists for their livelihoods (W. Rollason, 2013). Thus, the success of Rwanda's motorcyclists reflects the general trend in Rwandan poverty reduction.

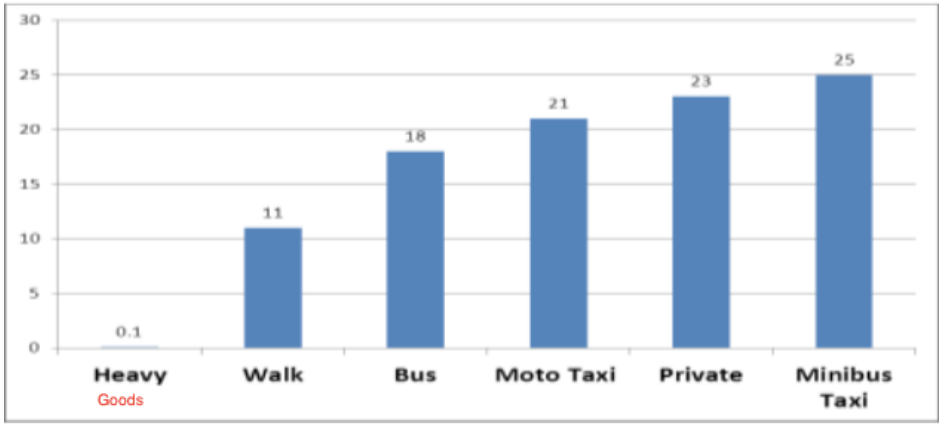


Figure 2 Modal shares of passenger trips in Kigali City in 2014. Source: (Zyl, Swanepoel, & Bari, 2014)

Figure 1 shows the daily modal split across all trip purposes in percentages. Mini-bus taxis have the highest share, followed by private transport and motorcycle taxis. Rwanda has made considerable progress in rebuilding its economic and social infrastructure since the end of the 1994's genocide against Tutsi (Rollason, 2012). Moreover, Rwanda was one of the first African countries to implement helmet laws and to limit the number of riders on motorcycles (Patel et al., 2016). These changes led to significant overall reductions in mortality from Road Traffic Injuries (RTIs) including markedly lower rates of motorcycle crashes compared to other LMIC countries but rates of RTIs still remain significantly higher compared to Western countries (Patel et al., 2016).

1.3. Problem Statement

According to Rollason (2012) and Rollason (2017), traffic accidents and injuries due to motorcycle taxis in Kigali have been increased recently. Though, motorcycle taxis are already abundant and still constitute to rise for both personal and commercial transport. In 2013 for example, Rwanda had registered more vehicles with two and three wheels than cars (WHO (2013) and Kumar (2011)). Furthermore, according to (WHO, 2018) road accidents in Rwanda are among the top ten causes of death. Thus, Kigali as a capital city faces a main public health problem with regard to injuries (Patel et al., 2016).

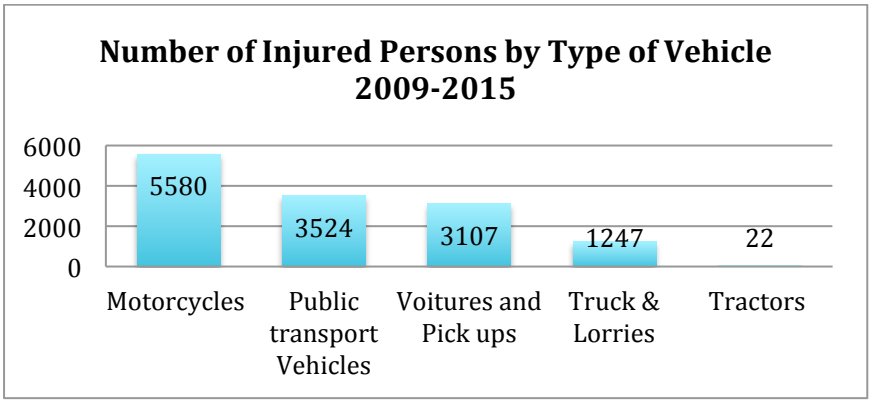


Figure 3 Number of injured Persons by type of Vehicle in 2009-2015. Source: Statistical Year Book, NISR, 2017

Figure 3 shows the number of injured persons in the period 2009-2015 per transport mode in Rwanda. Motorcycle riders account the highest number of injured persons compared to the other modes of transport (around 41.4%) in 2009-2015. It is obvious that motorcyclists have a greater exposure than the other driving modes as they are overly represented. In contrast, in terms of the number of killed persons, cars account the highest amount, around 32% (see figure 1.4). This means that the motorcyclists are the most vulnerable to severe injuries and may become disabled compared to other road users.

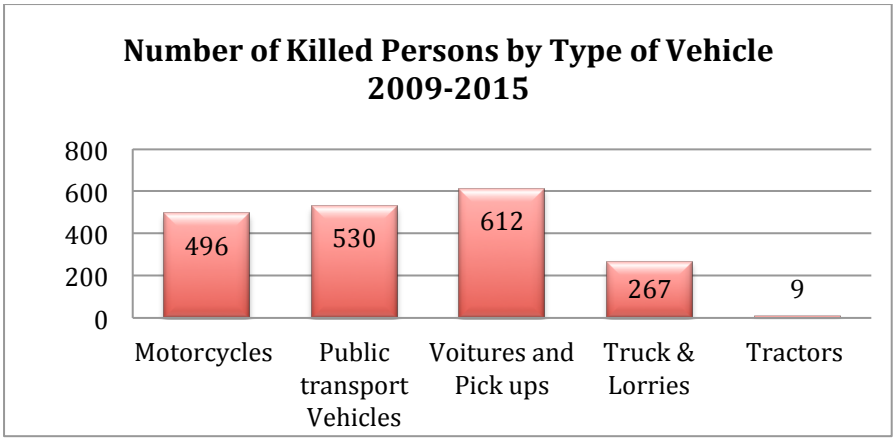


Figure 4 Number of killed persons by type of Vehicles in 2009-2015. Source: Statistical Year Book, NISR, 2017

According to police statistics, about 18.5% of the 162 road fatalities registered between August and October 2017 in Rwanda involved an accident with at least 1 motorcycle (NSABIMANA, 2018) thus there has been an increased involvement in grievous crashes involving other road users as well. These alarming casualty numbers highlight the need to pay more attention to motorcycles in road safety policies.

1.4. Key question of the research

The **primary research question** is: *"What are the factors influencing the involvement of motorcycle taxis in crashes in Kigali City, Rwanda"?*

1.5. Research Objectives

1. To determine the extent to which motorcycle taxi drivers comply with the traffic rules
2. To predict the occurrence of crash among motorcycle taxi drivers by using demographic factors and risky driving behaviors
3. To examine the difference in motorcycle taxi crash involvement and risky driving behavior among various age groups of motorcycle drivers
4. To Formulate potential measures to decrease motorcycle taxi crashes.

1.6. Justification of the Study

Motorcycle taxis play an important role in promoting economic development and facilitating transportation of people in Rwanda. However, the rapid increase of motorcycles resulted in rather high incidence of road traffic crashes. The inefficiency in the public

transportation system may increase the use of motorcycle taxis. On the other hand, the advantages of motorcycle taxis make them the most obvious and convenient way to get around especially in Kigali city as the city spreads out over several hills. Following the high rate of commercial motorcycles operating and of road injuries in Rwanda it is important to carry out this research work to investigate the reasons of motorcycle taxis' traffic crashes and make proposals to potential measures to decrease motorcycle crashes and increase the traffic safety level of motorcyclists. Moreover, the findings can be used to improve the public transportation system and to promote the safety of motorized vehicles in general.

1.7. Significance of the Study

This master thesis will:

- Provide a treasure trove of data regarding motorcycle taxi crashes
- Have a positive addition to the research on motorcycle taxis encouraging policy makers in improving traffic safety for motorcyclists at the City of Kigali or countrywide
- Set a foundation for future in-depth studies on motorcycle taxi drivers.

1.8 Methodological Framework

To attain an answer to the research question, the methodology framework presented in Figure 1.5 (below) will be used. Therefore, the work is mainly divided into three parts. The major work in the first part is related to literature review. The second part is to analyze the existing data that will be collected from Rwanda National Police and lastly, the data collection; preparation and analysis will be conducted among commercial motorcycle riders, stakeholders and motorcycle users. Therefore, the survey questionnaires will be distributed randomly among motorcycle drivers and users.

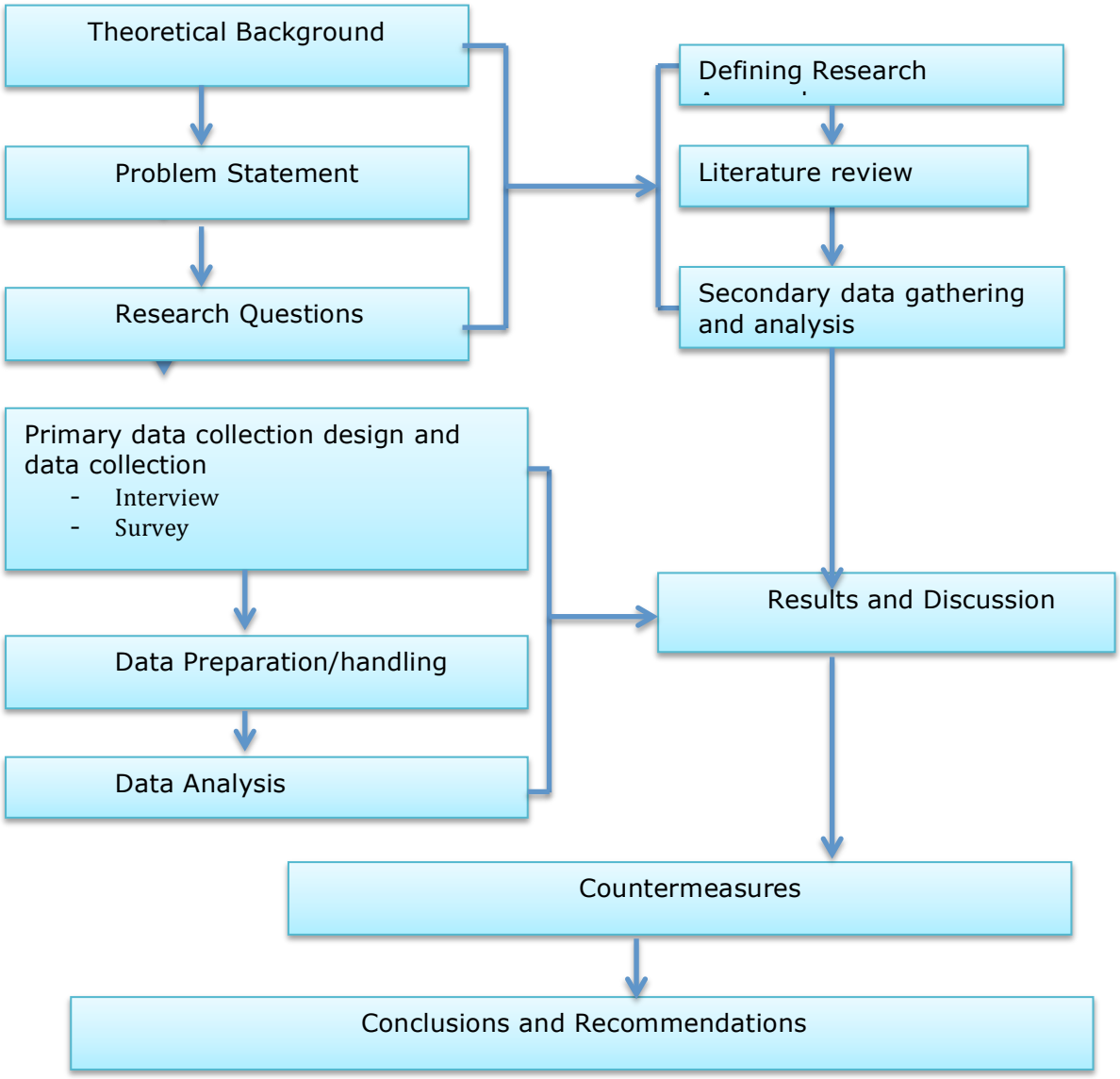


Figure 5 Overview of the research methodology

1.9. Study Assumptions

This research makes the following assumptions:

- The randomly selected sample of motorcycle taxi drivers is representative of the entire City
- The randomly selected sample of passengers using motorcycle taxis is representative of the entire City
- A structured face-to-face paper interview/survey is the best way to obtain accurate data
- Finding strong factors influencing motorcycle taxi drivers or "Motari" crashes of motorcyclists are the best way forward to improve motorcyclists taxi safety.

1.10. Limitations of the study

The following limitations can be stated:

- Scarcity of research based scientific information regarding motorcycle taxi crashes in Rwanda
- The motorcycle taxi drivers and users may not cooperate in data collection
- The respondents may give answers that make them look good (social desirability)
- The size of the sample is limited (small) because of budget and time constraints
- The existing data may not provide the required information

1.11. Delimitations of the study

This study will not investigate on:

- Private or public institutional motorcycles operating in Kigali City, but only on commercial motorcycle taxis
- Motorcycle taxis that are not operating in Kigali City on a daily basis.

Chapter 2. LITERATURE REVIEW

The purpose of this chapter is to provide a brief introduction on motorcycle taxis. This part also outlines the advantages and disadvantages of motorcycle taxis. This is then followed by the theoretical basis for the identification of factors which influence the motorcycle taxis crashes with the concept of the compliance with traffic laws and regulations of motorcycle riders, vulnerability of motorcyclists, risk-taking behavioral factors related to road users, environments and the infrastructure of motorcycles.

2.1. Rise of Commercial Motorcycles as Public Transport and its Adoption

Transport infrastructure is a key factor for a country's development in connecting people to goods, services, social and economic opportunities towards economic growth (Dinye, 2013). Transport infrastructure has grown considerably worldwide through a different series of mode networks that refer to both motorized and non-motorized means of transport of compartment passengers and goods. In most developing countries, the ownership of private cars is very low hence most people depend on public transportation, which is not well developed (Kumar, 2011). Therefore, this situation has enforced people and the market to develop new solutions to meet everyday travel needs. Hence the use of motorcycles started approximately in the 19th century both for personal mobility and public transport (Dinye, 2013).

2.1.1. The Rise of Motorcycles as Public Transportation

The motorcycle is one of the most popular modes of transportation worldwide. The past decade has seen significant growth in the use of motorcycles and ownership mainly in Low and Middle-Income Countries, especially in Asian developing countries where motorcycles are often used as the family vehicle (World Health Organization, 2015). Furthermore, the largest global motorcycle market is remaining dominated by the Asian region such as China, India, Indonesia and Vietnam (Nandwoli, 2014). However, several African countries report an increase in motorcycles as a form of public commercial transport. The World Health Organization (WHO) estimates that motorcycles and three-wheeled vehicles account for about 33% of all transport modes in Sub-Saharan African countries (WHO, 2015). Nevertheless, the number of motorcycles and three-wheelers varies enormously from one country to another.

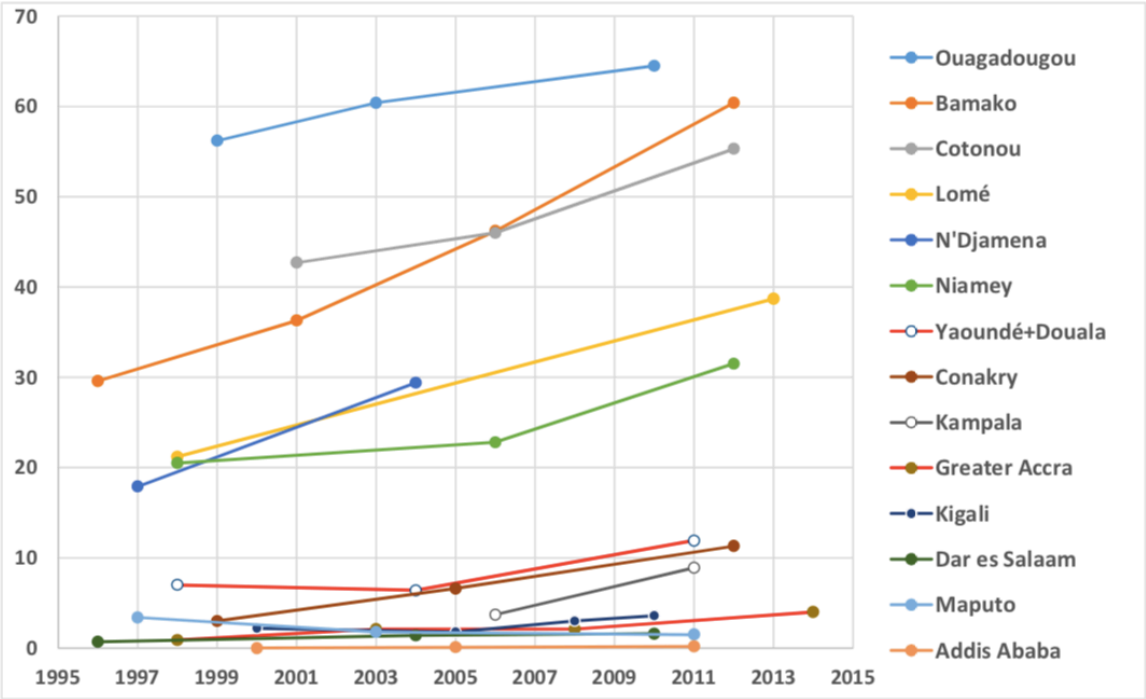


Figure 6 Evolution of the percentage of households owning motorcycle(s) or scooter(s) in various large cities in Sub-Saharan Africa (1995-2014), source: The DHS Program Indicator Data API as cited in (Pochet et al., 2017)

It can be seen from the above figure 6 that the cities in West Africa countries such as Ouagadougou, Bamako, and Cotonou represent the high majority of two- and three-wheeled motorcycle owned households, while the cities in East Africa countries such as Kigali, Dar es Salaam and Addis Ababa have a lower percentage (Pochet et al., 2017).

In Sub-Saharan African countries, in particular, the urban commercial motorcycle is relatively new. The motorcycles were introduced in West and Central Africa in the early 1970s. They are known under popular local names such as OKADA or ALALOK in Nigeria, KABU-KABU in Niger and BENDSKIN in Cameroun (Guézéré (2008) as cited in Olvera et al., 2012). In East Africa, Kenya and Uganda were the first countries to introduce the use of motorcycles as a popular transport around 1970s under the name of BODA-BODA (Olvera et al., 2012), whereas in Rwanda, the use of taxi-motos (commercial motorcycles) has grown very rapidly after the 1994s Genocide against the Tutsi (Goodfellow, 2015).

Several studies have been conducted on the increase of motorcycle use as a means of public transport (Ikeano, 1991; Ogunsanya and Galtima, 1993; Gbadamosi, 2006; Olubomehin, 2012; Aderamo & Olatujoye, 2013; Zuure & Yiboe., 2017). They found that the economic depression, inadequacy of public transportation, poor road infrastructure, the high

rate of unemployment prevailing in the 1980s, the relative lucrative nature of the commercial motorcycle business, the flexibility access of motorcycles to major routes that are used by less expensive transit services and door-to-door services are the major responsible factors for the growth in motorcycle taxis. Moreover, the increase of commercial motorcycles in most countries can be attributed to a higher flexibility to maneuver on difficult roads, time savings, its low cost of buying a new motorcycle and its low cost of maintenance compared to other modes of transportation (Olivera et al., 2010; Adetunji & Aloba, 2014).

Despite, the rise of commercial motorcycles as a means of public transport in many Sub-Saharan African Countries has led to various critics and discouragement of its use as a commercial means of urban transport as explained in detail in section 2.1.2.

2.1.2. Abolition of Commercial Motorcycles and Adoption

Interestingly, in many Sub-Saharan African countries the authorities criticized the use of commercial motorcycles as urban mode of transport. Initially, they ignored, were indifferent and tolerated them by considering it as a temporary situation. Further, the policy and decision makers perceive the commercial motorcycles as competitors of the official and traditional means of public transport operators such as minibuses, buses and taxicabs often driven by politicians and local businessmen (Sietchiping et al., 2012).

According to (Nnadozie (2009); Olubumehin (2012); Olvera et al (2012) and Michael et al (2013)) the commercial motorcycles have increased the number of road accidents, do not comply to traffic regulations, are involved in extreme violence acts, criminal activities, armed robbery and theft as well as snatching of valuables and pickpocketing, etc. Their power as a pressure group acting on the authorities, their aggressive behavior and the negative externalities they generate may result in the fact that they might be banned especially in some urban cities.

It is on the strength of this criticism that some African authorities called for the elimination of the use of commercial motorcycles as a means of urban public transportation (Olivera (2016) and Bishop et al (2018)). A ban of commercial motorcycle usage in some cities or limited use in certain areas of the city at certain times of the day are measures taken in this respect (Bishop et al., 2018).

However, the Sub-Saharan African national governments and decision makers are consistently accepting the trend due to the fact that the commercial motorcycles fill the gaps not only for users or commuters but

also for owners (by providing them income). They take actions such as introducing the adoption of laws and enforcement on the use of motorcycles such as use of helmets, reflective jackets, registration of motorcycles, driver's license for the operator, insurance for the driver and the passenger, etc. (Olivera, 2016).

2.2. Benefits of Commercial Motorcycles

Commercial motorcycles have indeed great benefits and help the society to develop. The major advantages are mainly associated with the mobility, economic impact and employment. All benefits will be briefly discussed below.

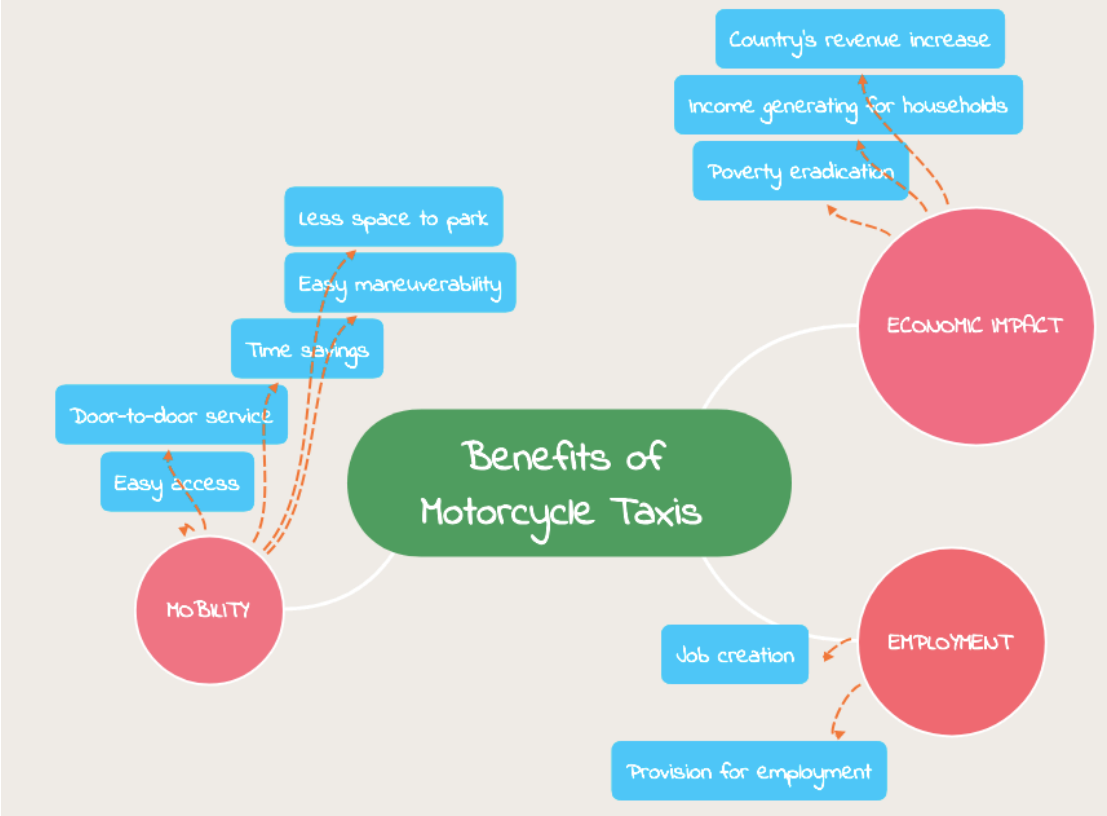


Figure 7 Summary of benefits of motorcycle taxis. Source: Own processing based on the Literature Review

2.2.1. Mobility

The benefits of commercial motorcycles in terms of mobility are very significant for urban traffic and commuting compared to other modes of transport. The commercial motorcycles or motorcycles in general are often the most convenient and quickest way of travelling both for long and short distances (Arosanyin, 2010). Motorcycles are narrow; they can filter through traffic though keep moving where cars stand waiting in traffic

jams, they provide door-to-door service and reduce the total traffic time for all road users. This makes motorcycles faster than any other modes of transport in urban traffic.
Furthermore, commercial motorcycles are small and light; and less weight means less wear of the road surface. They can operate at poor roads which are unreachable by other motorized modes of transport, they also use less space to park as the commercial motorcycles can be parked on the sidewalk, frequently the motorcyclists can use a spot that is too small for a car to park. Thus, in most countries special parking places are or can be created easily (Arosanyin, 2010). More importantly, commercial motorcycles offer connection links between other modes of transport routes (buses, taxi, train, etc.) and neighborhoods. Hence commercial motorcycles play the role of gap filler in urban passenger transportation (Howe & Davis, 2002).

2.2.2. Employment

One of the major positive impacts of the commercial motorcycle transport business in most developing countries is the provision of employment and an opportunity to earn money for many unemployed young people and many retired people (Howe & Davis (2002); Dorier-Apprill & Domingo (2004) and Meagher (2013)).

According to (Howe and Davis, 2003), commercial motorcycle operations have almost exclusively created jobs for males in most African countries; still there are untapped opportunities for women to settle as well. Hence, young men are generally attracted to riding commercial motorcycles as a profession, as it is an easy entry point for young people without or with low levels of education. Moreover, many people are in the sale of different brands of motorcycles and spare parts of motorcycles for maintenance and repair that create more jobs for the private business industry. In addition, efforts are now underway as part of a ReCAP programme to support skills trainings, safety awareness, certification and registration of commercial motorcycle transport involving female operators and creating more jobs (Festus & Nzokuru (2014) and Peters & Mokuwa (2017)).

2.2.3. Economic Impact

The commercial motorcycles are seen to improve the public transportation mobility and socio-economic effects in several cities worldwide (Zuure & Yiboe, 2017). Different numbers of beneficiary actors are involved in the system surrounding the commercial motorcycle such as the people who own and drive the motorcycle, the people who hire the motorcycle to use, the local and national authorities and the whole society in general.

According to (Olvera et al., 2012), since the beginning of the 21st century, the return on investment has increased in most developing countries because of the strong competition resulting from the strong growth of commercial motorcycles. Given that the sector offers great opportunities to many young people with a source of income, the motorcycle taxi industry is enabling many people to live. It was noted that some cities in developing countries were using a system of buying and distributing commercial motorcycles to unemployed young people in their cities as part of poverty eradication and as the way of improving public transport (Itodo (2005) and Festus & Nzokuru (2014)).

The commercial motorcycle business has impacted significantly on the developing countries' economy and society. The profitability for such business often depends on the availability of motorcycle operators whereas this encourages longer working hours per day (Olivera, 2016). Therefore, some motorcycle riders prefer to work at night when there is less competition and higher fares can be charged (Bishop et al., 2018).

According to (Bishop et al., 2018) in a study conducted in Uganda it was found that the owner of motorcycle operators could earn USD 56 per week while the operator who hires the motorcycles earns over half of that amount (USD 30). Despite this gap, this sector remains profitable (Olivera (2016) and Bishop et al (2018)). Thus, this level of average income seems sufficient to quickly recover the money invested in the motorcycle while generating revenue. Rollason (2013); Aboudou & Sounon, (2010); Ogunrinola (2011) and Quenot (2012) argued that working as a commercial motorcycle operator allows people to cope with their daily expenses as in particular, four out of five motorcycle riders spend part of their income on improving their household condition.

More importantly, commercial motorcyclists also contribute to the country's revenues. A country derives a lot of revenue from the money paid for tariffs on imports of motorcycles, fuels and lubricants; spare parts for motorcycles; tax receipts for motorcycle taxis; registration of motorcycles; driver's license for motorcyclists; insurance for motorcyclists and passengers; etc. (Aboudou & Bouko, 2010). Despite the positive effects of using commercial motorcycles as a means of transportation, some negative effects are also evident.

2.3. Negatives Impact of Commercial Motorcycles

Despite the positive impacts of the use of commercial motorcycles, it has indeed some negative impacts as well. The major disadvantages are mainly associated with the road traffic accidents, health impact, environment pollution and crimes. Some disadvantages will be briefly discussed below

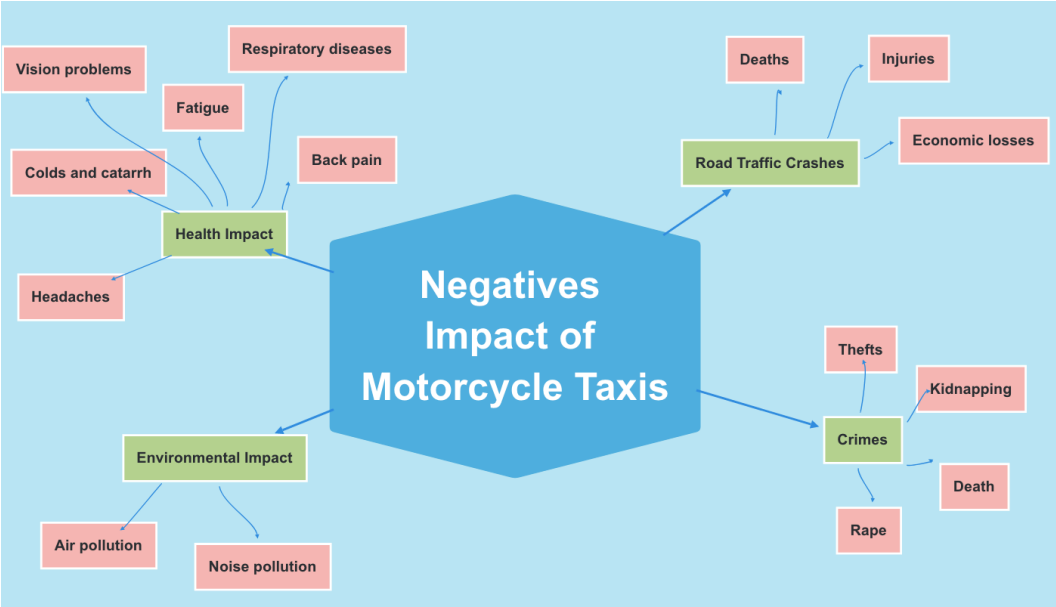


Figure 8 Summary of negatives impact of motorcycle taxis. Source: Own processing based on the Literature Review

2.3.1. Road Traffic Crashes

Road traffic crashes are a global disaster. Globally, almost a quarter of road deaths are motorcyclists (World Health Organization, 2015). This massive increase in fatalities due to the rise of commercial motorcycles in developing countries in particular, represents a higher accident and death rate than passenger cars per kilometer traveled (Dongo et al (2013) and Aderamo & Olatujoye (2013)). According to (Global Mobility Report, 2017), road transport crashes account for 97 percent of the deaths and 93 percent of the costs. On roads, the fatality risk for motorcyclists is 20 times higher than for car occupants, followed by cycling and walking, with a 7 to 9 times higher risk than car travel, respectively (Global Mobility Report, 2017).

According to (WHO, 2015), the Pacific Western and South East Asian countries report each for 34% of the world's motorcycle fatalities whereas the African countries report for 7%. This is due to the constant situation in which motorcycle usage is most predominant in Asian cities than somewhere else and also related to the fact that only 15 of the 43 African cities provided the data on the deaths by type of road user (WHO, 2015).

Nevertheless, there is an increase in motorcycles as many countries reported a growth in motorcycle taxis use; for example Tanzania has seen a motorcycle increase from 46% to 54% of its registered number of motorcycles in the last three years together with a rise of motorcycle fatalities from 13% to 22% of the total amount of its causalities (WHO, 2015).

(Adebayo, 2012) argued that road accidents mainly affect the economically important age group. It has been found that motorcyclists under the age of 40 were 36 times more likely to be killed than a car driver of the same age whereas motorcyclists aged 40 and over are about 20 times more likely to be killed than other drivers of the same age as well.

Likewise, motorcycle crash mortality is mainly attributable to head injuries; limbs injuries are the leading cause of morbidity (Umebese & Okukpo (2001); SUNDAY (2001) and Oluwadiya et al (2004)). Hence, road accidents and injuries significantly affect the socio-economic aspirations and development because of the premature loss of skilled and potentially useful professionals (young men and women who are able to work in the labor market) (Pratte, 1998).

2.3.2. Health Impact

Negative health risks are also involved in commercial motorcycle transport activities (Festus & Nzokuru, 2014). The long working hours of commercial motorcycle operators are the most unpleasant aspect increasing the incidence of illness and physical difficulties.

Given the strong competition among motorcycle riders the profitability of the activity depends essentially on the time devoted to it. In fact, the owner of a motorcycle should work six days a week and nearly ten hours a day including the waiting time for customers at the station point, while the operators who hire the motorcycle work on average of more than six days a week with about eleven hours per day as they are under a lot of pressure to collect the rent from the motorcycle and earn sufficient money to cover their daily living expenses (Olvera et al., 2016). Thus, they can work on average eight hours per day (excluding the waiting time and break) during which they are exposed to pollution, noise and road accidents (Olvera et al., 2016). According to (Konings (2006); Festus & Nzokuru (2014) and Olvera et al (2016)), the most frequent health risks among the commercial motorcycle operators are back pain, vision problems, fatigue, headaches, pneumonia, colds and catarrh.

2.3.3. Environmental Pollution

Transport is among the major source of air pollution that contributes to greenhouse gas emissions responsible for climate change. The increase in use of commercial motorcycles especially in developing countries emit fumes and carbon monoxide that leads to global warming and climate change (Dinye (2013) and Festus & Nzokuru (2014)).

In most developing countries, motorcycles are the major sources of air pollution in urban cities. However, motorcycles engines emit significantly more hydrocarbons, carbon monoxide, particulate matter (PM) and nitrogen oxides (Dinye, 2013). Indeed, these pollutants are a serious threat to human health and the environment such as respiratory diseases, cardiovascular diseases (heart and lung diseases) and vapors that contaminate the air, preventing people from swallowing clean air (Festus & Nzokuru, 2014).

2.3.4. Crimes

According to (Ukwayi et al (2013) and Festus & Nzokuru (2014)), the increase of commercial motorcycles as means of transportation has also another negative impact, namely different criminal activities. Indeed, commercial motorcycle operators are sometimes involved in crime against passengers, including kidnapping, rape, murder, death, armed robbery, removal of personal belongings (telephones, money and bags), etc.

2.4. Motorcyclists as Vulnerable Road Users

According to (Dinye (2013) and Jeffrey (2017)), motorcycle drivers are at greater risk than other motorized drivers. Motorcyclists have not only a high risk of an accident, but also a high risk of serious injury (Jeffrey 2017), motorcyclists who are driving one kilometer/mile are 27 times more prone to die and five times more prone to be injured than motorized vehicles (like cars, buses, trucks, bicycles, water, rail and air) (Jeffrey, 2017).

The factors that make motorcyclists vulnerable are the fact that they are rather small and not easy to see at junctions in particular. The unprotected state of the motorcyclist, no benefits from passive safety features such us seatbelts, etc. involve them to be more vulnerable road users. Moreover, the fact that the car drivers do not respect motorcyclists in the same way that they respect other car drivers endangers the motorcyclists more in road accidents (Jeffrey, 2017).

2.5. Causes of Motorcycle crashes

The major factors that contribute to motorcycle crashes and injuries are mainly associated with the road user, road environment and the motorcycle vehicle. All factors will be briefly discussed below.

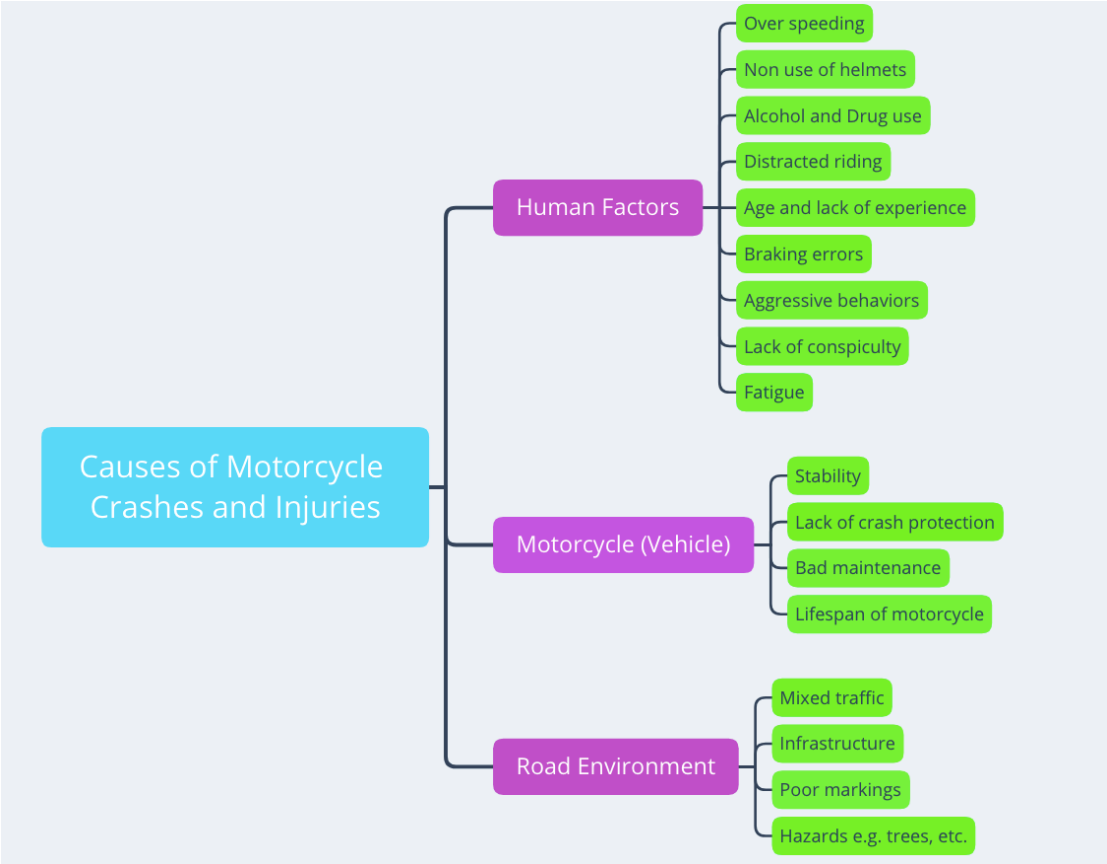


Figure 9 Summary of causes for motorcycle crashes and injuries. Source: Own processing based on Literature Review

2.5.1. Road User Behaviors

A number of studies have demonstrated several motorcyclists' risk-taking behaviors among road users with whom they interact in the same road traffic environment (Zamani et al (2009); Zamani et al (2010); Hongsranagon et al (2011); Tunde et al (2012); Gboyega et al (2012); Adetunji & Aloba (2014) and Trinh & Le (2016)). Nonetheless, there are some main road user related risk factors that put the motorcycle riders at an increased risk of casualty and serious injury such as non-compliance of traffic rules; over speeding; driving under influence of alcohol; non-use of helmets; etc. (Afroz 2006; Gordon 2004; Sexton et al. 2006 and Adetunji & Aloba, 2014).

2.5.1.1. Non-compliance of Traffic Rules

According to (Preusser et al. (1995); Kim et al. (2002); Eustace et al. (2010); Tunde et al. (2012); Johnson & Adebayo (2011); Jou et al. (2012); Seva et al. (2013); Adetunji & Aloba (2014) and Bishop (2018)), motorcycle riders' crashes are globally increasing accounting for more than 286 000 fatalities each year or about 23% of all road deaths mainly due to disobedience of road traffic rules by motorcyclists and all road users in general. Nonetheless, the factors influencing motorcycle fatal crashes may be quite different between countries.

Johnson & Adebayo (2011); Rollanson (2012); Gboyega, et al. (2012); (Matheka et al., 2015); Patel et al. (2016); Olvera et al. (2016) and Bishop (2018), in their studies conducted in several Sub-Saharan Countries, had found that speeding, poor knowledge of traffic code, nonuse of helmets, alcohol intake, wrong overtaking, overloading and mechanical defects as main significant factors responsible for high rates of accidents among commercial motorcycle riders.

Furthermore, it has been observed that commercial motorcycles frequently ignore road safety measures and have little regard for other road users; consequently, there is an increase in the risk of crashes involving other road users that share the same traffic space (Johnson & Adebayo (2011) and Adetunji & Aloba (2014)). Therefore, to face the challenge to comply with the traffic rules most countries have strengthened and put in place adequate minimum standards for regulation policies and other interventions to reduce the percentage of fatalities and injuries from motorcycle collisions (Johnson & Adebayo (2011) and Bishop (2018)).

Numerous studies have shown that in most developing countries the specific regulations to encourage motorcyclists to respect traffic rules are mandatory but the number of road injuries from motorcyclists and passengers is still increasing. However, in several countries specifically in Sub-Saharan African cities where the commercial motorcycles are popular, the enforcement has been inefficient due to local authorities that are not able to enforce the measures (Iribhogbe & Odai as cited in Johnson & Adebayo (2011); Tunde et al. (2012); Bishop & Amos (2015); Patel et al. (2016); Olvera et al. (2016) and Bishop (2018)).

2.5.1.2. Over speeding

Generally each country sets its speed limit of motorized vehicles towards traffic safety. Nevertheless, it was observed that many motorcyclists ignore the speed limit and cause road accidents (Kov & Yai, 2009). The motorcycle riders travel at high speed, implying a longer stopping distance. Moreover, the lack of protection for motorcycle users in a crash make them more vulnerable road users, especially in cases of excessive speed (World Health Organization, 2017).

However, over speeding and inappropriate speed are the most frequently risk taking behavior related factors contributing to an increase of motorcycle crashes worldwide (RoSPA, 2017). According to Horswill (2001) and Horswill & Helman (2003) the motorcycle riders actually travel faster than car drivers and young people are most likely to over speed hence express more risk taking behavior than older people; especially young males engage in risky or aggressive behavior by choosing higher speeds, exceeding more often than other road users, and taking advantage of the smaller gaps in traffic; in other words, young male motorcycle riders are most likely displaying this type of risk behavior regardless of their experience (Lajunen & Summala (1997); Fitzgerald et al. (2000); Stradling et al. (2000); Fergusson et al. (2003) and Huang & Preston (2001) as cited in Smith et al. (2012)).

(Smith et al., 2012) identified that an engine size over 500cc was the causal factor generally attributed to exceeding the speed limit as shown in 29 out of 39 crashes identified whereby motorcycle operators with an engine less than 500cc had more contributing factors such as reckless, less experience, speed limit override. Furthermore, according to (McCarthy et al., 2007) there is a relative difference in travel speed between motorcycle riders and surrounding traffic which has proven to be a direct contributing factor in 66% of motorcycle crashes.

2.5.1.3. Helmet Use

Helmet use is significantly decreasing serious injuries and death from motorcycle riders crashes, but still there is a lack of universal helmet laws all over the world (Ranney et al., 2010). According to Liu et al. (2008) and Pickrell & Ye (2012), wearing a motorcycle helmet results in 72% of decline in the risk of head injury and 37% in death risk; the non-use of motorcycle helmets results in a 40% higher chance to sustain a fatal injury to the head and 15% higher chance to sustain non-fatal injury compared to motorcycle riders with a helmet in an event of collision.

Therefore, the non-use of the helmet by motorcycle riders is an important factor affecting the risk of injury and death associated to road collisions.

Head and neck injuries are among the main causes of fatalities, serious injuries and disability for motorcycle riders. Thus, wearing the helmet can decrease the risk of serious injury to the head and brain by reducing the impact of force on the head or colliding with it (WHO, 2017). It is also important to standardize the crash helmet in order to avoid more risk of head injury and death from the poor quality of helmets (WHO, 2017).

2.5.1.4. Driving Under the Influence of Alcohol

In fact alcohol decreases the capability to concentrate, decreases reaction times, creates more confidence and increases the risk of being involved in collisions. Hence, it stays in the body for many hours after consumption and can affect the riders even in the morning after consuming it (RoSPA, 2017).

In a study conducted in some European Countries by (Penumaka et al., 2014), alcohol was present at 39% of 921 motorcycle crashes; a motorcycle rider was 2.7 times more likely to be involved in crashes than a car driver when under the influence of alcohol. Impaired driving due to alcohol consumption is an important factor that influences both the risk of traffic crashes as well as the seriousness of the outcome (Peden (2004) and Jama et al., (2011)). In developing countries where commercial motorcycles are popular as a means of public transport, the use of impaired riding due to alcohol intake or medical drugs can also be a cause for more motorcyclist crash involvement specifically in Sub-Saharan African counties in order to give them the potential to continue working extra hours for more income generation (Gboyega et al., (2012) and De Silva et al., (2014)). Moreover, the consumption of alcohol is also related with other risk behaviors for motorcycle riders such as speeding and non-use of crash helmets (Stübig et al., (2012) and Rossheim et al., (2014)).

2.5.1.5. Fatigue

Driving fatigue is also one of the causes of motorcycle crashes. According to (Ma et al. (2003); Charlton et al. (2006); Lisper et al. (1986); Nilsson et al. (1997); Williamson et al. (1996)), driver fatigue has been revealed to affect the driving performance whereby fatigue is categorized by the subjective experience of tiredness, bored, sleepy, reduced arousal and alertness, and declines the capability to keep attention and to react rapidly. Furthermore, it has been observed that in several Sub-Saharan African countries most of the commercial motorcycle drivers prefer to work extra time (e.g. working at night) in a way of making more money

or desire for more income-generating in order to satisfy their daily needs (Gboyega et al. (2012) and Olvera et al. (2016)). Indeed, as motorcyclists drive several hours a day for several days while feeling sleepy, they increase the risk of being involved in a collision caused by fatigue.

2.5.2. Road Environment

2.5.2.1. Mixed Traffic

The mixed traffic environment with various motorized vehicles significantly increases the likelihood of motorcycle collisions. In most developing countries with a rise in motorcycles, the mixed traffic environment leads to an increased risk of crashes (Manan & Várhelyi (2012) and Zulkipli et al., (2012)).

According to Harnen et al., (2004) and Arosanyin et al., (2013) traffic conflicts are the highest common fundamental issue among the motorcycle riders and other road users. Therefore, a rise in the volume of traffic on the main or secondary roads and intersections as well as increases in the exposure of motorcycle riders to other road users travelling at different speeds increases the risk of collision (Harnen et al. (2003) and Haque et al. (2010)).

Vulnerable road users, such as motorcyclists, cyclists and pedestrians, are an important element of the mixed-traffic. The more the road is mixed with different types of vehicles and vulnerable road users, the greater the mass variation in the event of a collision. As a result, the vulnerable road users as the motorcycle for instance, being the smallest type of motorized vehicle, should maximize the lateral space that sometimes causes them to change their lateral position in the middle of other vehicles around them. This may therefore affect the severity of a traffic accident (Babu et al., 2014). On the other hand, the movement of other motorized vehicles in the motorcycle rider's path, when the drivers have not seen or do not expect the motorcyclist in a lane can also lead to an accident (Mulvihill et al., 2013). One assessment of the lane sharing revealed that this practice is related to 1-5% of motorcycle crashes in United States of America (Sperley & Pietz, 2010).

2.5.2.2. Road Infrastructure Design

Though the human behavior is a major contributor to traffic collisions, the road infrastructure design provides a physical structure to guide the road users and is affected by their activities, thus a poor design can have negative consequences for motorcycle riders (Le & Nurhidayati, 2016). According to (Le & Nurhidayati, 2016) the lane width must be greater

than 1.6 m between motorcycle riders to allow another motorcycle to overtake on the motorcycle lane.

Several studies have indicated that motorcycle riders are vulnerable road users. Particularly a higher proportion of collisions happened at roundabouts, bends, intersections, in roads with a tight radius and curves due to deceleration or acceleration, or stability issues making loss of control likely (Harnen et al., (2003); Harnen et al., (2004); Vlahogianni et al., (2012) and Huan & Yang (2014)). Most developing countries specifically African cities are not providing a dedicated motorcycle lane design to reduce the effects of mixed traffic. However, better road infrastructure design like road geometry and road layout could favorably influence both the probability and severity level of motorcycle crashes (Abdul Manan, 2014).

2.5.3. Risk factors Related to the Motorcycle Vehicle

The stability of motorcycles depends on the speed of travel and the sufficient friction between the tires and the road (Seiniger et al., 2012). Certain types of motorcycles could become unstable when the available friction limit is exceeded or when the acceleration or braking forces are too high (Seiniger et al., 2012). Contrary to automobile vehicles, the motorcycles have the capability to bend around corners. Therefore, the roll angle that occurs while the motorcyclist is bending, is very sensitive to changes in applied force. Hence any marked increase or decrease in roll angle can result in a loss of control and thus an increased risk of collision (Teoh (2011) and Seiniger et al. (2012)).

2.5.3.1. Bad Maintenance of Motorcycle

Safer motorcycle vehicle plays a critical role in preventing crashes and reducing the likelihood of serious injuries. Motorcycle defects due to bad maintenance may also cause accidents. Therefore, it is recommended that the motorcycle should be maintained regularly to make sure that all parts are in excellent condition to avoid more accidents. The general frequency of checking the motorcycle depends on the type of motorcycle you are using and the road condition in which you ride, but in general better do regular maintenance between 4000-6000 km riding (Kathleen, n.d). Furthermore, verify that your motorcycle is in good condition before every trip and frequently check your tires, change the oil whenever needed, headlamps, turn signals and gear, etc. All these are of the utmost importance towards the motorcycle safety.

2.5.3.2. Lifespan of Motorcycle

Indeed another issue to consider in terms of improving motorcycle safety is the lifespan of the motorcycle. It is suggested that on average the motorcycle can last twelve to fifteen years with a respectable mileage of 100,000 km of engine (Max, 2017). Hence, it may depend on the road conditions travelled whereby the kilometers can be added in case the motorcyclist rides on paved roads though it can be less if the motorcyclist rides along unpaved roads which is the case in several African countries including Rwanda.

2.6. Inadequate Post-Crash Care

According to (Patel et al. (2017) and WHO (2018)), the limited or delayed detection and provision of care to those involved in road accidents especially to vulnerable road users such as motorcyclists, cyclists and pedestrians increase the severity of injuries. However, the treatment of injuries after a collision is tremendously sensitive to time, thus any delay of a few minutes could mean the difference between life and death. Therefore, improving post-accident care requires ensuring access to timely pre-hospital care and improving the quality of pre-hospital and hospital care through special training is strongly recommended in most developing countries.

Chapter 3. Research Methodology

This chapter explains the methodological framework that was used to carry out the study. It is divided in two major parts; the first part is related to the data collection process whereby the second part deals with the data analysis and interpretation.

3.1. Data Collection Process

The most important part of any research concerns the data collection method. In this study, various methods have been used to gather as much as possible responses from the main target groups related to important factors in motorcycle safety. The figure below shows the steps carried out in this respect.

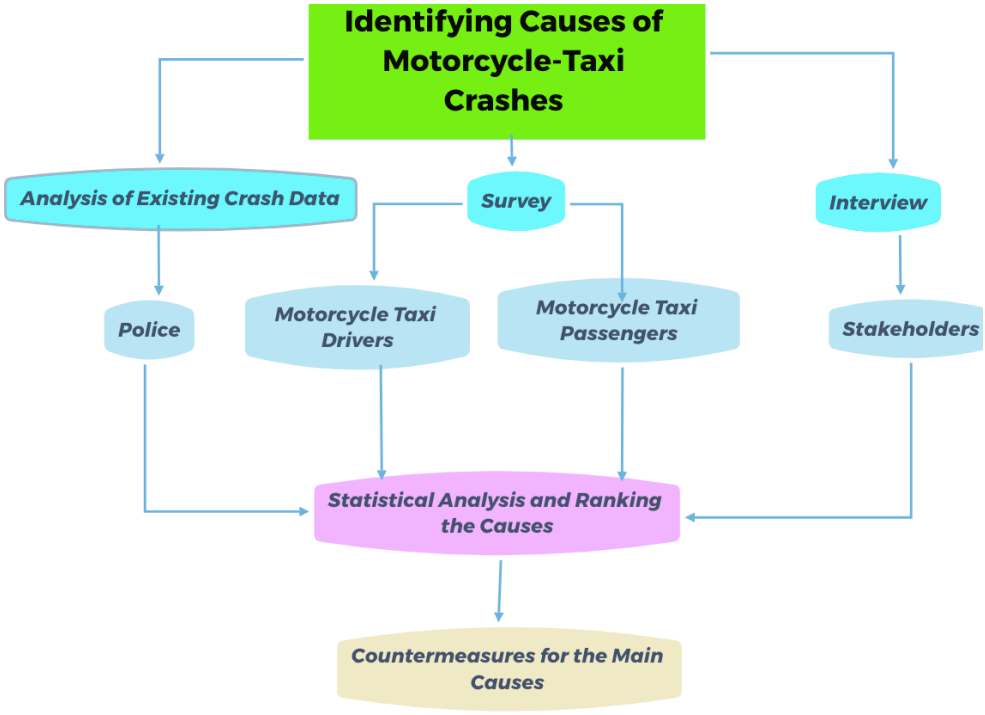


Figure 10 Summarized methodological process

Then, a strategy to gather information was planned. First, the research was granted a permit from the Rwanda National Council for Sciences and Technology (NCST) that helped to approach all the institutions, which were concerned in this study. Indeed, after getting a Research Permit and all necessary permits to approach the motorcycle association as well as their stakeholders, the survey took place from 05th to 20th May 2019 in Kigali City. The motorcycle taxi drivers were selected randomly at the popular restaurants of motorcycle taxi drivers (recommended by FERWACOTAMO) and parking places where they wait for passengers; the motorcycle users were found at parking places and at the dropping places

whereas the interview with stakeholders was done through setting an appointment.

Table 1 Interview Timeline with Motorcycle Stakeholders

No	Names of Organization	Position	Date of meeting
1	RADIANT Insurance Company	Director of Claims and Legal	06/05/2019
2	RURA	Transport Planning Development Officer	07/05/2019
3	WHO	Health Promotion Officer	14/05/2019
4	RTDA	Road Safety Expert	15/05/2019
5	World Bank	- Highway Engineer and, - Transport Specialist	16/05/2019
6	FERWACOTAMO	Discipline Coordination	17/05/2019
7	MININFRA	- Transport Division Manager and, - Safety and Licensing Compliance Engineer	17/05/2019
8	RNP	Director of Road Accident Investigation	19/05/2019

After identifying the causes of motorcyclists' crashes, countermeasures are formulated. The causes of motorcycle crashes were deduced from the responses of the surveys and interviews and the police data.

3.1.1. Survey tools and ODK Collect

The research used smartphones and tablets to collect the data from motorcycle taxi drivers and motorcycle taxi users by using the Open Data Kit (ODK) collect. Given the weaknesses of some tools (e. g. paper) and the rapid evolution of technology, the use of smartphones or tablets enable fast and efficient data collection by helping to collect accurate, reliable and understandable data (Raja et al., 2014).

ODK (Open Data Kit) Collect is a mobile platform that renders the logic of the application and supports the manipulation of data types, including text, location, images, sound, video, and video bar codes (Hartung et al., 2010 and Hong et al., 2011).

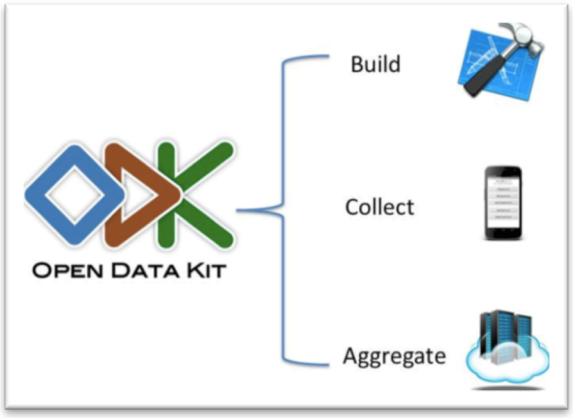


Figure 11 Steps of ODK data collection, source:www.google.com/search

To use ODK collection, the original questionnaire must be created in an XLS form to simplify the creation of forms in Excel. Therefore, survey forms have been created as XLS forms using ODK Build or XLS forms, then survey data submissions and data visualization is handled by an administrator server. However, the collected data is directly submitted to an online server (ONA server) when connecting to the Internet or allows the surveyor to save the data and submit it later when connected to the Internet. Then these answers are downloaded from the ONA server in Excel format for further analysis.

	A	B	C	D
1	**type**	**name**	**label**	**hint**
2	begin_group	group_profile	Sample ODK Survey	
3	date	date1	Date today	
4	date	birthdate	Birth date	
5	text	name	What is your name?	
6	end_group	profile_end		
7	begin_group	group_others	Other stuff about you	
8	geopoint	geopoint	Where are you right now?	
9	integer	siblings	How many siblings do you have?	optional
10	integer	days_of_work	How many days in a week do you work?	
11	calculate	workdays	How many days in a week do you work?	
12	note	no_work	You only have ${workdays} days of rest.	
13	select_one education	education	Highest educational attainment	
14	select_one yes_no	philippines	Are you from the Philippines?	
15	select_multiple country	countries	If not, which country are you from?	

survey | choices | settings

Figure 12 Example of how to create XLS form. Source: https://schoolofdata.org/creating-your-odk-data-collection-form-excel/

3.1.2. Questionnaire design

The questionnaire survey was designed to be answered in less than 15 minutes, to maximize the response rate and to limit respondents' boredom. The average response time was about 10 minutes as many questions were closed questions. In addition, the survey was made available through the app in English, but the surveyors translated the questions in the local language, which is Kinyarwanda.

The prepared questions were focusing on the following main points.

- Traffic regulation
- Income generation
- Risk-taking behaviour of motorcycle taxi drivers
- Accident involvement
- Personal information

Detailed information of all questionnaires used during the current study can be found in annex 2.

3.2. Data Cleaning

Before diving into the analysis phase, the first step was to gather the answers to all the surveys and group them into an easy file to manage to ensure data quality. As the data collected directly from questionnaires may not be immediately usable for analysis; this data needs to be cleaned, formatted and corrected. Moreover, the most important variables that can help to reach the research objectives need to be selected. After preparing the data it was saved as .sav and the coding was developed in SPSS software.

3.3. Model and Tests

According to (Lee, Ihaka, & Triggs, 2012; Shmueli, 2010; Rawlings et al., 2006 and Granville, 2015), statistical modeling helps to develop and test theories using causal explanation, prediction, and description. Models can be used to make sense of the behavior of the variables using certain mathematical expressions. Moreover, it is assumed that models with high explanatory power have excellent predictive power. Therefore, in this research, Analysis of Variance (ANOVA), Independent Sample t Test and Binary Logistic Regression will be implemented to achieve the objective.

3.3.1. Binary Logistic Regression

In many studies, the outcome variable (dependent variable) of interest is categorical. In this case, to model the relationship between the response variable and a set of independent variables, multiple linear regression cannot be implemented as some of the model assumptions will not be met hence logistic regression plays an important role. A logistic regression model is a statistical approach that is used to estimate the probability of observing a response given some predictor variables by considering that the dependent variable is categorical (Hosmer, & Lemeshow, 2000).

For a binomial response, the interest is to estimate the odds of an event to occur. Let p denote the probability of success and 1-p the probabilities of failure, the odds are defined as p/1-p. The logistic model is defined as

$\log\left(\frac{p}{1-P}\right) = \beta_0 + \sum_{i=1}^{m} \beta_i X_i$ Where *m* represents the number of explanatory variables included in the model (Hosmer, & Lemeshow, 2000).

In this study, the interest is to estimate the log odds of crash involvement. The response is binary (Yes and No) whereas explanatory variables were age, experience, working hours, phone use, alcohol use, speeding and motorcycle ownership.

3.3.2. One-Way Analysis of Variance (ANOVA)

ANOVA is a statistical procedure commonly used by many researchers in different disciplines, including psychology and neuroscience. In medicine, it is used to compare three or more treatment groups and describe how these samples differ from each other. Remember that the compared samples must be independent (unbound). Given a response variable and an explanatory variable, an ANOVA model is written as follows (Lunney, 1970).

$y_{ij} = \mu_j + \varepsilon_{ij}$ Where y_{ij} is the response outcome of subject i from group j.

ε_{ij} is the error term which follows a normal distribution $N(0, \sigma^2)$.

μ_j Represents the mean response in-group j.

The null and alternative hypotheses to test are:

$$H_0: \mu_1 = \mu_2 = \cdots = \mu_j$$

$$H_1: \text{Not all } \mu\text{'s are equal}$$

One or the other of the hypotheses is concluded by comparing the calculated value F with the value of the table of the distribution F. In this research, the interesting outcomes were speed, phone use and alcohol consumption. The interest is to compare the average difference between various age groups of motorcycle taxi drivers.

3.3.3. Test of Independence Chi-Square Test

The Chi square test is a statistical test, which measures the association between two categorical variables (Garson, 2012)

In this research, Variables of interest were speeding and motorcycle ownership. Chi-Square test was chosen to test whether speeding is associated with motorcycle ownership.

The following are formulated hypothesis:

H0: Speeding is independent to motorcycle ownership
H1: Speeding is not independent to motorcycle ownership

Chapter 4. Data Analysis and Results

This chapter is about the analysis of responses collected through the questionnaires and model estimation. The descriptive analysis is divided into three parts; the results of the motorcycle taxi drivers, motorcycle users and motorcycle stakeholders, then, the model estimation was performed for further analysis.

4.1. Descriptive Analysis of Motorcycle Taxi Drivers

The survey was conducted on 124 motorcycle taxi drivers, 57 motorcycle taxi users and 8 stakeholders after cleaning for erroneous or incomplete surveys. The graphs and tables presented below provide information about different variables or factors involving motorcycle taxi drivers in crashes.

Table 2 gives information about general characteristics of motorcycle taxi drivers. In fact, it is rare to see any female motorcycle taxi driver, therefore, all respondents were male, the mean age (respectively SD) of the participants was 31 (5.78). Overall, of the 124 motorcyclists surveyed, most respondents were single (56.1%), (43.1%) married or (0.8%) divorced. The results also show that 47.6% respondents have experience of more than five years, 38.7% have experience between three to five years, 12.9% one to two years of experience and only 0.8% of the respondents have less than one year experience. Finally, the respondents' highest degree was mainly from primary school (61.8%), high school (30.9%), technical/college (4.9%) and university (0.8%) level.

Table 2 Characteristics of Motorcycle Taxi Drivers, Source: Own Visualization (n=124)

Type	Frequency	Percentage
Gender		
- Male	124	100
- Female	0	-
Age		
- Less than 25 years	23	18.5
- 25- 30 years	42	33.9
- 30- 35 years	33	26.6
- More than 36 years	26	21.0
Marital Status		
- Single	69	56.1
- Married	53	43.1
- Divorced	1	0.8
- Others	0	-
Experience		
- Less than 1 year	1	0.8
- 1- 2 years	17	13.7
- 3- 5 years	48	38.7
- More than 5 years	58	46.8
Education Background		
- None	2	1.6
- Primary School	76	61.8
- High School	38	30.9
- Technical School/College	6	4.9
- University Level	1	0.8

4.1.1. Level of Compliance of Traffic Signs

The non-compliance of traffic signs is an important factor, which helps to identify the level of involvement of motorcyclists in crashes (Moskal et al., 2012). Indeed, 52% of participants agreed to comply with traffic signs most of the time, 17% occasionally, 10% rarely whereas 21% agreed to never comply with traffic signs. It can be assumed that drivers, who tend to ignore some traffic rules, are more involved in traffic crashes. The graph below shows the percentage of the compliance level of respondents.

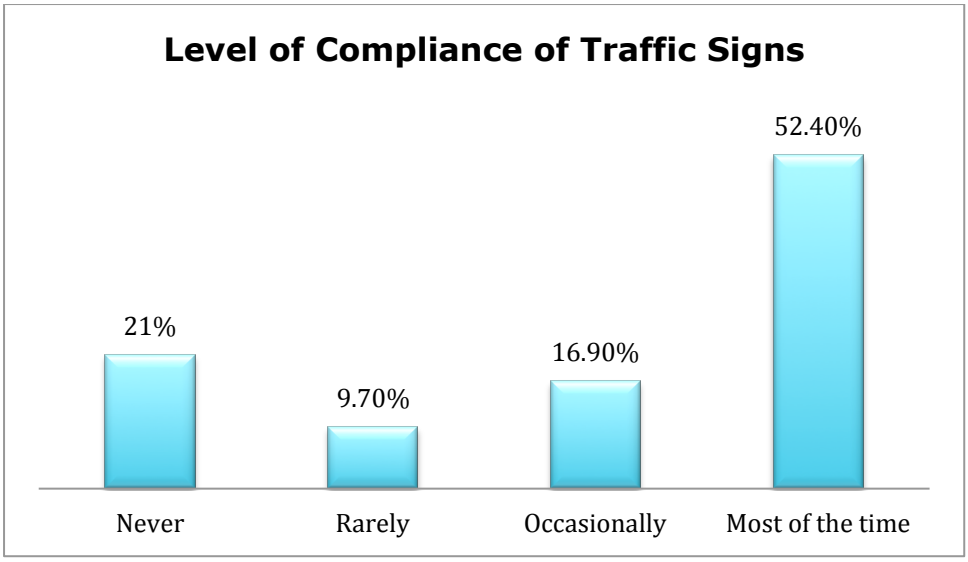


Figure 13 Level of compliance to traffic signs, source: Own visualization (n=124)

4.1.2. Alcohol/Drugs Use

Alcohol/drugs consumption is also inquired in the questionnaire as it can be identified as an important contributor to motorcycle crashes (De Carvalho et al., 2016). Therefore, the alcohol/drugs use of the respondents was categorized into four levels namely never, rarely, occasionally and most of the time. The graph below illustrates the percentage of alcohol/drugs use while riding a motorcycle taxi hence, 47.60% of the motorcycle taxi riders revealed to take alcohol/drugs rarely, 29% reported to take it occasionally, 2.4% use alcohol/drugs most of the time whereas 21% of the respondents reported to not take alcohol/drugs when they drive.

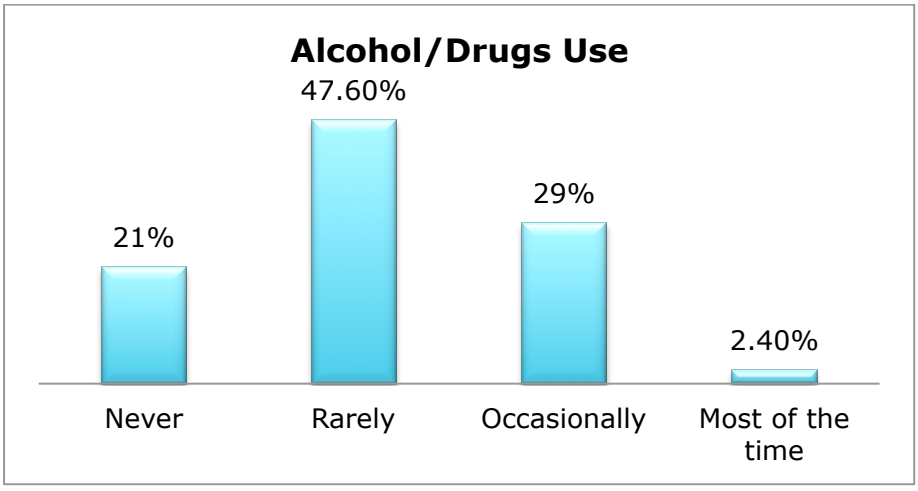


Figure 14 Alcohol/drugs use while driving motorcycle-taxi, source: Own Visualization (n=124)

4.1.3. Phone Use

The question of using the phone while riding a motorcycle has been identified, as it is a key distraction factor in motorcycle crash involvement (Oxley et al., 2013). 39.50% of motorcycle drivers reported to use the phone occasionally, 30.60% stated to use the phone rarely, 2.40% use it most of the time while 27.40% of the motorcycle drivers revealed to never use the phone while driving.

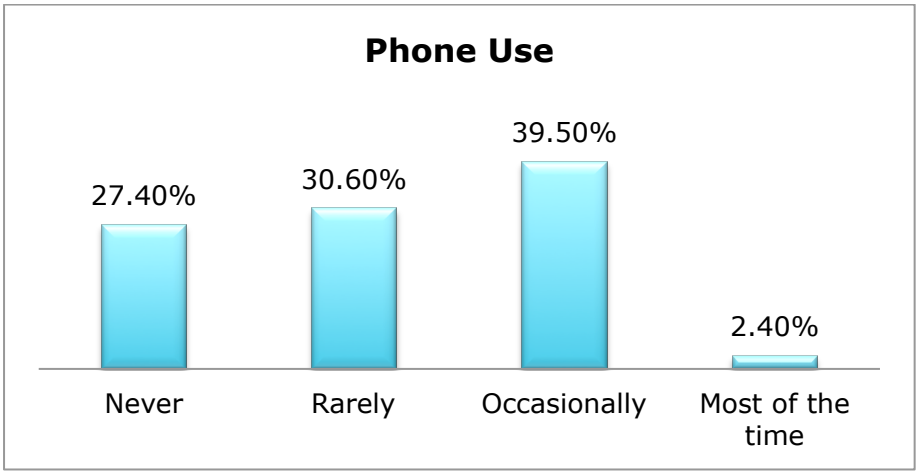


Figure 15 Phone use while riding motorcycle taxi, Source: Own Visualization (n=124)

4.1.4. Speeding

Speeding is one of the reasons found to be significant, and to increase the potential of crash occurrence (Chang & Yeh, 2007). Therefore, the results of the survey show that the highest number of respondents revealed to exceed the speed of 60km/h (maximum allowed speed on many roads in the city of Kigali) most of the time (58.10%), 31.50% occasionally, 8.10% rarely and 2.40% reported to never exceed 60km/h.

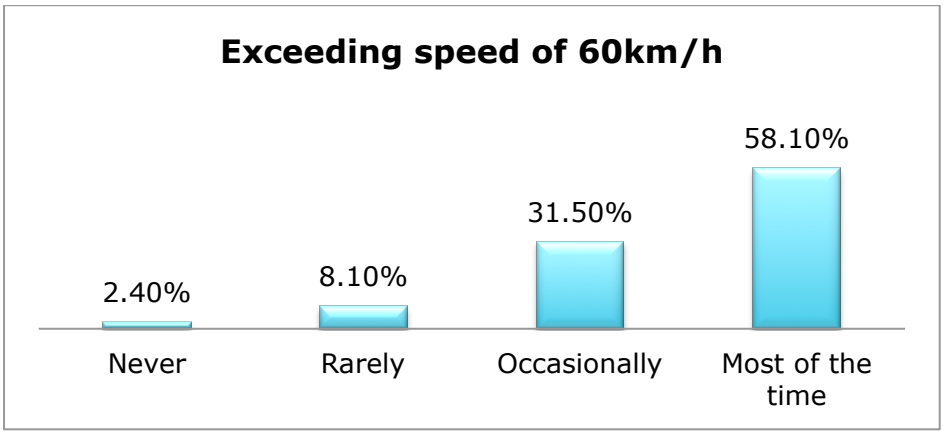


Figure 16 Compliance of speed limit by motorcycle taxi drivers, Source: Own Visualization (n=124)

4.1.5. Violation of Speed Limit Late at Night or Early Morning

Traffic signs, lights and speed limits are often ignored particularly during late night and early morning (Clarke et al., 2004). The graph below shows speed violation at late night or early morning; 82% of the motorcycle drivers admitted to disregard the speed limit most of the time, 11% occasionally, 4% rarely while only 3% reported to never disregard the speed limit.

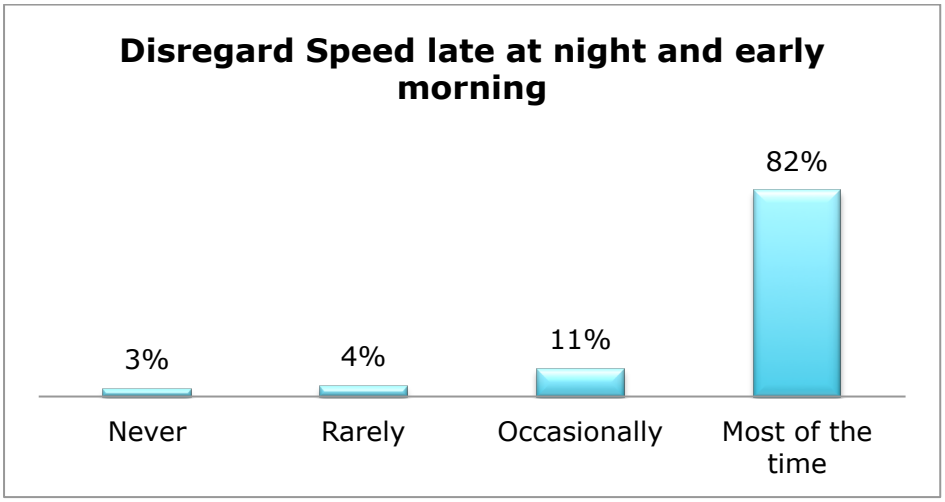


Figure 17 Disregard speed limits late at night or during early morning, source: Own Visualization (n=124)

4.1.6. Basic Technical Control of Motorcycle Taxi

The question related to the basic technical check was asked to motorcycle taxi drivers (change oil, battery, check brakes and tires) to identify the technical issues that can engage motorcycle drivers into crashes. Consequently, the results of the survey show that 100% of the respondents reported to do regular basic technical checks.

4.1.7. Working Hours per Day

Riding for several hours a day can act as contributing factor in a number of vehicle crashes including motorcycle crashes (Bambach et al., 2012). Likewise such question was asked to motorcycle drivers whereas mean working hours (SD) of participants was 11.94 (2.096) as the graph below demonstrates. This average of almost 12hours per day seems to be high and might cause fatigue.

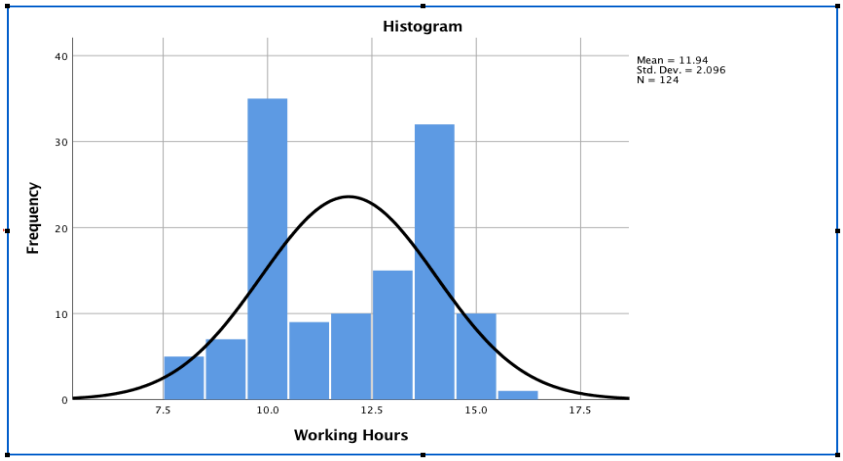


Figure 18 Average of working hours per day among motorcycles drivers, Source: Own Visualization (n=124)

4.1.8. Ownership of Motorcycle Taxi

According to the current results, most of the surveyed motorcycle riders do not own the motorcycle they ride, rather they either rent or lease them from investors ("Ababosi or Bosses") for around 5,000frw (around 5 Euros) per day. This question has been asked to motorcycle riders, as it might be a contributing factor of working several hours to generate more income. 56% of the motorcycle taxi drivers reported to not ride their own motorcycle while 44% revealed to drive their own motorcycle.

4.1.9. Carrying Passengers with Heavy/Big Luggage

The question regarding the way motorcycle taxi drivers carry passengers with their belongings has been asked to know whether this could be a factor of motorcycle taxi crashes. Indeed, most respondents reported to not carry a passenger with heavy luggage (i.e. 68%) since they can get fines from RNP, as it is not allowed to carry a passenger with luggage while 21% revealed that they could take such risk as long as the passenger agreed to add extra money for the luggage.

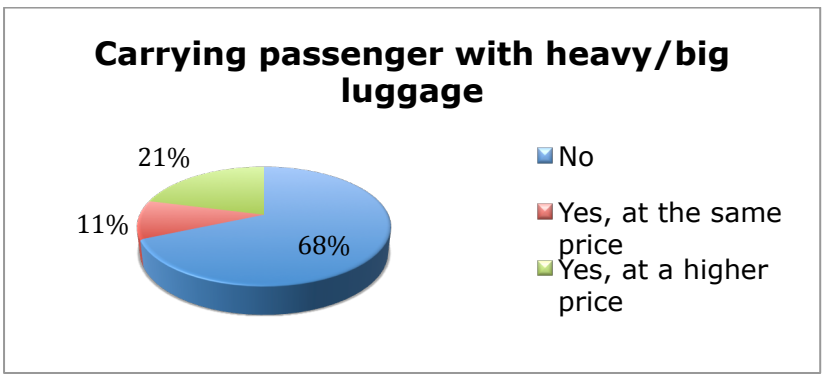


Figure 19 Carrying passengers with heavy/big luggage, Source: Own Visualization (n=124)

4.1.10. Kilometers Driven by Motorcycle Taxi Drivers per Month

According to (ec.europa, 2019) drivers who ride more kilometers are more exposed to the dangers of road traffic and will usually have more crashes. Therefore, during the current study the majority of respondents reported driving a motorcycle taxi between 3000 and 5000km/month.

4.1.11. Monthly Income generating by Motorcycle Taxi

The motorcycle taxi has played an important role in reducing poverty in recent years in Rwanda (Rollason, 2012). Therefore, the question regarding the monthly salary of motorcycle taxi drivers has been asked as well as the family members that depend on it. In fact, 99% of participants indicated earnings between € 100 and € 250 per month, which is even better than other basic jobs (primary and secondary teachers, nurses, etc.). In addition, 68% of the respondents also reported having more than three family members who depend on this salary, which means that the motorcycle taxi activity can be considered as a development success towards poverty reduction in the CoK.

4.1.12. Working Rate

However, the question about the level of how motorcycle taxis would like to work was also asked to motorcycle drivers to determine their level of desired income generation. As a result, 52% of the participants wanted to work more and earn more, while 48% reported to be satisfied with their current income without working too many hours.

4.1.13. Complaints of passengers to motorcycle taxi drivers

Of the 124 participants, 91% received passenger complaints, while 9% received no complaints. Then, participants who received passengers' complaints were asked to report the type of complaint they received the most. 56% of the passengers asked the motorcycle taxi not to drive at a high speed, while 44% asked motorcyclists to speed up. Likewise, from this result, it can be assumed that the passengers of the motorcycle can play an important role - negatively or positively - in motorcycle crashes.

4.1.14. Car Drivers Giving Space to Motorcycle Taxi Drivers

To improve the motorcycle safety, such a question regarding the level of sharing road infrastructure with other road users especially car drivers has been asked to motorcycle taxi drivers e.g. during traffic jams, overtaking, etc. The majority of participants reported that the car drivers rarely give

space or share the road infrastructures with motorcycle taxi drivers (69.4%) as shown in the graph below.

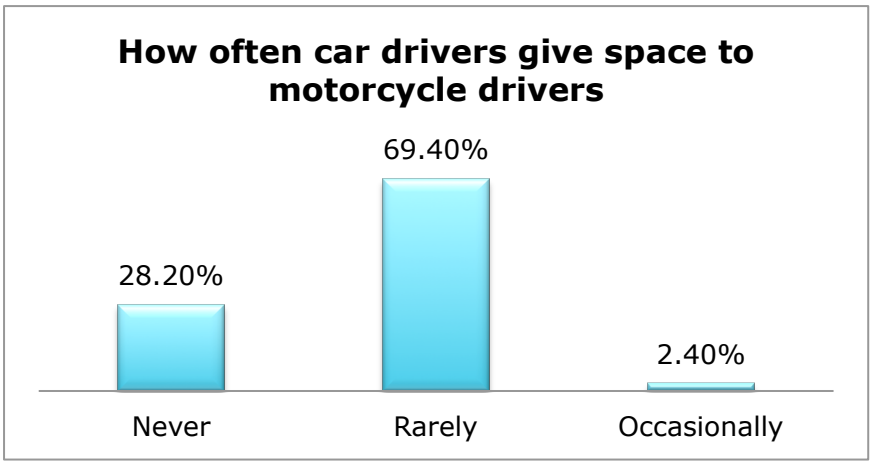


Figure 20 Car drivers' conduct to motorcycle taxi drivers, Source: Own Visualization (n=124)

4.1.15. Traffic Safety Training among Motorcycle Taxi Drivers

To improve the safety of motorcycle taxis, the question of traffic safety training was asked to the motorcycle taxi drivers to determine their level of traffic safety and subsequent interventions. Indeed, as shown in the graph below, most participants did not actually participate in any road safety training.

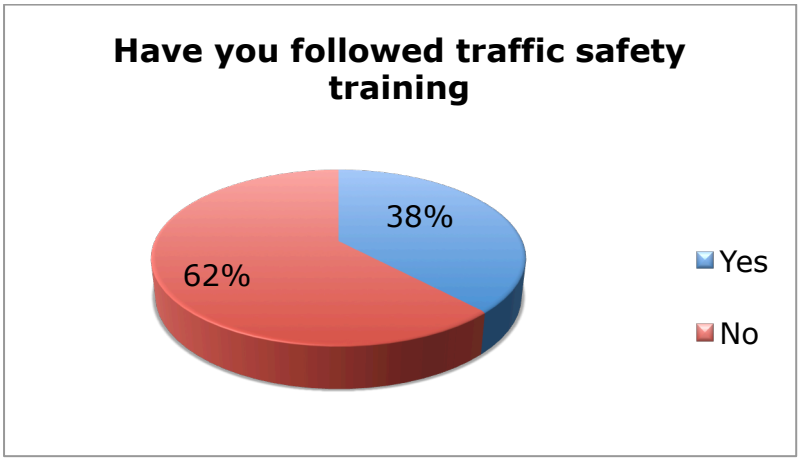
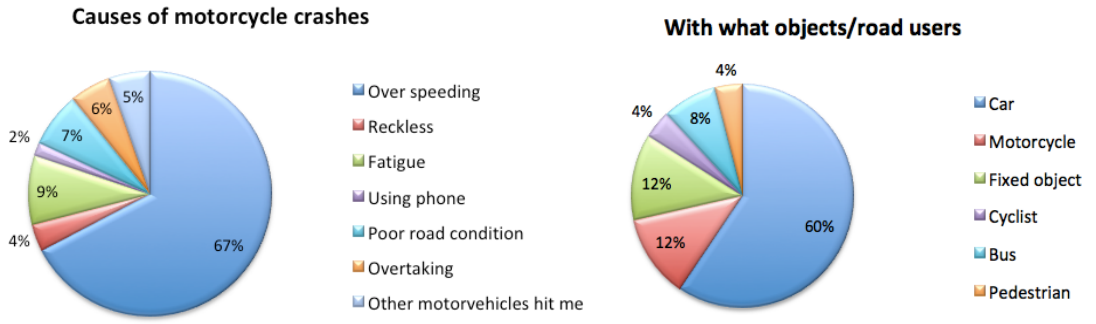


Figure 21 Traffic safety training among motorcycle taxi drivers, source: Own Visualization (n=124)

4.1.16. Motorcycle Taxi Drivers Crash Involvement and Causes

Among the 124 participants 43% state to have been involved in crashes. Then, the participants who were involved in motorcycle crashes (even slight crashes) during the last twelve months were asked to report the crash causes. The graph below summarizes the obtained results.



(a) (b)

Figure 22 Most causes of motorcycle crashes (graph a) and objects/road users involved (graph b), Source: Own Visualization (n=53)

4.1.17. Severity of the Crash

The question concerning the severity of the crash was asked to the motorcycle taxi drivers who were involved in at least one crash within the last twelve months. Most respondents reported slight and serious injuries (45% and 40% respectively), 12% non-injury while 3% resulted in a death.

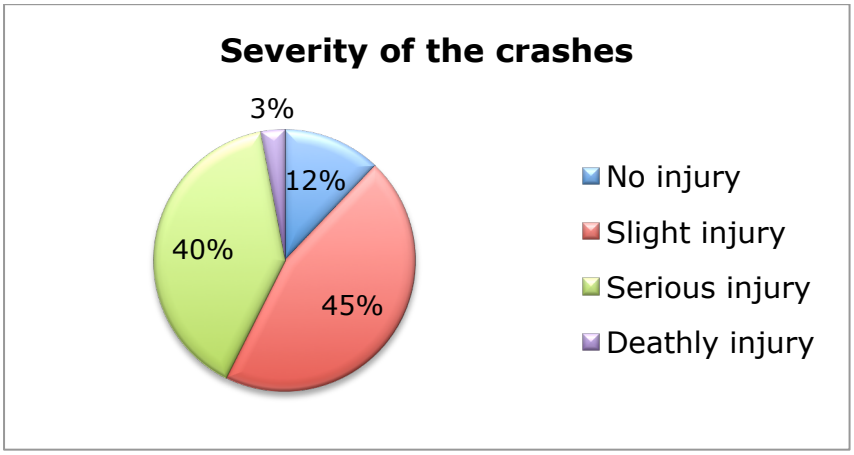


Figure 23 Severity of the motorcycle taxi drivers crashes, Source: Own Visualization (n=53)

4.2. Descriptive Analysis of Motorcycle Taxi Users

To further explore the factors influencing motorcycle taxi crashes it is important to consult the opinion of the motorcycle users, as public views are important in solving road safety-related issues. Furthermore, the users are the ones who might feel intimidated by motorcycles' crashes. This part gives the overall picture of the results obtained from 57 motorcycle users specifically about their level of motorcycle usage, motorcycle safety, crash involvements, causes of the crash and most risk-taking behaviors of motorcyclists.

The table below gives information about general characteristics of the surveyed motorcycle taxi users. Overall, of the 57 motorcycle users interviewed, 50.9% were male whereas 49.1% were female. Most respondents were single (61.4%) or (38.6%) married. Finally, the respondents' degrees were mainly from the university (36.8%), high school (29.8%), (17.5) primary school, (14.0%) and technical/college while 1.8% did never obtain any degree.

Table 3 Characteristics of Motorcycle Users, Source: Own Visualization (n=57)

Type	Frequency	Percentage
Gender		
- Male	29	50.9
- Female	28	49.1
Age		
- Less than 26 years	19	33.3
- 26-32 years	23	40.4
- More than 32 years	15	26.3
Marital Status		
- Single	35	61.4
- Married	22	38.6
- Divorced	0	-
- Others	0	-
Education Background		
- None	1	1.8
- Primary School	10	17.5
- High School	17	29.8
- Technical School/College	8	14.0
- University Level	21	36.8

4.2.1. Level of Motorcycle Usage

The graph below shows the level of motorcycle usage for 57 motorcycle taxi users surveyed. The result shows that motorcycle taxi is a useful mode of the transport in the CoK as many passengers depend on it.

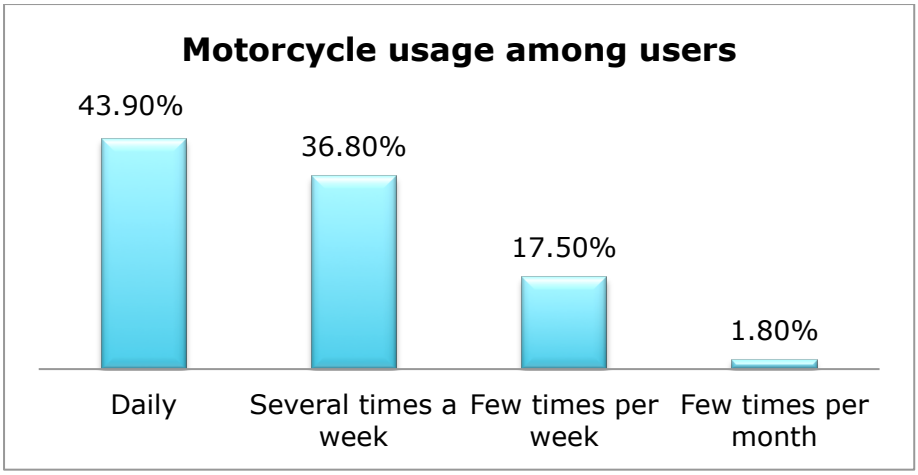


Figure 24 Motorcycle usage level among users, Source: Own Visualization (n=57)

4.2.2. Safety Level of Motorcycle Taxis

Despite motorcycle taxis being a useful mode of transport, the majority of the participants do not consider it as a safe mode of transport as shown in the graph below.

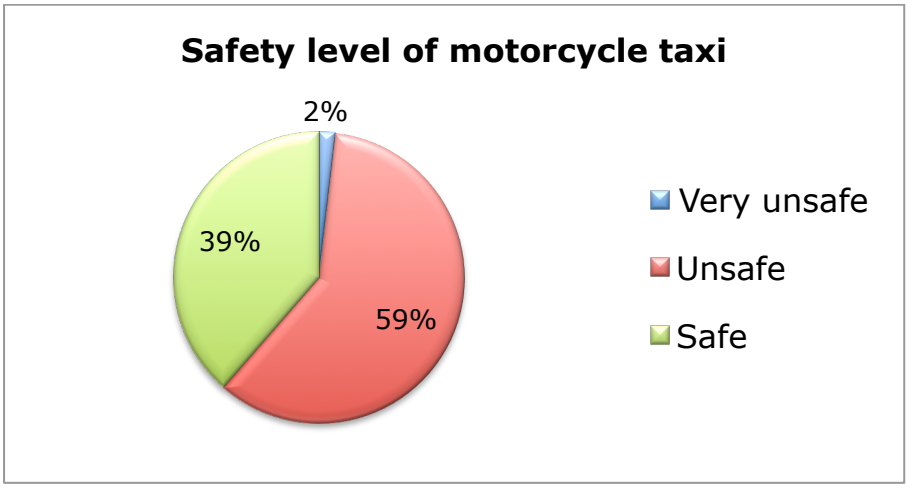
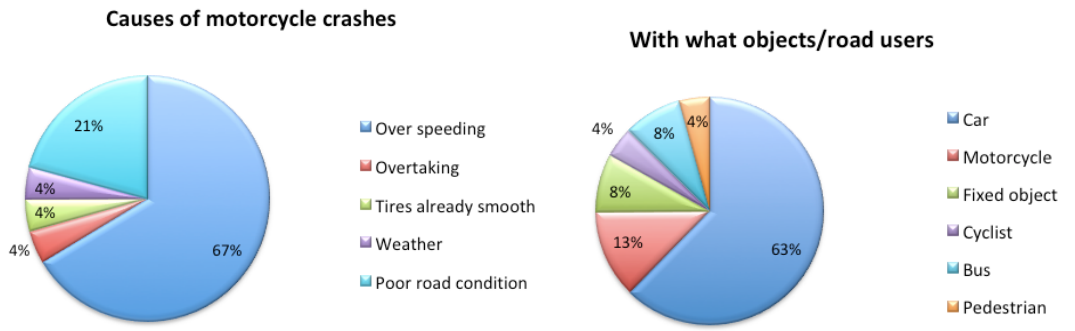


Figure 25 Safety level of motorcycle taxi, Source: Own Visualization (n=57)

4.2.3. Motorcycle Crash Involvement and Causes

Among the 57 participants 42% have been engaged in crashes. Then, the participants who were involved in motorcycle crashes (even less severe) while using a motorcycle taxi were asked to report the accident causes. The graph below summarizes the obtained results.



(a) (b)

Figure 26 Causes of motorcycle crashes (graph a) and objects/road users involved in (graph b), Source: Own Visualization (n=24)

4.2.4. Most Risk-Taking Behavior of Motorcycle Taxi Drivers

After giving the causes of the crash in which the participants were involved in, they were asked to report what they identify to be the risk-taking behaviours of motorcycle taxi drivers. Results are shown in the graph below.

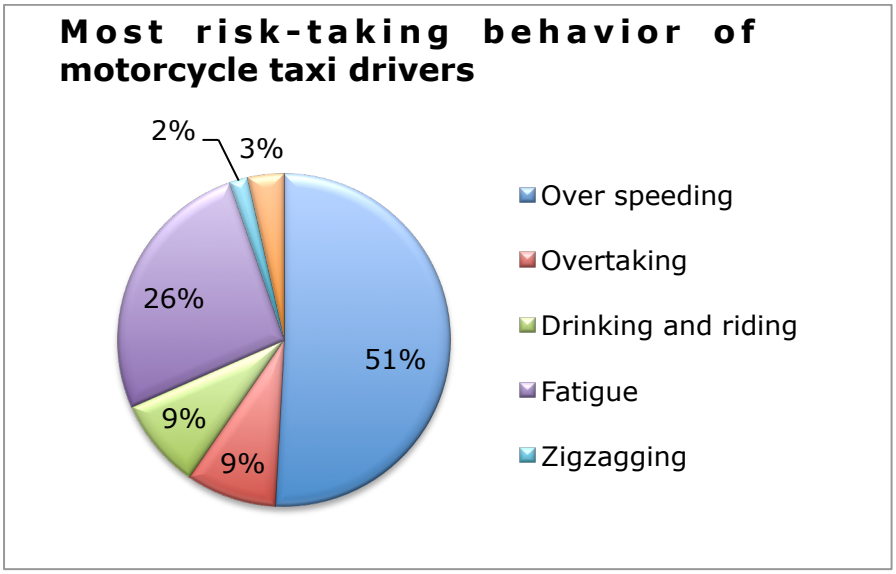


Figure 27 Most risk-taking behavior of motorcycle taxi drivers, Source Own Visualization (n=57)

4.3. Descriptive Analysis of Motorcycle Taxi Stakeholders

To address motorcycle taxi safety issues consulting the body comprising all the main road safety stakeholders, including the non-governmental sectors is important. In this research, eight stakeholders have been consulted namely Rwanda National Police (RNP), Ministry of Infrastructure (MININFRA), Federation Rwandaise des Convoyeurs du Taxi-Moto (FERWACOTAMO), RURA, RTDA, RADIANT Insurance Company, WHO and

World Bank. Those stakeholders were selected to get an overview of the road safety situation in the City of Kigali.

4.3.1. Current situation of motorcycle taxi safety

According to the eight stakeholders consulted, 5 reported motorcycle taxis as safe mode of transportation whereas 3 reported motorcycle taxis as unsafe mode of transport in the CoK.

4.3.2. Most Common Causes of Motorcycle Crashes

The most common causes of motorcycle taxi crashes have been asked to the motorcycle stakeholders. The majority of stakeholders reported speeding and fatigue as the main causes of motorcycle taxi crashes.

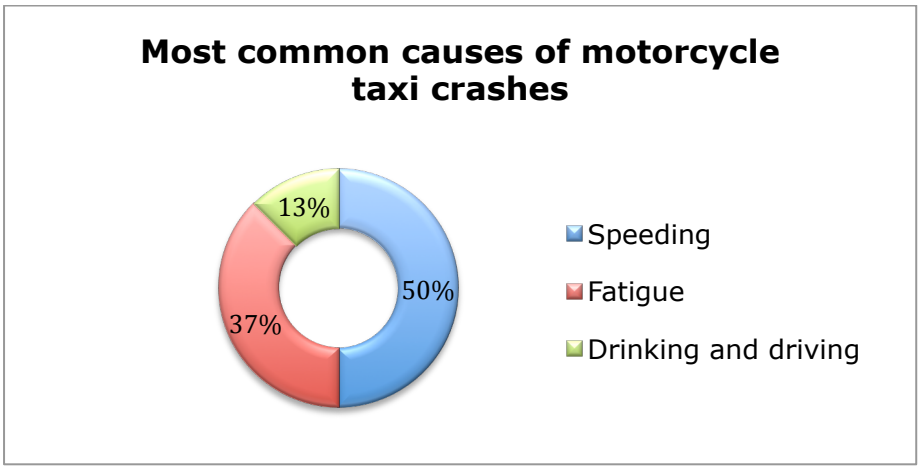


Figure 28 Most common causes of motorcycle taxi crashes by stakeholders, Source: Own Visualization (n=8)

4.3.3. Reasons for Motorcycle Taxi Drivers Engaging in Risk-Taking Behaviors

The stakeholders, who are in charge of road safety generally, listed the reasons that influence the motorcyclists' intention to engage in risk-taking behaviors as shown in the graph below.

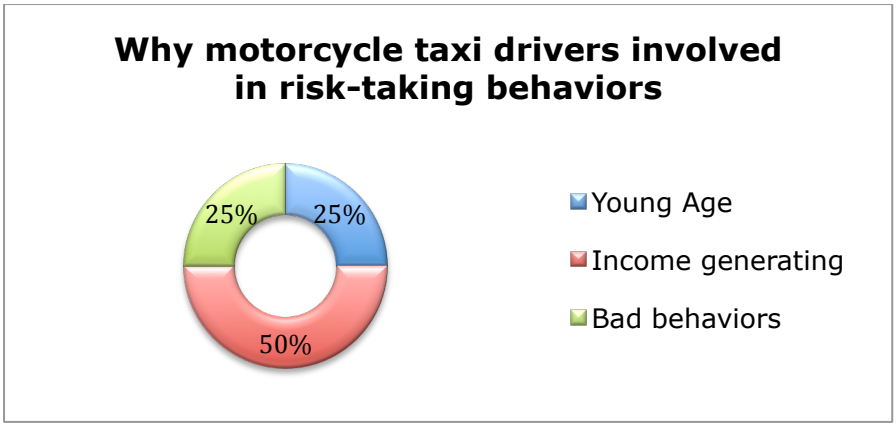


Figure 29 Reasons for motorcycle taxi drivers engaging in risk-taking behaviors, Source: Own Visualization (n=8)

4.4. Analysis of Existing Data from Rwanda National Police (RNP)

During the interview conducted on May 19, 2019 with the Director of Road Accident of RNP to discuss on the causes of the motorcycle taxi crashes that occurred during the last three years (2016, 2017 and 2018), the Director of Road Accidents reported that the most common causes of motorcycle taxi crashes recorded were speeding, fatigue and inappropriate misbehaviors of motorcycle drivers. Therefore, such misbehaviors are known as violation of traffic lights, refusal to stop once arrested by Traffic police agent (indiscipline), riding without driver's license, lack of transport license, lack of insurance certificate and riding under influence of alcohol.

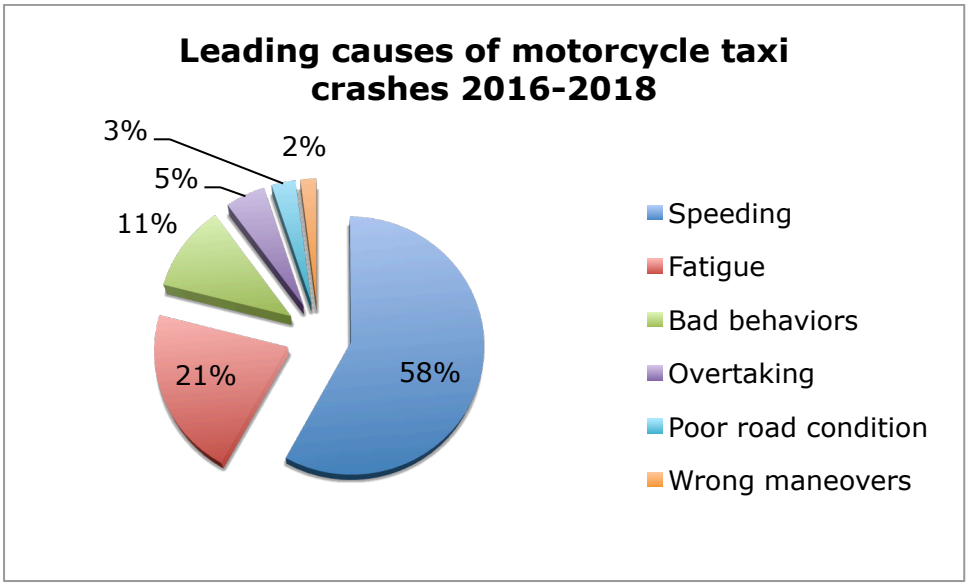


Figure 30 Leading factors of motorcycle taxi crashes from existing data from police 2016-2018, Source: Own Visualization

4.5. Identified Causes of Motorcycle Taxi Drivers Crashes from the Survey and Existing Police Data

Figure 31 below provides an overview of the main identified causes of motorcycle taxi crashes from the four target groups of the study after doing a descriptive analysis.

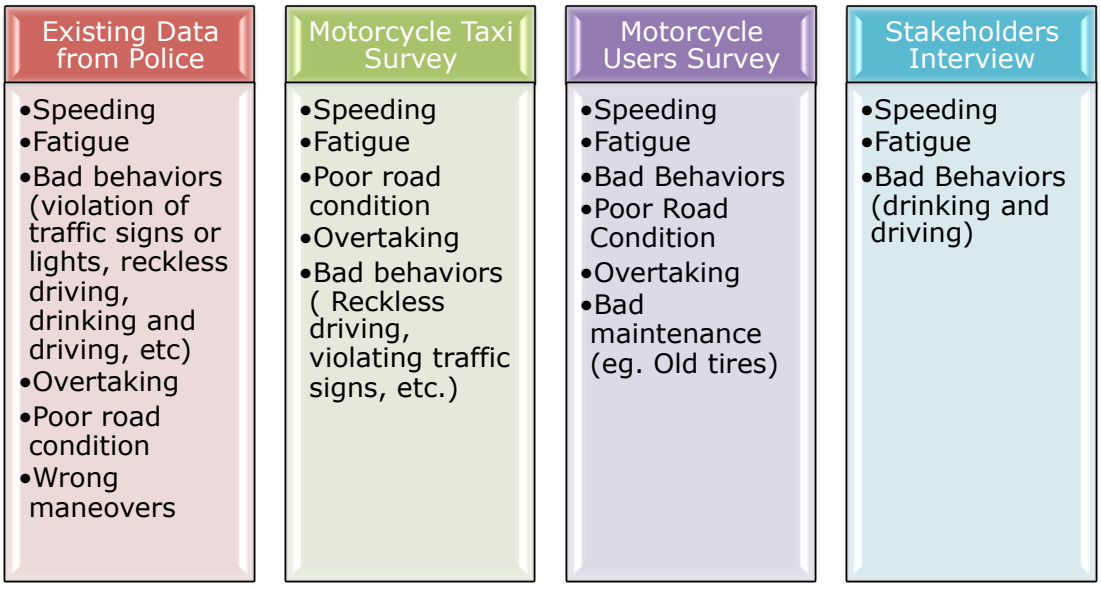


Figure 31 Common causes of motorcycle taxi crashes from the survey, interview and existing police data

Based on the results of the descriptive analysis and the existing crashes from the Rwanda National Police (RNP) it can be concluded that speeding was the foremost factor influencing motorcycle taxi crashes in the CoK, followed by fatigue, bad behaviors (e.g. reckless driving, violating of traffic signs & lights, drinking and driving, etc.), poor road condition and overtaking as it is illustrated in the figure below.

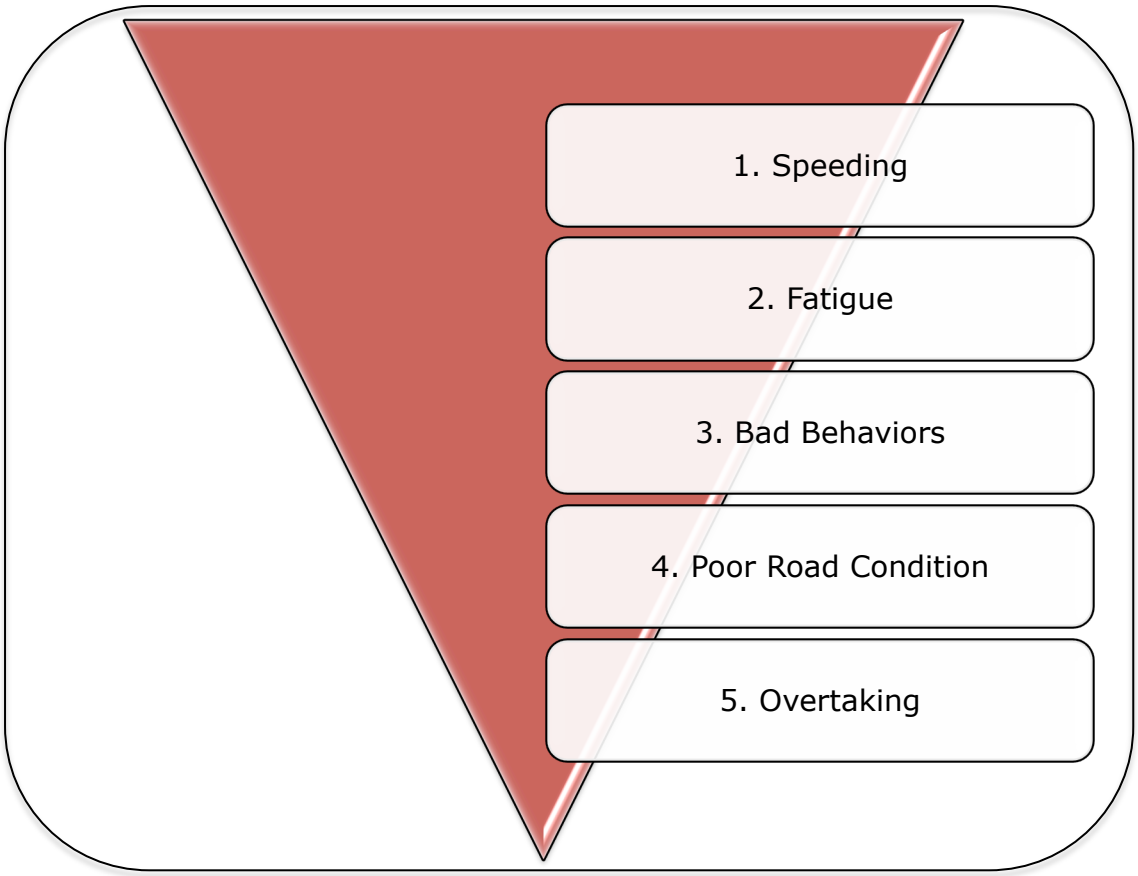


Figure 32 Ranking the main causes of the motorcycle taxi crashes in the CoK, Source: Own Visualization

However, to determine the most important variables for motorcycle crash prediction and predict future probability of motorcycle crashes, ANOVA, t-test and regression estimation were performed to link the response variable and independent variables in order to define and conclude the most explanatory variables for motorcycle crashes in the CoK.

Therefore, based on the information provided by descriptive analysis, five variables were identified (see figure 4.19 as the most important factors that can predict motorcycle crashes. Hence, some variables have been included in the model to test or conclude whether these variables significantly affect motorcycle crashes.

4.6. Socio-Demographic Factors and Risky Driving Behaviors

One-way ANOVA, and independent sample t- test were conducted to determine the difference on different risky driving behaviors such as phone usage while riding, speeding, and alcohol use based on drivers' socio-demographic factors like age and motorcycle ownership.

4.6.1. Age and Phone Use

Accordingly respondents' age was categorized into four groups (Group 1; less than 25; Group 2: 25-30; Group 3: 30-35; Group 4: >35) and assessed for the presence of significant difference with regard to phone usage while driving. A one-way between-groups analysis of variance (ANOVA) was conducted at an alpha level of .05. The mean value of phone use while driving among the four age groups is depicted in Table 4 below; the mean value of respondents on the phone usage seems to decrease as age increase

Table 4 Respondents' Mean and Standard Deviations on the Phone Usage while driving across age groups (n=124)

Age Categorized	N	M	SD
Less than 25 years	23	3.09	.417
25-30 years	42	2.31	.643
30-35 years	33	1.94	.788
More than 35 years	26	1.42	.758
Total	124	2.17	.862

The result of the ANOVA analysis also asserted a statistically significant main effect difference at p< .05, across the four age groups, F [(3,120) = 26.4, P =. 001)] indicating the four age groups significantly differed in self-reported risky behavior of using a phone while driving.

Table 5 Output of the one-way analysis of variance (ANOVA) on Phone Usage and age (n=124)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	36.416	3	12.139	26.472	.000
Within Groups	55.027	120	.459		
Total	91.444	123			

A Post-hoc comparison was done by LSD parameter to determine which age groups' means were significantly different. The response of motorcyclists on the frequency of phone usage while riding of group 1 (< 25 years) was significantly different from that of group 2, [(25-30 years, P=. 0001)], and group 3 [(30-35 years, P=. 0001) and group 4 (> 35 years and above, p=. 0001). Similarly, there was a statistically significant, F [(3, 123) = 26.4, P=. 0001)] difference between motorcyclists in-group 2 and those in-group 3, p=. 020), and in group 4 (p =.0001) and lastly,

those in group 3 were significantly different from that of respondents in group four at p=.004.

4.6.2. Age and Alcohol use

Another one-way analysis of variance was conducted to examine if there is a difference in alcohol use of drivers and the different age categories. As featured in table 6 below, the mean value of respondents on the alcohol use seems to decrease as age increase.

Table 6 Respondents' Mean and Standard Deviations on Alcohol Use while driving (n=124)

Age Categorized	N	M	SD
Less than 25 years	23	3.13	.344
25-30 years	42	2.38	.492
30-35 years	33	2.00	.000
More than 35 years	26	1.00	.000
Total	124	2.13	.765

The result of the ANOVA analysis also asserted the presence of a significant difference [(3,120) = 189, P =. 0001)] among the four groups on the alcohol use and driving behavior.

Table 7 Output of the one-way analysis of variance (ANOVA) on Alcohol Usage and age (n=124)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	59.422	3	19.807	189.946	.0001
Within Groups	12.513	120	.104		
Total	71.935	123			

A Post-hoc comparison was done by LSD parameter to determine which age groups' means were significantly different. The response of motorcyclists on the frequency of alcohol usage while driving of group 1 (< 25 years) was significantly different from that of group 2, [(25-30 years, P=. 0001)], and group 3 [(30-35 years, P=. 0001) and group 4 (> 35 years and above, p=. 0001). Similarly, there was a statistically significant, P=. 0001)] difference between motorcyclists in-group 2 and those in-group 3, p=. 0001), and in-group 4 (p =. 0001) and lastly, those in-group 3 were significantly different from that of respondents in-group four at p=. 0001.

4.6.3. Speeding behavior and Age

Speeding behavior of motorcycle taxi drivers was also computed with a mean score of the two items employed to assess respondents' adherence of speed limits in the areas. Mean speed of motorcycle drivers is negatively related with age; if age increases, speeding behavior gets smaller and smaller.

Table 8 Respondents' Mean and Standard Deviations on Speeding (n=124)

Age Categorized	N	M	SD
Less than 25 years	23	3.9565	0.14405
25-30 years	42	3.8333	0.23856
30-35 years	33	3.6667	0.42696
More than 35 years	26	2.7500	0.81548
Total	124	3.5847	0.63349

The result of the ANOVA output also showed a presence of a statistically significant difference F [(3,120) = 38.2, P =. 0001)] with regard to motorcyclist age and speeding behavior.

Table 9 Output ANOVA analysis on the role of age on speeding behavior (n=124)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24.113	3	8.038	38.201	.0001
Within Groups	25.248	120	.210		
Total	49.361	123			

A Post-hoc comparison was done by LSD parameter to determine which age groups means were significantly differed (see Appendix 3). The mean score of respondents on the speeding behavior in-group 1 (< 25years), was significantly different from those in group 3 [(>35 years, P=. 0001)] and group 4, [(>35 years, P=. 0001)]. However, there was no statistically significant mean difference among those in-group one and two. The post hoc analysis clearly showed that the mean score of those participants >35 years was significantly different from the rest of the three groups.

4.6.4. Motorcycle Ownership and Speeding Behavior

In the current study there are drivers who are driving their own motorcycle as taxi and there are also employed drivers. The assumption is that drivers tend to speed, violate traffic laws and generally drive recklessly due to the reason that the owners of the motorcycle demand a daily stated amount of money that may be difficult to meet up unless they drive fast. Considering this, a Test of independence Chi-Square was conducted to test if there is a significant association between speeding behavior and motorcycle ownership. The speed of the two groups is depicted in table 4.11 below.

Table 10 Speeding and Motorcycle Ownership Cross tabulation (n=124)

			Motorcycle Ownership		
			Yes	No	Total
Speeding	Never	Count	3	0	3
		Expected Count	1.3	1.7	3.0
	Rarely	Count	10	0	10
		Expected Count	4.4	5.6	10.0
	Occasionally	Count	24	15	39
		Expected Count	17.3	21.7	39.0
	Most of the time	Count	18	54	72
		Expected Count	31.9	40.1	72.0
Total		Count	55	69	124
		Expected Count	55.0	69.0	124.0

Table 11 Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	31.903[a]	3	.000
Likelihood Ratio	37.371	3	.000
Linear-by-Linear Association	30.510	1	.000
N of Valid Cases	124		

Note: Since 3 cells (37.5%) have expected count less than 5; in this case Likelihood Ratio value was selected to conclude the test of independence.

From the table above (4.12), the P-value=0.000 which is less than α=0.05 (α is the level of significance for the test), this means the null hypothesis is rejected and conclude that the speeding behavior is associated with motorcycle ownership. The motorcyclists who own motorcycle tend to respect the limit speed.

4.7. Predictors of crash occurrences among motorcycle drivers

A simultaneous logistic regression analysis was used to model which factors influence the likelihood of crash occurrence among motorcycle taxi riders during the past year. The predictor variables in this phase were age, speeding and driving hours, and the outcome variable was crash occurrence during the past year (yes: 1, no: 2). The independent variables entered were examined for the presence of multi-collinearity among them by checking their variance inflation factor. The issue of multi-collinearity was not a problem among the independent variables since none of the explanatory variables indicated a tolerance level, which is close 0.1. The result of the logistic analysis indicated that the predictor variables entered have a statistically significant improvement over the constant only model X^2 (6.25, df=8, P<. 0001). The Cox& Snell and then R^2 value was .61. This value suggests that 61 percent of the variability is explained by this set of predictor variables. The significance level, the odds ratio, and the 95 % confidence intervals (CI) for odds ratio (OR) for each significant predictor is presented in Table 4.13 below.

Table 12 Variables of the logistic regression model

						95% C.I.for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Age	.363	.112	10.432	1	.001	1.438	1.154	1.793
Speeding	-2.839	.726	15.313	1	.000	.058	.014	.242
Working Hours	-.239	.218	1.201	1	.273	.787	.514	1.207
Constant	2.805	5.769	.236	1	.627	16.532		

a. Variable(s) entered: Age, Speeding, and Working Hours.

As it can be observed from the above table, the influence of age and speeding behavior were significant in predicting crash occurrence during the past year in the CoK while working hours was not significant in the model, although it can play a very important role in predicting motorcycle taxi crashes.

Chapter 5. Discussion and Recommendation

The aim of this study was to determine the factors influencing motorcycle taxi crashes in the City of Kigali. Hence, this chapter discusses the results of the literature review, descriptive analysis, ANOVA, Chi-Square test and Logistic Binary Regression Model analysis. It deeply reflects on the main objectives of this study and how they relate to the study findings. Further, a set of recommendation is presented to the practitioners and scholars to improve both motorcycle taxi safety and research.

5.1. Discussion

5.1.1. Risky Driving Behavior among Various Age Groups

The results of the ANOVA stated the presence of a statistically significant difference on speeding, alcohol consumption and phone use mean scores of motorcycle taxi drivers in accordance with their age; the t-test showed that motorcycle ownership influences speeding.

5.1.1.1. Speeding and Age

The present study showed that the speed of motorcycle taxi drivers is negatively related with age, which means that as the age increases the speeding behavior reduces. In this study, 75% of the participants were less than 30 years and agreed to exceed the speed limit most of the time. The same results were found in previous studies in some African countries (e.g., Adogu et al., (2009) and Oladepo & Brieger, (1986) stated that young people are most likely to over-speed). Also the young people tend to speed to get more motorcycle passengers given their economic difficulties. A study conducted in Iran reported that being young and single was a factor that augmented engaging motorcycle drivers to speed (Zamani-Alavijeh et al., 2010), therefore young motorcycle taxi drivers express more risk or aggressive behavior than older people.

5.1.1.2. Alcohol Use and Age

With regard to alcohol consumption, this study revealed that the mean value of respondents on the alcohol use seems to decrease as age increases. The result showed that 55% of the 65 participants whose age is less than 30 years revealed to consume alcohol/drugs occasionally while they drive and 100% of the 23 participants under 25 years; while none of the participants over 35 years old reported to occasionally consume alcohol while driving. This is due to the fact that the motorcycle taxis in Kigali City can work 24 hours consequently, some motorcycle drivers may choose to continue working until late in order to earn more money to

satisfy their daily needs, thus, taking alcohol gives them a stamina of working extra hours. The young motorcycle drivers consume alcohol due to their low risk perception and high-perceived efficacy. This finding was consistent with many past studies confirming the usage of alcohol in developing countries where motorcycle taxis are popular. The use of alcohol or medical drugs particularly for drivers with a young age is increasing as alcohol gives them the potential to continue working for many hours to generate more income (Peden (2004); Jama et al., (2011); Gboyega et al., (2012); De Silva et al., (2014)). Besides, according to (Stübig et al., (2012) and Rossheim et al., (2014)) the alcohol use can also be associated with other risk driving behaviors e.g. speeding, violation of traffic signs, etc. Therefore, alcohol consumption can be a good predictor of motorcycle taxi crashes.

5.1.1.3. Phone Use and Age

The availability of mobile devices and their use are associated with a higher chance of being involved in a crash while driving (Phommachanh et al., 2017). With regard to phone usage and age, the result showed a significant difference. 60% of the 65 participants under 30 years reported to use their phone occasionally while driving. This might be attributable to the fact that nowadays-young people are more active on social media and they can also communicate with their regular passengers. A study conducted in Vietnam by (Truong et al., 2016) confirmed that an increasing in age was associated with lower mobile phone use. Also, in a study conducted in the same country (Truong et al., 2019) revealed that among 40% of the motorcycle riders surveyed reported to have experienced a crash/fall while using their phone.

5.1.2. Speeding and Motorcycle Ownership

The results indicated that there was a significant association of speeding between motorcycle ownership. Among the 124 participants surveyed, 56% were not riding their own motorcycle, among them 78% revealed that they over speed most of the time while driving. From the perspective of the study, those who did not own a motorcycle were more exposed to situations that lead them to over speed due to the fact that they should pay the owner (around 5 euros/day) and earn their own income. These findings are consistent with the results of previous studies conducted in Uganda and Nigeria (e.g., Bishop et al. (2018); Adogu et al. (2009); Oladepo & Brieger (1986)).

5.1.3. Discussion of model results

The results of the binary logistic regression on crash factors involving motorcycle taxis drivers revealed that speeding behavior and age were significant variables in predicting the occurrence of a crash over the past year. The model result coincides with the results of the descriptive analysis (existing police data, interviews with stakeholders, surveys of motorcycle taxi drivers and motorcycle passengers), which indicated that speeding is the main factor influencing motorcycle crashes. Many literatures tried to explain the reason why young motorcycle drivers engage in over-speeding. The next section presents these reasons in some developing countries.

A study conducted in Colombia (Jimenez et al., 2015), stated that sensation seeking among young adults, economic hardship and peer pressure motivate motorcycle drivers to engage in speeding behavior. Numerous literatures have confirmed that speeding is a fundamental problem resulting from self-efficacy (behavior intention), social influence, and income generating. Motorcycle taxi drivers wish to earn more to satisfy their daily needs and/or to pay the rent to the owner of the motorcycle ((Bishop et al., 2018; Adogu et al. (2009); Oladepo & Brieger (1986); Wu & Loo (2016); Gboyega et al. (2012) and Olvera et al. (2016)).

Another study by (Bambach et al. (2012); Adogu et al. (2009) and Tuan & Mateo-Babiano, (2013) confirmed that, when the motorcycle taxi drives several hours a day the risk of being engaged in a crash caused by fatigue increases. The result of the logistic regression analysis showed a non-significant effect of working hours but the descriptive analysis confirmed that extra working hours might play a very important role in the prediction of motorcycle crashes. In general, as working hours increase, the probability of being involved in motorcycle crashes also increases.

5.2. Countermeasures

The proposed countermeasures are based on the main identified causes of motorcycle taxis crashes in the Cok.

Ranking	Factor	Proposed Solution
1	Speeding	- Setting regular and specific campaigns focusing on increasing risk perception and reducing perceived self-efficacy by using on-road posters, TV & Radio and social media - Install speed governors in motorcycle taxis to limit exceeding speed - A risk driving score system to be used by traffic and insurance companies - Install speed cameras with an automatic plates recognition system - Increasing a positive attitude among passengers towards respecting the speed limit - Install physical traffic calming measures
2	Fatigue	- Education and campaigns to both motorcycle owners and drivers - The government should reduce some charges (for cooperatives, high taxes) for motorcyclists as they increase their expenses and push them to work many hours - Perform regular medical check-up
3	Bad behaviors and overtaking	- Education and campaigns on traffic rules, conduct, mindset change and fines - Install a video surveillance (CCTV) system on public roads - Campaigns to Vehicle drivers to respect the right of motorcycles.

4	Poor road condition	- Install traffic signs for motorcycles - Provide well known parkings for motorcycles - Widen road lanes (dedicated physical/painted motorcycle lanes)
5	Age	- Special training for young motorcyclists focusing on increasing risk perception and reducing perceived self-efficacy - Improving the driver-licensing system - Provide a provisionary license for young motorcyclists (18 to 25 years old) and give them a permanent license after analyzing their behavior for a certain period.

5.3. Limitations

- Short time of collecting data: As the research was intended to include many types of participants it was not easy to reach them in the given limited time
- Difficult to get Research Permit: In Rwanda there is a long process of getting a research permit; it requires to apply to National Council for Sciences and Technologies (NCST), where a recommendation letter is given to be used to request information in the targeted institutions. This process is time consuming, as there will be a time to wait for response from NCST and time to get approval from different targeted institutions as well.
- Difficult to meet with stakeholders: The stakeholders seemed to have many other different unscheduled responsibilities, which made it difficult to fix exact time for appointment.
- It was not easy for all motorcyclists to get the time of responding to all the questions of questionnaire as this time was disturbed by the availability of the passengers.
- As it has identified in other different researches, the use of face-to-face questionnaires may influence the response of participants as they have the desire of having positive social image.

5.4. Recommendations

The following recommendations are made considering the results of this thesis.

- To efficiently manage and improve the safety of motorcycle taxis as formal mode of transport, the MININFRA jointly with its stakeholders should reorganize motorcycle cooperatives and assign specific road safety responsibilities to each institution. The responsibility should be defined based on the 5 E'S of road safety improvement (Engineering, Education, Encouragement/Engagement, Enforcement and Evaluation).
- The CoK should conduct other more detailed studies on a big scale to investigate and categorize the causes of motorcycle accidents and other road users in general.
- The campaigns being conducted in CoK should be specific and focused on few targeted causes of motorcycle taxi crashes. And these campaigns should start with the most identified factors, for example speeding, fatigue
- To achieve road safety of motorcycle taxis, there is a need to address other road users specifically cars drivers as many cars drivers consider themselves to own the road.
- As speeding was identified as a main cause of motorcycle taxi crashes, it should be given more attention from all perspectives (infrastructure, behaviour change and enforcement).
- Road safety education in the Cok needs to be framed to educate (regular training) motorcycle taxi drivers to hold accurate perception about their driving skills. By considering these issues, there should be a place to give education and training to motorcycle drivers with a wrong perception about their driving skills.
- Despite conducting more researches on causes and improvement of motorcycle taxi safety, there is a strong need to elaborate an integrated crash data collection system.

Chapter 6. Conclusion

Motorcycle taxis play an important role in public transport of the City of Kigali, as they are fast, provide door-to-door service, easily to pass in congestion, and require less space to park. Despite all these advantages, they are the most dangerous form of public transport used in the City of Kigali. This study has identified the main factors that influence motorcycle taxi crashes in the City of Kigali as speeding, fatigue, risky behaviors, poor road condition and overtaking. The study has found age to be a key factor that influences many risky driving behaviors such as speeding, alcohol and phone usage. The motorcycle ownership has also been identified to have an influence on speeding. Setting regular and specific campaigns, installing speed governors in motorcycle taxis to limit exceeding speed and improving road conditions were proposed as the main countermeasures towards motorcycle taxis safety.

The findings from this research can help the City of Kigali as well as the police to find the key emphasis areas on reducing road crashes caused by motorcycle taxis and achieve the target of improving road safety. As the City of Kigali has obligated the usage of helmets for all motorcycle taxis and users, it is a good indication that it can also address all other factors causing motorcycle crashes.

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Annex

Annex 1. Research Consent Form

Dear Participant,

My name is Esthelyne DUSABE; I am a master student at the University of Hasselt, Belgium in the Transportation Sciences program with specialization in Traffic Safety.

You are invited to participate in a research study about commercial motorcycle safety. The purpose of this study is to identify the main factors influencing the involvement of motorcycle taxis in crashes in Kigali City, Rwanda.

This research is intended to be informative, beneficial and helpful to find out the useful safety countermeasures that could be taken to reduce the commercial motorcycle taxi crashes in Kigali City, Rwanda.

Your participation in this research study is voluntary but highly appreciated. You are free to choose not to participate or to withdraw at any time. The information provided is anonymous and will be treated in strict confidence. The information obtained in the study may be published academically.

Consent

I have read this consent form and have been given the opportunity to ask questions. I give my consent to participate in this research study.

Participant's signature…….Date:……..

Researcher's signature……..Date:……

Annex 2. Questionnaires

1. Commercial Motorcycle Riders Questionnaire

SECTION A: Traffic Regulation

In this section, I would like to ask you for some information regarding your daily business as a commercial motorcycle rider.

1. Have you had any training theory regarding traffic rules?

i. Yes
ii. No

- If yes, for how long?

i. Less than 3 months
ii. 3months- 1 year
iii. More than 1 year

2. Do you have a driving license for riding a motorcycle?

i. Yes
ii. No

3. When did you start riding as a commercial motorcyclist?

i. Less than 1 year ago
ii. 1- 2 years ago
iii. 3- 5 years ago
iv. More than 5 years ago

4. Does your motorcycle have the following items?

i. Indicators
ii. Side mirrors

iii. Light brakes
iv. Lights
v. Horn
vi. Tires in good condition

5. Do you regularly do a technical check of your motorcycle such as fluids (change oil), battery, tires, brakes, etc.?

i. Yes
ii. No

- If yes, how often per year?

……..

6. Does your motorcycle have a GPS for tracking speed?

i. Yes
ii. No

7. Do you have the following protective system?

i. Driver helmet
ii. Reflection jacket
iii. Other (boots, gloves, etc.)
iv. Passenger helmet

8. Do you carry a passenger with heavy/big luggage?

i. Yes, at the same price
ii. Yes, at a higher price
iii. No

9. How many kilometers do you drive by motorcycle taxi per month?

i. Less than 3000
ii. 3000- 5000
iii. 5000-7000
iv. 7000-9000
v. More than 10000

10. Which other transport modes do you possess?

i. Car
ii. Bicycle
iii. Other (specify)…….

Section B: Income generation

In this section, I would like to ask you in detail about your daily activities and how much money you earn as a motorcyclist rider.

1. Do you ride your own commercial motorcycle or does it belong to someone else?

i. Own
ii. Someone else's

1b. How much do you pay to the owner of the motorcycle per month (In case the motorcycle belongs to someone else)?

1. …….

2. Do you have any other income?

i. Yes
ii. No

3. How many days per week do you work to satisfy your family needs?

……

4. How many hours per day do you work to satisfy your family needs?……..

5. How much do you earn per month?

i. Less than 100,000 frw
ii. 100,000-250,000 frw
iii. 250,000-350,000 frw
iv. 350,000-450,000 frw
v. More than 450,000 frw

6. How would you like to work and how much would you like to earn?

i. I would like to work/earn less
ii. I work in average and earn enough
iii. I would like to work more and earn more

Section C: Risk taking behavior of motorcyclist rider

In this section, I would like to ask you in detail about risk taking behaviors

1. Have you ever disobeyed road traffic regulations (e.g. traffic lights, traffic signs, etc.)

i. Never
ii. Rarely
iii. Occasionally
iv. Most of the time

- What kind of traffic regulations do you violate most?

i. Traffic lights
ii. Traffic signs
iii. Zebra crossing
iv. Other (specify)…….

2. How often do you ride at a speed higher than 60 km/h?

i. Never
ii. Rarely
iii. Occasionally
iv. Most of the time
v. Always

3. How often do you disregard speed limit late at night and early morning?

i. Never
ii. Rarely
iii. Occasionally
iv. Most of the time

v. Always

4. How often do you ride a commercial motorcycle after taking some alcohol/drugs?

i. Never
ii. Rarely
iii. Occasionally
iv. Most of the time
v. Always

5. How often do you use a mobile phone while riding a motorcycle?

i. Never
ii. Rarely
iii. Occasionally
iv. Most of the time
v. Always

6. Have you ever got complains from your passenger about the way you drive?

i. Yes
ii. No

- If yes, what kind of complains?

……

7. Do car drivers give you enough space (for overtaking, in a traffic jam, etc.)?

i. Never
ii. Rarely
iii. Occasionally
iv. Most of the time
v. Always

8. Have you followed any traffic safety training?

i) Yes
ii) No

- If yes, what kind of training did you follow?

…….

- How many times?

…….

Section D: Accident involvement

1. Have you ever been involved in any (even less severe) motorcycle accident?

i. Yes
ii. No

- If yes, how many times during the last twelve months?

……..

2. What was the cause of the accident? (Note: In case of several accidents, answer the following questions based on the most severe accident)

i. Over speeding
ii. Overtaking
iii. Using phone
iv. Competing with other riders to get a passenger
v. Reckless
vi. Tires issues
vii. Fatigue
viii. Weather
ix. Poor road condition
x. Others

3. Which objects/road users were involved in the crash?

i. Car
ii. Bus
iii. Truck
iv. Motorcycle
v. Pedestrian
vi. Cyclist
vii. Fixed object (poles, trees, etc.)
viii. Others

4. On which day did the accident occur?

i. Week day: - Day

- Night

ii. Weekend: - Day

- Night

5. Were you alone or you boarded a passenger?

i. Alone
ii. With a passenger

6. How severe was the accident?

i. No injury
ii. Slight injury
iii. Serious injury
iv. Deathly injury

7. Who experienced the severity?

……..

SECTION E: PERSONAL INFORMATION

In this section, I am going to ask you about your identification and background, feel free to answer all my questions.

1. What is your gender?

i. Male
ii. Female

2. How old are you?

.....

3. What is your marital status?

i. Single
ii. Married
iii. Divorced
iv. Others

4. In which District of Kigali City do you live?

i. Kicukiro
ii. Gasabo
iii. Nyarugenge

5. Number of family members that you take care of?

i. Myself
ii. 2
iii. 3
iv. 4
v. More than 4

6. What is your educational background?

i. None
ii. Primary school
iii. High school
iv. Technical school/college
v. University level

2. Passenger Questionnaire

Section A: General Questions

1. How often do you take a commercial motorcycle?

i. Daily
ii. Several times a week
iii. Few times a week
iv. Few times per month
v. Rarely

2. How would you describe the safety level of a motorcycle trip in Kigali City?

i. Very unsafe
ii. Unsafe
iii. Safe
iv. Very safe

3. Have you ever been involved in any (even less severe) motorcycle taxi accident?

v. Yes
vi. No

- If yes, how many times in the last twelve months?

……..

4. What was the cause of the accident? (Note: In case of several accidents, answer the following questions based on the most severe accident)

i. Over speeding
ii. Overtaking
iii. Using phone
iv. Tires already smooth
v. Fatigue
vi. Weather
vii. Poor road condition
viii. Others

5. With what objects/road users?

i. Car
ii. Bus
iii. Truck
iv. Pedestrian
v. Cyclist
vi. Fixed object (poles, trees, etc.)
vii. Others

6. On which day did the accident occur?

iii. Week days: - Day

- Night

iv. Weekends: - Day

- Night

7. How severe was the accident?

i. No injury
ii. Slight
iii. Serious
iv. Death

8. Who experienced the severity? ……

9. What are according to you the most risk taking behaviors of commercial motorcycle riders?

i. Over speeding
ii. Overtaking
iii. Using phone
iv. Competing with other riders to get a motorcycle passenger
v. Drinking and riding
vi. Fatigue
vii. Zigzagging
viii. Violating traffic lights or signs
ix. Others

SECTION B: PERSONAL INFORMATION

In this section, I am going to ask you about your identification and background, feel free to answer all my questions.

1. What is your gender?

i. Male
ii. Female

2. How old are you?

……

3. What is your marital status?

i. Single
ii. Married
iii. Divorced
iv. Others

4. In which District of Kigali City do you live?

i. Kicukiro
ii. Gasabo
iii. Nyarugenge

5. What is your education background?

i. None
ii. Primary school
iii. High school
iv. Technical school/college
v. University level

3. Stakeholders Questionnaire

General Questions

1. Institution name……

2. What is your position?

……..

3. How would you describe the current situation of motorcycle safety in Kigali?
……

4. What is according to you the most common cause of motorcycle accidents in Kigali?
…….

5. Why are motorcyclists involved in risk taking behavior?
……

6. What your company does to further reduce the cost of road crashes? (insurance companies)
……

7. What are the countermeasures that have been implemented by your institution in the last 2 years to reduce motorcycle accidents?
…….

7.1. What has been the impact?

…….

8. What are your futures plans to improve motorcycle safety in Rwanda?

……

Annex.3 Post-Hoc of Multiple Comparisons

Dependent Variable: Phone Use

LSD

(I) Age Categorized	(J) Age Categorized	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Less than 25 years	25-30 years	.777*	.176	.000	.43	1.13
	30-35 years	1.148*	.184	.000	.78	1.51
	More than 35 years	1.664*	.194	.000	1.28	2.05
25-30 years	Less than 25 years	-.777*	.176	.000	-1.13	-.43
	30-35 years	.370*	.158	.020	.06	.68
	More than 35 years	.886*	.169	.000	.55	1.22
30-35 years	Less than 25 years	-1.148*	.184	.000	-1.51	-.78
	25-30 years	-.370*	.158	.020	-.68	-.06
	More than 35 years	.516*	.178	.004	.16	.87
More than 35 years	Less than 25 years	-1.664*	.194	.000	-2.05	-1.28
	25-30 years	-.886*	.169	.000	-1.22	-.55
	30-35 years	-.516*	.178	.004	-.87	-.16

*. The mean difference is significant at the 0.05 level.

Dependent Variable: Alcohol Use

LSD

(I) Age Categorized	(J) Age Categorized	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Less than 25 years	25-30 years	.749*	.084	.000	.58	.92
	30-35 years	1.130*	.088	.000	.96	1.30
	More than 35 years	2.130*	.092	.000	1.95	2.31
25-30 years	Less than 25 years	-.749*	.084	.000	-.92	-.58
	30-35 years	.381*	.075	.000	.23	.53
	More than 35 years	1.381*	.081	.000	1.22	1.54
30-35 years	Less than 25 years	-1.130*	.088	.000	-1.30	-.96
	25-30 years	-.381*	.075	.000	-.53	-.23
	More than 35 years	1.000*	.085	.000	.83	1.17
More than 35 years	Less than 25 years	-2.130*	.092	.000	-2.31	-1.95
	25-30 years	-1.381*	.081	.000	-1.54	-1.22
	30-35 years	-1.000*	.085	.000	-1.17	-.83

*. The mean difference is significant at the 0.05 level.

Dependent Variable: Speeding

LSD

(I) Age Categorized	(J) Age Categorized	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Less than 25 years	25-30 years	.12319	.11899	.303	-.1124	.3588
	30-35 years	.28986*	.12459	.022	.0432	.5365
	More than 35 years	1.20652*	.13130	.000	.9466	1.4665
25-30 years	Less than 25 years	-.12319	.11899	.303	-.3588	.1124
	30-35 years	.16667	.10670	.121	-.0446	.3779
	More than 35 years	1.08333*	.11446	.000	.8567	1.3100
30-35 years	Less than 25 years	-.28986*	.12459	.022	-.5365	-.0432
	25-30 years	-.16667	.10670	.121	-.3779	.0446
	More than 35 years	.91667*	.12028	.000	.6785	1.1548
More than 35 years	Less than 25 years	-1.20652*	.13130	.000	-1.4665	-.9466
	25-30 years	-1.08333*	.11446	.000	-1.3100	-.8567
	30-35 years	-.91667*	.12028	.000	-1.1548	-.6785

*. The mean difference is significant at the 0.05 level.