INFRASTRUCTURE DESIGN ON ROAD SAFETY ALONG OUTERING ROADS IN NAIROBI CITY COUNTY, KENYA

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DECLARATION

The research project is my original work and has not been presented at any other university.

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ABBREVIATIONS AND ACRONYMS

AV: Autonomous Vehicle

KURA: Kenya Urban Roads Authority

NTSA: National Transport and Safety Authority

RTA: Road Traffic Accidents

WHO: World Health Organization

OPERATIONAL DEFINITION OF TERMS

Road safety: The measures and strategies put in place to protect the road users for injuries and death.

Road design: The features and characteristic of the road particularly drainage system, road lighting and road signages in the current study.

ABSTRACT

Urban road accidents have been on the increase across the globe, including in Kenya, with far-reaching social and economic impacts. Various factors contribute to road accidents and the associated effects in the literature. The factors contributing to and influencing road accidents vary from location to location, as informed by the research studies undertaken. Consequently, the current research evaluated road infrastructure design's effects on road safety in Nairobi City County and identify the possible solution to the causes. The research adopted a descriptive research design to answer the research questions. The study's target population are the road users of Outering road in Nairobi's Embakasi region, including drivers, conductors, and passengers, boda-boda operators and pedestrians. The research adopted a stratified and systematic sampling method to identify the sample population, with the sample size being 404 participants. The sample population included 308 passengers and pedestrians, 45 drivers (including boda-boda drivers), 45 conductors, four police officers, 1 KURA official and 1 NTSA official. The specific target group were drivers and conductors of Embassava and the passengers that are transported by the vehicles of the Sacco using the Outering road, as well as boda-boda operators. Semi-structured questionnaires were the primary tool for soliciting data from respondents from the target respondents. Data was analysed through descriptive analysis, correlation analysis, and regression. The study showed that road signage significantly affected road safety, while road drainage and lighting had no significant effect. The predictors accounted for 26.7% of the variance in road safety. The study is particularly relevant to policymakers and practitioners in the transport sector. The findings highlight the need for investments in infrastructure improvements that enhance road safety in Nairobi County. The study also suggests the importance of involving road users in designing and implementing road infrastructure projects.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The transport infrastructure across the globe is considered essential for connecting people to critical goods and services and stimulating economic growth. Even so, a difference in access to transport channels, including road networks, affects access to essential services and loss of job opportunities. According to the World Bank, over 1 billion people live more than two kilometres to an all-weather road, most considered developing countries (World Bank, 2022). Across urban cities, the challenge of adequate transportation and access roads is reported in the fast-growing urban environment. According to Wu et al. (2021), European and Chinese urban environments have implemented good and intensive road designs facilitating the highest accessibility. American cities face the challenge of accessibility to walking and transit ways.

Road transport is dominant in most parts of Africa, including Sub-Saharan Africa. The road network is favoured because the countries are landlocked and cheaper for the local population compared to the other modes of transport (Tchanche, 2019). Even so, the road networks in Africa face many challenges, including a lack of well-developed road infrastructure, poor maintenance, and frequent reported accidents. Despite the challenges, the African governments have put road development investments in place to develop modern road infrastructure and facilitate traffic flow (Zajontz, 2022). However, improving the road infrastructure has not fully eliminated traffic fatalities that impact road safety in Africa, with the fatalities considered an upside trend (Chen, 2010; Jones, et

al., 2020). Consequently, Africa needs to implement road infrastructure development that will improve road safety status on the roads.

Governments worldwide, including Kenya, have worked on upgrading the road infrastructure to facilitate efficient and safe means of transport for people and goods. In Kenya, the government has put in place parastatals and carrier governing bodies such as Kenya Urban Roads Authority (KURA), National Transport and Safety Authority (NTSA), and Kenya National Highways Authority (KENHA) which aim at improving the safe use of roads in the country (Muriithi & Kiiru, 2021; Lolkidianye, 2012). Policies and legislation development and implementation through traffic police have been witnessed in the country. Despite the growth in road infrastructure and its management, road safety has remained a significant challenge faced by road users and governments in the country and across the globe.

Risk factors for people's physical and mental health include road safety. Road traffic accidents are the world's most significant cause of mortality for children and young adults aged 5 to 29, according to the World Health Organization (WHO) (2018). Despite numerous attempts to lower the frequency of road accidents, the number keeps increasing. Policymakers may want to consider boosting metrics for community education and traffic enforcement while also considering road infrastructure upgrades to raise drivers' fear of being stopped (Rasch et al., 2022; Fanai & Mohammadnezhad, 2022). Even so, road designs are a significant aspect that could influence users' behaviours and adherence to road traffic rules and regulations. Consequently, poor road design and other factors contribute to increased road carnage in the urban environment.

The moderation of road safety In urban centres worldwide, including Nairobi, can be significantly influenced by road infrastructure design. All users' conduct on the road is moderated by how the road network is designed, which is believed to affect traffic crash incidence (Mohan, et al., 2017). As a result, road infrastructure design could assist the traffic department in establishing and enforcing laws on the road as well as speed limits that are appropriate to the function of routes.

Tragically, many Kenyans, like people in other countries, have lost their lives or been severely injured or disabled in traffic accidents that could have been prevented with better traffic education, attitudes toward law enforcement, an awareness of potential dangers, and maintenance of roadways (Rasch et al., 2022). Road users, including pedestrians, cyclists, motorists, to drivers of vehicles like buses, vans, and lorries, are at risk of being involved in a traffic accident whenever they venture onto the roads. However, pedestrians, cyclists, and motorcyclists, especially those in developing countries, are at risk. A standard theory is that individual users are the primary cause of traffic accidents (Ahmed et al., 2022; WHO, 2021). Over ninety-five per cent of all car accidents may be attributed to human behaviour (Borhan et al., 2018). Most of the victims are between the ages of 15 and 44, and they are a direct result of irresponsible, dangerous driving conduct and violations of traffic laws that they exhibit. While both sexes have a similar risk assessment, females are more likely to focus on avoiding danger, while males are more likely to attempt to manoeuvre around it (Znajmiecka-Sikora & Salagacka, 2022; WHO, 2021).

Globally, a higher rate of fatalities occurs on urban streets than on rural roads, according to research published in 2022 by the AAA Foundation for Traffic Safety. Most of the United

States' 4 million miles of public-access highways are in rural regions. At the same time, "a disproportionate percentage of speeding-related deaths" occur on metropolitan roadways due to poor regard for traffic laws and enforcing officers. As such, 19,595 individual lives have been lost in American cities, whereas just 16,340 have died in rural areas. In addition, as urban populations and car miles grow, so will the rising trend in projected crashes. As a result, automobiles, pedestrians, and bicycles that share the road on many city streets need to develop a positive attitude towards adherence to road rules and road design that cater to the user need of the different types of road users.

Because 80% of Europeans live in urban areas, road safety is a primary societal concern. The excessive use of private cars is primarily to blame for the congestion, noise pollution, and road accidents that plague European cities. According to Attwell, Glase and McFadden (2011), road use and safety strategies are greatly influenced by how communities manage their transportation systems about their overall health and safety goals and how they are balanced with economic, social, and environmental considerations. Motorized transportation has marked a shift away from walking, biking, and public transit in favour of modes of transportation that have comparatively higher economic, environmental, and health costs for society (Rasch et al., 2022).

The number of individuals killed in road accidents within the European Union decreased by 53% between 2001 and 2016 owing to the interventions set in the E.U. white paper 2001, which greatly incorporated the public views of road users. However, significant variations exist from one country or area to another, indicating varying public perceptions of road safety and related accidents. In addition, the number of lives lost on the world's roads is affected by geographical (population size, density of infrastructure) and

socioeconomic factors (level of education, occupations, transit and tourist traffic, characteristics of the vehicle stock, behavioural aspects, etc.). The Baltic States, Germany, Spain, Luxembourg, Slovenia, and Sweden all had 50% or more reductions because of the positive public opinion on intervening safety factors. In contrast, the declines in the Netherlands, Finland, and the United Kingdom were not as dramatic, despite those nations' long-standing status as some of the world's safest.

In most cases, the number of people killed or injured in automobile accidents is decreasing due to the high public regard for active safety features in modern passenger vehicles. Road traffic has gotten much safer, notably in Greece, Spain, Cyprus, Latvia, Lithuania, Luxembourg, and Portugal, despite a more extensive vehicle fleet and usually more excellent traffic performance, thanks to a positive attitude towards road safety and rules (Meesmann et al., 2018).

Regionally, perilous driving ways of behaving represent up to 90% of accidents in Nigeria, including improper speeding and speed-related factors, an absence of comprehension of traffic guidelines, including street signs and markings, drink driving, hazardous driving, driver exhaustion, and unseemly surpassing (Obafemi &Obafemi, 2021). Studies have found links between human, mechanical, and environmental factors, and traffic accidents (Odufuwa et al., 2017). This study focuses on the human attitude, which encompasses a wide range of characteristics of road users, such as age, medical fitness, mental health, alcohol consumption, and educational level.

Several risk factors for road traffic accidents have been identified by research. Some of these require driver education, and one way to start this process is to look at people's

perceptions of these risk factors to see where they are currently at. Poor road conditions, poor urban planning, and increased traffic are the leading causes of city accidents. The linked road safety standards that reduce road accidents include not exceeding the speed limit, not drinking, and driving, and not using a cell phone while driving. Public perception of these metrics forms the basis for program design and implementation. Therefore, an accurate database and reporting of these RTA statistics are also vital in informing and influencing public opinion on the causes of RTAs. The research sought to assess the risk factors with the road users' view and experience.

The studies of road users' behaviour try to track actual road usage behaviour and gauge perceptions of generally accepted safety measures. It is usually acknowledged that human factors play a role in most traffic accidents if not all. The primary goal of the current study is to explain how road infrastructure design affects traffic safety and accidents in urban environments.

1.2 Statement of the Problem

Road safety is essential to social and economic development in Africa and worldwide(Lombard & Coetzer, 2007). Despite the improvement of road development across the world and in Africa, deterioration of road safety is on the upward trend, with its ripple effect on society and economic development. The number of road traffic accidents is one measure of road safety that continues to rise at an alarming rate, particularly in low- and middle-income countries, despite numerous efforts by the government and relevant stakeholders to put in place measures to reduce road traffic accidents and improve overall road safety (WHO, 2021). Most of the fatalities from road traffic accidents (RTAs) occur in African nations, where the death rate is highest (25–34

per cent) (Muguro et al., 2022). Kenya's death rate from RTA is estimated by the World Health Organization (2021) to be 28 per quota.

Additionally, since 2015, the number of fatalities and injuries in the nation has increased by 26% and 46.5%, respectively. The lack of complete RTA data collection prevents the government from planning and making necessary policy changes to remediate the problem. Numerous national transport and safety authority (NTSA) reports providing insight into the RTA trends, procedures, and traffic safety. Furthermore, as reported by different publications and shown in efforts to overhaul lax enforcement, the efficiency and reach of the initiatives and laws implemented by competent agencies have been patchy (Hope, 2018). There is also literature from different parts of the world that have evaluated road carnage to identify the various facilitating factors. The leading causes are human factors related to social psychological issues, road design, and law enforcement factors. Road infrastructure design has been at the centre of road safety. There has been no clear conclusion or recommendation on road infrastructure design's role in urban road safety and how this could be leveraged to enhance security in the future. As such, this study investigated the influencing aspects of road infrastructure design on urban road safety in Nairobi County.

Road design is an essential aspect of road infrastructure as it enhances road safety and enables accessibility and ease of use of the road facility. Even so, poor road design is considered detrimental to road users' safety as it influences the user's behaviour and exposure to the risk of accidents. The users' road safety consequently depends on how road projects are implemented and operated. In literature, road infrastructure design-related issues have been identified as contributing to increased road carnage in

developing countries (Ezra, 2019). Still, none has undertaken an in-depth evaluation of the status of Nairobi County after the significant road upgrades.

Moreover, road infrastructure design has been identified as a solution to improving road safety (Hakkert & Gitelman, 2014; Ahmed, 2013), although their implementations in road infrastructure have been assessed in developing countries. Consequently, there is a need for an in-depth evaluation of the current road infrastructure design contribution to road safety in Kenya and the possible solution that can be put forward to overcome the negative aspects, if any. However, the influences of modern road design projects on road safety have not been evaluated in-depth to inform the current and future road designs.

Road accidents in Kenya are considered to impact the country's social and economic development. Consequently, this is associated with the loss of skilled labour personnel and bread winners in families, which has a ripple effect on the economy and society. The long-term cost of caring for injured people also strains the healthcare sector, which is already over burden. The government also incur a charge in road repair of roads from road carnage that compound the costly impact of road accident on the country's economy. In literature, road infrastructure design-related issues have been identified as contributing to the increase in road carnage in developing countries. Still, none has undertaken an in-depth evaluation of the status of Nairobi County after the significant road upgrades. Consequently, there is a need for an in-depth review of the existing road infrastructure design contribution to road carnage and road safety in Kenya and the possible solution that can be put forward to overcome the negative aspects, if any.

1.3 Research Objectives

The specific objectives of the study were:

i. To examine the influence of drainage systems on road safety in Nairobi County.
ii. To establish the effects of lighting on road safety in Nairobi County.
iii. To assess the effects of road signage on road safety in Nairobi County.

1.4 Research Questions

i. How does the drainage system affect road safety in Nairobi County?
ii. How does lighting affect increase road carnage in Nairobi County?
iii. What are the effects of signage on road safety in Nairobi County?

1.5 Assumptions

The research had several assumptions in the data collection and reporting. The study will assume that the collected feedback will represent the larger population of Nairobi County. Secondly, the researcher will assume that the respondents surveyed will provide accurate feedback.

1.6 Significance and Justification of the Study

Road safety is an essential aspect of consideration increase in the number of road users, and vehicles on the road. Road safety issues such as road accidents has ripple effect to the society and the country at large, hence an important area to be evaluated, with focus in improving road user safety and lowering the social and economic effects associated with poor road safety. One aspect of the changing road infrastructure is development of modern road design that aims at improving road use efficiency through accommodating the ever-increasing number of road users. Consequently, it is important to evaluate the

road design aspect in relation to safety to inform on continuous road design improvement. Therefore, choice of road design in the study was due to its continuous evolving to accommodate travel needs and its significant role to road accidents.

The research also focusses on Nairobi County, as it the urban environment that consist modern developed road infrastructure such Nairobi express way, Thika superhighway, Eastern bypass, Outering road among others. The traffic in Nairobi is also high compared to other cities within the country; hence require more sophisticated road design to cater for the need. In addition, there is minimal research done on the modern design road in Nairobi which offers opportunity for undertaking the research. The research also narrowed down to Outering road, which is considered by NTSA as the most unsafe road due to the number of accidents reported on the road despite the road being 13Km long, and a dual carriage. Therefore, it is of interest to evaluate if road design aspect of the road contributed to the accidents reported.

Undertaking the study had various significance. First, the study is crucial in providing information to the stakeholders and users of roads in Kenya. This study provides an insight on the effects of the road infrastructure design aspects on the road safety in Nairobi. The information is crucial for decision maker and policy makers on making informed decisions associated with the road infrastructure design. The study might also contribute to the government bodies such as NTSA on identification of risk factors associated with the road infrastructure design and this could lower in the long term the cost associated with road carnage. The research might also contribute to the body of knowledge by providing appropriate empirical research of road infrastructure design

aspects on road safety in Kenya. It might also contribute by recommending research gap that require further research in relation to the road infrastructure design in Kenya.

1.7 Scope and limitations

The research was limited to Nairobi County with focus to the road users in Nairobi County. The study was also be limited to determining the factors that contribute to the increase in accidents in Nairobi County. Data was collected on a sample location rather than the entire road network, so the accuracy of the information depends on the accuracy of the surveyed population.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The chapter provides a review of theoretical and empirical works of other authors in relation to factors influencing urban road safety. The first section contains an evaluation of the factors influencing the road safety, followed by theoretic framework of the research, the conceptual framework. Finally, summary of the literature and empirical gaps is provided.

2.2 Review of Related Empirical Review

2.2.1 Road Safety

Study of road safety utilizes risk, exposure, and accidents as the base for the definition of road safety (Hakkert, et al., 2002). Traffic accident and the associated impact are considered as the main measure of road safety in the roads. The probability or the chances of being killed through the road accident hence holistically represents the road safety for a, road, region, or country (Wegman, 2017).

Traffic accident refers to an injury that involves a vehicle in which one person has been killed or injured. Road carnage on the other hand refers to accidents involving vehicles where many people are killed or succumb to the injuries. Joewono et al. (2015) conducted research in Indonesia to determine the root causes and categories of motorcycle traffic offences which impacts road safety of users. The survey study used structural equation modelling to evaluate the variables affecting motorcyclists to commit traffic offences and their causal links, focusing on three major cities: Bandung, Yogyakarta, and Surabaya. Comparison of the three cities analysed uncovered parallels and contrasts in the relative

importance of many elements hypothesized to contribute to traffic safety. Motorcyclists' blatant disregard for traffic laws may be attributable, in part, to the poor engineering and upkeep of our roads. As such, public perception was determined by both the road design and individual behavioural patterns. Based on the study's findings, drivers' and passengers' attitudes account for most road fatalities caused by factors like speeding, drunk driving, distractions like using a smartphone or tablet, running red lights, and failing to wear safety equipment like helmets by motorcyclists. Therefore, sustainable transportation and policies concerning budgetary and economic problems, spatial planning, and investment in road infrastructure should all prioritize road safety. In addition, raising public awareness about the need of following traffic regulations is essential for enhancing of the road safety in roads.

There are other studies that have undertaken in-depth research on the road safety on the roads. The driving style of the drivers such as speeding is a factor that increases road safety risks on the road (Sagberg, et al., 2015; Elvik, et al., 2019). There are also human factors that are considered to impact on the road safety that includes fatigue of the drive, risky overtaking, inexperience of drivers, substance abuse such as use of alcohol, violation of traffic rules and lack of attention while on the road (Bucsuházy, et al., 2020; Zhang, et al., 2019).

Another study conducted by Holmgren et al. (2020) on road safety revealed that the bicycle is an important mode of urban transportation in Sweden due to its numerous benefits. However, bicyclists are more defenceless than clients of other vehicle modes, and the quantity of bike related wounds and fatalities are excessively high. The user's perceptions of the associated benefits and safety influence the choice to use a bicycle as a

mode of transportation. To reduce related traffic fatalities and enhance road safety and policies, the local government of Lund City carried out research to support the identification of the locations of so-called bicycle impediments places where bicyclists perceive unsafe conditions in an urban traffic network.

Moody, Bailey, and Zhao (2020) used multilevel structural equation modelling to analyse the divergent views on A.V. road safety held by 33,958 people from 51 nations. Findings showed that on an interpersonal basis, young men's opinions on the present safety of A.V.s were more positive, and they expected fewer years to pass before A.V.s were safe enough to use. Given that young men are more prone to engage in unsafe driving behaviour, it is possible that the safety advantages of A.V.S will become more apparent more quickly if they are well received by this demographic. People in large cities who are gainfully employed and have greater incomes and levels of education likewise anticipate a shorter time frame until A.V.s may be used safely. After accounting for differences between individuals, the multilevel model isolates national-level impacts. Greater knowledge of A.V.s is associated with greater pessimism about the current and future safety of A.V.s in developed nations with higher rates of motorization and lower road mortality rates. It is anticipated that fewer years will pass before A.V.s are considered safe for use by citizens of poorer countries, who face more serious road safety issues, particularly those involving 2- and 3-wheeled vehicles. The association between higher A.V. safety perception among risk-taking road users, in developing nations, and the sociodemographic groups and geographic locations having the largest road safety difficulties and most in need of improvement presents an opportunity to close the worldwide road safety gap. Public perception therefore is critical in the design of A.V.s.

Campaigns in several nations try to change people's perspectives about driving to save lives and improve the road safety (Faus, 2021). However, the overall number of traffic accidents has not decreased in tandem with the decline in deaths. However little, events continue to be a major issue. One possible rationalization for this observation is called "attribution mistake." Most motorists falsely assume they have a lower accident risk than other drivers (Horvath, Lewis, & Watson, 2012). Current initiatives aimed at improving road safety don't do much to address this issue since they emphasize broad, generalized data with little relevance to individual drivers' experiences. Reports on the location and causes of traffic accidents in a Scottish city were developed to demonstrate the public how important they are in changing people's minds about problem areas (Buchanan, 2015). The goal of the research is to find out whether people's perceptions of danger change because of reading RTA reports and database data.

Overall, the road safety studies have identified its significance in the different part of the globe and the push to improve it. There are many factors that impacts road safety with research identify present and future measures to limit the contributing factors.

2.2.2 Road design

According to Vorko-Jović, et al. (2006), the road design features were identified to contribute to road safety. The study identified that the type of road surface put in pace has effect on the accident and fatalities, hence impacting the road safety. Hammad, et al. (2019) identified that the road condition is made worse by the weather condition such as high temperature and rainfall which increases the risks of having road accidents. Mutune (2017) evaluated the factors that increase incidents of road accidents focusing on Black spot along Mombasa-Malaba Road. The study identified that the road surface condition

influenced the speeding, driver manoeuvre and traffic flow along the road which increases risk of accidents hence lower road safety. Drivers that are not informed about the surface condition could easily cause accidents. The study also recognized the road design such as curving section and T-junctions along the road report higher accident incidents especially when the driver over speeds. The traffic design influence traffic flow, speed, and safety on the road (Mutune, et al., 2017).

Porcu et al. (2020) did a study to assess the danger to road safety posed by public transit buses while considering parameters such as frequency, severity, and exposure in a single function. A case study methodology was utilized to determine the risk frequency and severity using data from 3,457 bus incidents provided by a large Italian bus operator. The findings indicated that the risk bus accident function ranked each route's safety performance. The function was used to construct a road traffic safety management system for bus transit operators who were interested in the estimation of accident risk on routes, the monitoring of safety performance, and the certification procedure in accordance with current safety regulations. As such, the database information provided in-depth understanding of the susceptible routes and bus operators to traffic fatalities, thus influencing public opinion regarding the same. As such, accident database generates relevant implications for programming of safety and management guidelines and protocols, as well as informing the perspectives of bus operators and passengers.

Due to population pressure and business opportunities, linear communities are common along metropolitan roadways in emerging countries. These settlements have altered the public's view of traffic fatalities by inspiring a fundamentally new approach to street design, traffic flow, and road safety. Additionally, the shared space is a roadway design

strategy that reduces distinctions between automobiles and people. Using this as a foundation, a comprehensive review by Moody & Melia (2014) regarding shared space schemes by the national guidance to local highway authorities in the U.K. revealed that most pedestrians deviated from their desired lines, generally gave way to vehicles, and felt safer under the original road layout. To reduce traffic-related accidents, vigilance was therefore required while adopting shared space systems, especially in areas with heavy traffic volumes. With the help of a set of guiding principles called shared space, it is possible to successfully integrate movement with the other civic purpose of streets and urban areas. The increased interaction between people and the road and the shared space on the road corridors may raise the danger of accidents on the roads, particularly in urban settings.

The road infrastructure design is considered to influence the road safety in various ways. The influence is associated with negative road engineering aspects such the roadside condition, horizontal curvature along the roadway, and sight distance to facilitate the driver to manoeuvre to prevent accidents (Ahmed, 2013). Consequently, the road characteristics are associated with road safety outcomes (Marshall & Garrick, 2011) although the underlying aspects that lead to the role of road design on safety has not been fully evaluated (Marshall & Garrick, 2010). There is also mixed reaction of whether the road design factors such as road curvature contribute of do not contribute to road safety (Wang, et al., 2013).

Despite the in-depth analysis of the analysis of the road design factors influencing road accidents, there lack of assessment of the road design in capital cities and how this could contribute to road safety and accidents. The road design of Nairobi has also not been

evaluated in depth to identify how it could contribute to accidents that are reported. Hence, there is need to undertake further research on assessment of the road design factors and how they contribute to road accidents in the context of Kenya and particularly in Nairobi County with its unique setup.

2.2.2.1 Drainage systems and road safety

The road safety is associated with sufficient drainage characteristics on the road (Alber, et al., 2020). The road surface drainage is influenced by the road geometric design and porosity of the material used (Alber, et al., 2020). Poor drainage on the road is associated to premature deterioration of the road exposing it to unsafe condition for the road users. Water also is considered to increasingly act as lubricants of the highway that could increase the probability of losing of tires grip leading to accidents (Mukherjee, 2014). Despite the importance of the road drainage system, it has been a challenging task to obtain sufficient road drainage (Aranda, et al., 2021). It is expected that road design to factor in effective method of fast training storm water from the road (Wang, et al., 2020). Consequently, it is crucial to evaluate how the road drainage influences road safety, and factors to consider in drainage to reduce accidents on the roads.

The drainage channels should be installed in an effective manner to handle expected stormwater flows and reduce the possibility of traffic hazards, the channels should be situated and shaped accordingly. to avoid ponding and to stop water from spreading onto the traffic lanes. Only a small quantity of rain should seep into the pavement layers because road surfacing materials have been designed to be effectively impermeable (Mukherjee, 2014). To account for the rapid changes in land use and the effects of climate change in the urban context, current technology such as hydrological modelling is

considered essential (Kalantari, et al., 2014). Consequently, it is considered crucial for road drainage design to consider all factors that could impact its functionality such as changes in land use, climate change, slope along the road design and expected quantity of water to be drained (Jiménez-U, et al., 2022; Awwad, 2021).

2.2.2.2 Lighting and road safety

Lighting on the road is considered crucial to facilitate road users to effectively utilize the roads. Consequently, effective road design is expected to incorporate road lighting design. Increase in road light luminance is associated with decrease in the percentage of night crashes in the urban environment (Jackett & Frith, 2013). Therefore, lighting is considered to have positive impact to road safety although the role is highly debatable among the researchers (Mayeur, et al., 2010). In addition, there is a road lighting threshold where road safety is high, and excess of which the illuminance could lead to the roads not to be safe (Xu, et al., 2018). The bright lighting in urban roads is considered that it helps in enabling users to see and use the road at night, but it is also considered it can compromise safety of the users (Marchant, et al., 2020). The road lighting designs at road intersection are considered to influence occurrence or lack of occurrence of accidents (Bullough, et al., 2013).

According to Jackett and Frith (2013) extension of efforts to increase understanding of the advantages of intersection illumination, lighting of rural roads, and lighting of state highways for safety is very crucial. New technology guidelines can be created to help with decisions about when and where to use adaptive LED technology to increase or decrease illumination levels. Additionally, a thorough assessment of the advantages of employing white (wide spectrum) light for safety might be included. Moreover, there is

need for implementation of user centred lighting design that focus in meeting the road users' needs (Atıcı, et al., 2011). Raynham, (2004), identified that lighting is crucial for drivers and pedestrians on the road and is crucial for further research to be undertaken to better understand road lighting design.

There are other studies that have been undertaken that have negated the significance of road lighting on road user's safety. The road lighting has been considered to cause accidents as the vehicle collides with the road lights especially at night (Wanvik, 2009). Brighter lighting is considered to impact the vision of the drivers on the road which could contribute to further risk of accidents and injuries on the roads (Marchant, et al., 2020). Therefore, it is crucial that additional research be done to assess the impact of lighting on the road safety of the urban upgraded highways. The examination of road safety features of street lighting in various regions of the world. Obeidat, et al. (2022) confirmed that putting in place lighting resulting to significant decrease in the number of accidents that is reported on the road using the case study of the roads in Jordan.

Armas and Laugis (2007) in their research identified that various aspect of road lighting design needs to be considered as they impact the safety of the road users. The aspect considered included the light luminance, angle of the light source in relation to line of sight, and light glares (Armas & Laugis, 2007). Other important aspect of road lighting design identified includes light brightness quality, lighting uniformity, glare restriction, lighting the surrounding and lighting specific road section such as pedestrian crossing, and high traffic area (Van Bommel, 2014). Wood (2020) also points the importance of sufficient lighting and visibility on the road for the other road user to be visible and increase their safety when using the road.

2.2.2.3 Signage and road safety

The road signages are crucial in offering of road users' information while using the roads. Effective use of the road signages are crucial in improving the road use safety. Even so, the effectiveness of the road signs is dependent on their recognition by users, sufficiency of information provided, adequacy is size, location of the signs, accuracy of information, frequency of the signs, and the size of the city that signs are used (Choi & Chong, 2022). Traffic sign information volume must be moderate to ensure sufficient and prevent overload of users that can result in road safety risk due to fixation duration (Han, et al., 2022).

The road signage is considered to influence the safety of the road. The important aspect of signage is comprehension for the signs and the amount of information availed relevant to the road users (Kaplan, et al., 2018). More personalized road signages that meet the road users need is crucial in enhancing of road safety on the road (Kaplan, et al., 2018). Provision of real time guidance information for the different road situation is considered a step of enhancing road safety on the roads. Even so, it is recommended that further research of developing safe road guidance services bases on sign and assessing direct causal relationship between road safety and road signages (Choi & Chong, 2022).

One of the contributing factors resulting to accidents in lack of the road users paying attention to information provided by marking and signages on the road (Sundfør, et al., 2019). The road signages and marking are required to be visible, large and be able to communicate the required information to the road users and influence their behaviour (Babić, et al., 2020). It was also confirmed by Vignali, et al. (2019) that the visibility of

the road sign and the attention paid to the different sign influence the driver behaviour and could lead to unsafe road use.

2.3 Theoretic framework

There are various theories that have been put forward, helping in evaluating the road accidents and associated causing factors. This section is going to discuss this theory that as a basis of interpretation and discussion of the study findings.

2.3.1 Domino Theory

The domino theory is one of the accident causation theories that aim to identify the cause of accident and focus on elimination of the cause. The first version of the theory was put forward by Herbert William Heinrich in 1931. The theory posits that accidents are as a result unsafe act relating to human factors and the unsafe environmental factors (Sidek, et al., 2014). The theory provides a basis of evaluating the road accidents by evaluating the various environmental factor that could contribute to unsafe road that could lead to accidents (Mwamba, et al., 2022). Consequently, the theory provided an opportunity of identifying the lighting, drainage and signages aspects that can lead to unsafe roads and recommend elimination of the causal factors to improve road safety.

2.3.2 Human factor theory

The human factor theory (HFT) is another theory that helps explain accident causation as it relates to human factors. The theory posits that chain of activities associated with human error result into an accident. The human factors are categorized in to three in the theory that is inappropriate activities, inappropriate response, and overload. In appropriate respond is related to ignoring rules and safeguards and recognizing risk or

hazards and not acting. Overload on the other hand is associated with errors associated with environmental factors such as distraction, situational factors such as inappropriate labelling and internal factors that associated with personal stress, individual related aspects (Yılmaz & Turan, 2022). Qiao et al. (2020) utilized HFT to assess the human factors that result to accidents and found the theory feasible in evaluating human related causes to accidents. Consequently, the theory states that when road infrastructure is improved, people tend to compensate for this improvement by taking more risks. For example, when a road is widened, drivers may choose to drive at a faster speed than before, thus increasing the risk of an accident. Therefore, it is important for research on the effects of road infrastructure design on road safety to consider how drivers may be compensating for improvements in infrastructure when making decisions about their driving behaviour. the theory was crucial in evaluating the human related factors associated with urban carnage in Kenya. Therefore, the theory contributed to evaluating if road lighting, drainage and signages could influence the behaviour of the road uses resulting in increase in accidents and reduction of the road safety.

2.4 Conceptual Framework

The section below captures the conceptual framework of the study, identifying both the dependent and the independent variable.

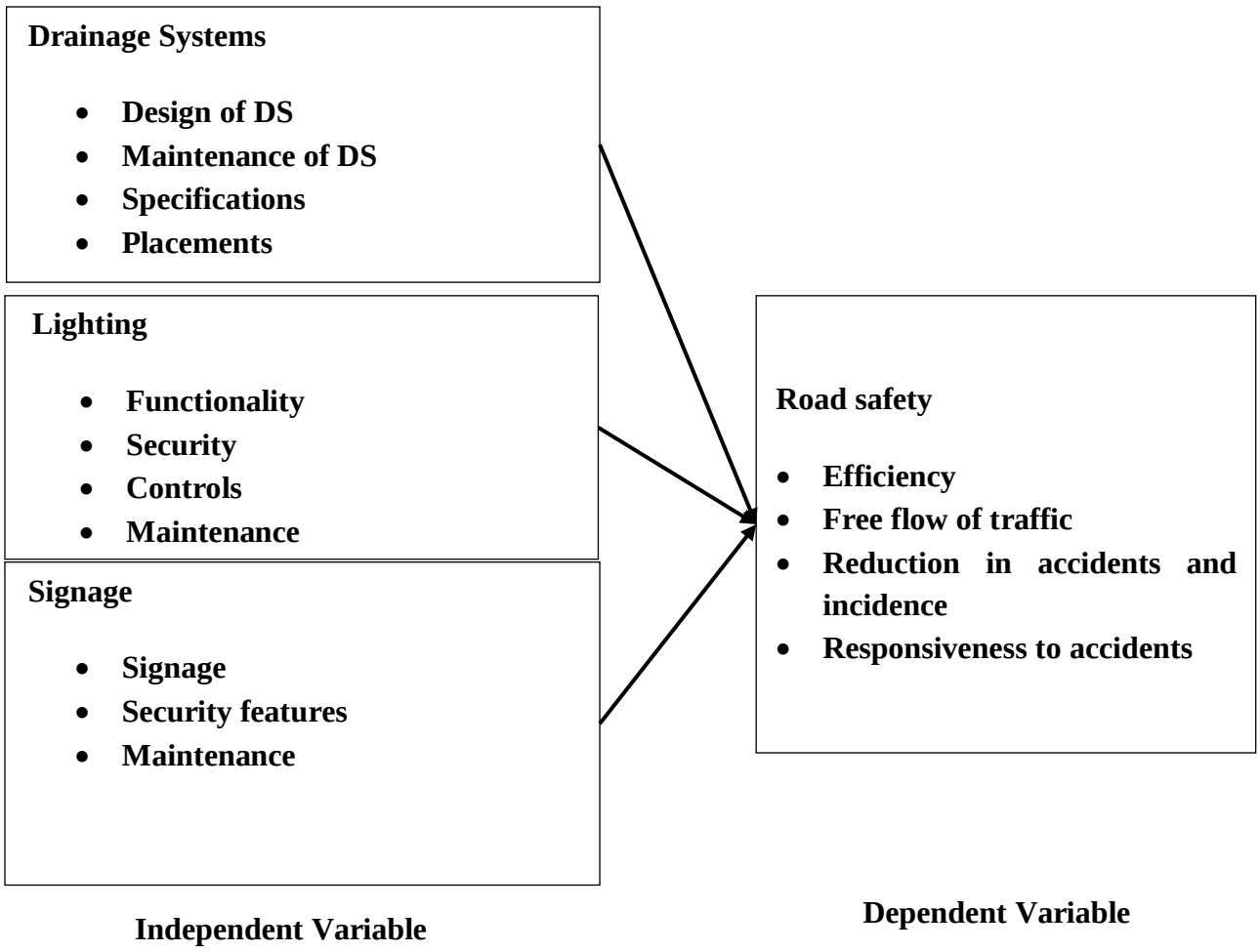

Figure 2.1: Conceptual Framework

Source: Researcher (2021)

2.5 Summary and research gap

There are literature evaluating road safety from the association with road infrastructure design that is signages, lighting and drainage system. The road drainage system was important in road safety by ensuring there was no stagnation of water in the driveway. Even so, there was minimum information available on the effectiveness of road drainage system in the context of Kenyan roads. For road lighting, the different road factors such as light luminance, lighting design and lighting location were important contributors to road safety. Even so, there was a gap on the lighting design effectiveness in the context of

developing countries and in Kenya on road safety. Additionally, there were some literatures that had contradicting findings, for instance Jackett and Frith (2013) identifying importance of laminating light on safety while Marchant, et al. (2020) identified increasing lighting luminance lead in increase in accidents. Road signages were identified to add to provision of information to road user to enhance their safety. Even so, the characteristics of the road signages such as size, position, clarity of information, and visibility to road users was considered to vital for road safety and can be unique for different roads. Consequently, evaluating appropriateness of road signages in each road due unique environment is crucial and are for further research.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter details the approach of research that the author intends to use for the thesis. The section details the data collection method, data analysis, research design and philosophy, and ethical consideration. In addition, the aspects of pilot study, operationalization of the research variables as well as data processing and analysis are discussed.

3.2 Research Design

A research design aims to maximize the "Validity of the findings" by "planning, structuring, and carrying out" the research. It is merely regarded as the researcher's plan for carrying out the research (Cooper & Schindler, 2007). Correlation, explanatory, and descriptive study designs are the most popular types. The current study adopted descriptive research design. A descriptive research design gives an exhaustive description of all the variables being studied. The descriptive research design allowed an adequate description of all the elements under study pertaining to effects of fatalities reports, database, and linear settlements on the public perception regarding causes of road fatalities in urban areas.

3.3 Measurement of Variables

The study had four variables namely road safety, road drainages system, road lighting, and road signages. These variables were measured as outlined in Table 3.1 below.

Table 3.1: Analysis of variables

Variable	Indicators	Measurement Scale
Road Safety	Frequency of road accidents Severity of road accidents Compliance with traffic rules Perception of road safety Awareness of road safety measures	Ordinal/Likert scale
Road Drainage	Effectiveness of drainage channels Efficiency of road surface material Maintenance of drainage systems Perception of system adequacy Impact on water accumulation hazards	Ordinal/Likert scale
Road Lighting	Adequacy of road lighting Uniformity of lighting distribution Presence and positioning of lights Perception of lighting impact Maintenance, and functionality	Ordinal/Likert scale
Road Signage	Visibility and legibility of signs Clarity and accuracy of information Placement and positioning of signs Frequency and density of signage Perception of signage effectiveness	Ordinal/Likert scale

Source: Researcher (2021)

3.4 Location of study

The research was undertaken in Nairobi County in Kenya targeting of the road users along the areas were Outer Ring Road cuts across. The specific focus was users of Outering road as it is considered the leading road with highest road accidents and the associated fatalities.

3.5 Target Population

The target population refers to the population that is considered to have the information needed to answer the research question. This is the population of interest to the researcher which contains all the elements that the researcher is interested in and thus can draw conclusions adequately about the universe (Mugenda, 2003). The researcher targets all the road users in Nairobi County, using the Outering road. The highway was chosen because it recorded the highest number of incidences of traffic fatalities (NTSA, 2021).

The different road users were considered on the road as part of the sources of information to facilitate answering of the research question. The target users for questionnaire survey were Embassava Sacco Drivers that work along the Outering road, and commuters that uses the Outering road. There were also questionnaire guided interviews with key informants in Outering road that include traffic police, Kenya Urban Roads Authority (KURA) and NTSA officials.

3.6 Sampling Techniques and Sample size

3.6.1 Sampling Techniques

The sampling strategy is considered as an objective method adopted to acquire sample population that accurately represents the larger population and allow generalization of the research finding. Due to the high cost and lengthy nature of populace-wide coverage, researchers usually settle on a suitable sample in drawing inferences from target populations especially where the population is diverse and has numerous elements.

Due to complexity of the road users and the need for all the user's categories to be considered in the study, a combination of stratified and systematic random sampling was

adopted in the study. The stratification was based on the road user's category that include pedestrians, drivers (public and private vehicles), drivers, and traffic officers. A systematic random sampling technique was used under each stratum to facilitate non-bias selection of the participants under each of the category. Cooper and Schindler (2006) define systematic random sampling as a probability sampling technique in which a random sample is chosen from a bigger population with a fixed periodic interval. Calculating the sampling interval involves multiplying the population size by the desired sample size to arrive at the predetermined periodic interval.

3.6.2 Sample size

The sample size of study represents the number of participants that are targeted to be incorporated in the study. For Embassava Sacco Drivers, consultation with the management representative, there are approximately 450 drivers that work along the Outering road considering conductors are also qualified drivers. For the passengers, for the Sacco alone it is 450 vehicle that use the Outering road, and each carry 32 passengers and makes 4 to 5 trips, leading to approximately 72,000 passengers using the Outering road each day. The users of roads users from the evaluation are over 72000. The drivers and Conductors under the Embassava Sacco per day is 450 drivers and 450 conductors like the number of vehicles operating on the road, and the total target population was at least 72900 users.

Slovin's formula provides an opportunity of determining the sample population from the known population sample. The formula of the method is given by:

$n= N/(1+N\varepsilon^2)$ where n is the sample, N is the population size and ε is the margin of error.

The current research aims to work at 95% confidence interval hence margin of error of. 0.05,

For road users (passengers, drivers, and Conductors), the sample size was:

$$n = 72900/(1 + 72900 * 0.052)$$

$$n = 398$$

The target ration for the interview was 45 drivers/boda-boda drivers (10% of drivers), 45 conductors (10% of conductors) and 308 passengers and pedestrians. For the key informants, there was at least four traffic police officers that was interviewed and was engaged from their place of work to book for interviewing time. There was one KURA and one NTSA officials that was included in the key informant group.

3.7 Research Instruments

A Semi Structured questionnaire was utilized to gather information from the study's intended sample for the public opinion survey. It contained both open and close ended questions. When gauging traffic hazards and dangers, public perception can be quite instructive. There was four distinct parts to this survey. Participants' demographic information (such as their age, gender, occupation, and accident experiences) was collected in Section A. The second section of the questionnaire capture the user's perception on the causes of road carnage. The last section of the questionnaire was the user's perception on the strategies that can be adopted to reduce road carnage in urban roads. For the key informants, interview schedule was adopted in collecting of the required information.

3.8 Piloting study

The research instrument and the methodology that was adopted in the study was exposed to pilot test. The pilot test was undertaken in selected urban roads in the outskirts of Nairobi urban environment which was not in the final study scope. The feedback from the questionnaire survey facilitated improvement of the questions in the questionnaire to ensure the information gathered in reliable and can help in accurately assessing the research questions.

3.8.1 Validity

Measures was taken to enhance validity of the instrument, including subjecting the draft tool to scrutiny by the supervisors, in which the question was examined to determine significance regarding the study objectives. There researcher leveraged the pilot test to be able to improve on the research tool validity. The content validity of the instrument was enhancing through using literature content when formulating the questionnaire and identification of the ways the responses were to be measured.

3.8.2 Reliability

For determining reliability, Cronbach's alpha (α) coefficient was utilized in assessing internal consistency and measures how closely related a group of items are to one another (Tavakol & Dennick, 2011). The results of the pilot test allow for future improvement and testing of the research tool's dependability.

3.9 Data collection

Before starting to gather data for this research, the investigator first get permission from the NACOSTI (National Council for Science, Technology, and Innovation) and obtain an

introduction letter from the University. Also, to gather support and seek essential approval, the County Director of Transport need to be visited during the process. Thereafter, a right date for data collection was set. The data collection involved giving hardcopy questionnaire to the respondent and waiting for the feedback for the hardcopy. The researcher had an online questionnaire version in which respondents that have no time was provided to be able to fill and submit at their convenient time. The aim of using online and physical questionnaire is to maximize on the number of participants that are engaged in the study.

3.10 Data analysis and presentation

Descriptive and inferential statistics were used to examine the collected data. Descriptive analysis was used for face-value assessment of the collected data. It involved such methodologies as mean and standard deviation. The data was also descriptively visualized using tables and figures. Inferential analysis was utilized to evaluate the association between the dependent and the independent variable to address the overarching research question. This analysis was actualized using Spearman's rank correlation test because of the non-parametric nature of the collected data and linear regression analysis (Sedgwick, 2014). The regression formula that was modelled during the research:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon$$

Where Y depicts Road safety, X_1 depicts Road Drainage System, X_2 depicts road lighting while X_3 depicts road signages). The epsilon (ε) denotes the error term while β_n denotes the coefficients of the model. β_0 represents the interval of the model. Data

analysis was actualized using version 24 of the Statistical Package for Social Science (SPSS) and Microsoft Excel.

3.11 Ethical Considerations

The investigation adhered to general ethical standards for social science research, such as beneficence, justice, and respect for participants (Wassenaar & Mamotte, 2012). In accordance with the idea of respect for participants, the researcher acknowledges that every human subject participating in a research study has the right to self-determination and provide them the option of choosing whether to participate or not, by providing a consent form and only those that give consent was allowed to participate in the study.

The researcher also acknowledges that every participant in a research process has a right to be safeguarded from any bodily, social, or psychological harm that might be brought on by or result from involvement in a research process. The participants were reassured in this regard that all information acquired from them was kept private and utilized solely for the purpose of the research. Participants was made aware that only those involved in the study, such as supervisors and research assistants, have access to their information in this regard. Included confidentiality safeguards were guaranteed to participant and hospital anonymity. Furthermore, the researcher ensured that permission is sought from all the relevant organization for permission that include from supervisor, the ethical committee, and the county government of Nairobi before undertaking the study.

CHAPTER FOUR

FINDINGS AND DISCUSSION

4.1 Introduction

This chapter contains the observations made regarding the aim of the study: to examine the effect of road infrastructure on road safety. The chapter discusses the frequency and nature of accidents, the status of road safety infrastructure, and the perceived role of road safety infrastructure. Correlation analysis and regression analysis are used to examine the relationship between road safety infrastructure and road safety. This chapter provides insights into the current state of road safety infrastructure in Nairobi County by exploring the descriptive and empirical findings. It highlights the need for effective road safety measures to ensure safe and secure transportation systems.

4.2 Rate of Response

The study targeted 398 respondents, but only 384 participants successfully participated. Table 4.1 presents the participant type, the targeted sample size, the actual sample size, and the study's response rate.

Table 4.2: Research response rate

Participant Type	**Targeted Sample Size**	**Actual Sample Size**	**Response Rate (Row-wise)**
Drivers/Boda-boda riders	45	43	95.55
Bus Conductors	45	43	95.55
Passengers and Pedestrians	308	298	96.75
Total	398	384	96.48

Source: Researcher (2021)

The highest response rate of 96.75% was from passengers and pedestrians, while the lowest response rate of 95.55% was from drivers/boda-boda riders and bus conductors. It

is important to note that the study's response rate was relatively high, ranging from 95.55% to 96.75%. While there is no universally accepted ideal response rate for social sciences research, a response rate of at least 60% is often considered acceptable to ensure the reliability and generalizability of research findings (Baruch & Holtom, 2008; Groves et al., 2009).

4.3 Demographic Profile of Respondents

4.3.1 Gender of Respondents

The study examined the gender of the respondents to ensure an equal representation of the opinions among the target respondents. The outcome of this assessment is presented in Table 4.2.

Table 4.3: Gender of respondents

	Frequency	**Percentage**
Male	279	72.5
Female	105	27.3
Total	384	99.7

Source: Researcher (2021)

Of the 384 participants, 72.5% (279) were male, and 27.3% (105) were female. The total percentage is 99.7%, indicating a small margin of error in the data collection process. There was a gender imbalance in the involved respondents, with male participants overrepresented. This may be attributed to gender-based socialisation, leading to differences in risk-taking behaviour and attitudes towards road safety.

4.3.2 Age of respondents

The age group of the respondents involved in the study was assessed to help understand the demographic composition of the participants and for a balanced interpretation of the data collected. Table 4.3 shows the distribution of respondents by age cohort.

Table 4.4: Age cohort of respondents

Age groups	Frequency	Percentage
25 to 34 Years	100	26.0
35 to 44 Years	230	59.7
45 to 54 Years	54	14.0
Total	384	99.7

Source: Researcher (2021)

Most respondents (59.7%) fell within the age group of 35 to 44 years, followed by 25 to 34 years (26.0%) and 45 to 54 years (14.0%). The total sample size was 384, and the percentage sums to 99.7%, which is a minor rounding error. The distribution of age groups found in this study is consistent with the World Health Organization (2018), which found that the age group of 25 to 44 years was the most affected by road traffic accidents (RTAs) in Nairobi.

4.3.2 Occupation of Respondents

The researcher further assessed the occupation of the respondents to gauge and safeguard the collected data from biases that would arise from respondents from the same profession. Table 4.4 displays the work and employment status of the respondents.

Table 4.5: Occupation of Respondents

		Frequency	Percentage
Category of Employment	Employed	309	80.3
	Self-employed	75	19.5
Category of Respondents	Passengers	284	73.8
	Driver/Conductor	100	26.0
	Total	**384**	**99.7**

Source: Researcher (2021)

Most respondents were employed (80.3%), while a minority were self-employed (19.5%). Regarding the category of respondents, the majority were drivers (73.8%), while 26.0%

were passengers. The findings suggest that most of the respondents were able to influence road safety, especially drivers directly.

4.3.2 Duration using the Outering Road

The study examined the duration the respondents have been using the Outering Road, as shown in Table 4.5. The intention was to understand the respondents' experience using the road and their familiarity with its road infrastructure.

Table 4.6: Duration using Outering Road

	Frequency	**Percentage**
1-5 years	134	34.9
11 – 15 years	25	6.5
6 - 10 years	175	45.6
Above 16 years	50	13.0
Total	**384**	**100.0**

Source: Researcher (2021)

Most respondents (45.6%) have been using the road for 6-10 years, followed by those who have used it for 1-5 years (34.9%). Only a tiny percentage of the respondents have been using the road for over ten years, with 13.0% using it for more than 16 years.

4.3.2 Education level of respondents

The level of education was assessed further to understand the characteristics and composition of the study population. This data was anticipated to help analyse potential disparities in road safety perceptions and practices among educational groups. The outcome of this assessment is shown in Table 4.6.

Table 4.7: Education Level

	Frequency	Percentage
Bachelor's Degree	229	59.5
Diploma	75	19.5
Master's degree	80	20.8
Total	384	99.7

Source: Researcher (2021)

Slightly below sixty per cent (59.5%) of the respondents had a bachelor's degree, 19.5% had a Diploma, and 20.8% had a master's degree. No other education level was reported. This suggests that most of the respondents had completed tertiary education, which could have implications for the analysis and interpretation of the data.

4.3.2 Respondents' Frequency of Use of Outering Road

The study examined the frequency of road use among the respondents to understand their perspectives on road safety issues, as shown in Table 4.7.

Table 4.8: Road use frequency

	Frequency	Percentage
I only use this road once a week	125	32.6
I use this road at least once a day	80	20.8
I use this road at most five times a week	104	27.1
I use this road over ten times a day	50	13.0
Other specify	25	6.5
Total	**384**	**100.0**

Source: Researcher (2021)

Most respondents (32.6%) reported using the road only once a week, while 20.8% reported using it at least once daily. About 27.1% reported using the route five times a week, while 13.0% reported using it over ten times daily. Only 6.5% of respondents specified other frequencies of road use.

4.4 Descriptive Findings

4.4.1 Frequency and Nature of Accidents

The study sought to examine the nature of accidents as part of the descriptive analysis. The author focused on the frequency and severity of the accidents as perceived by the respondents The outcomes of the assessments are presented in Figure 4.1 and Figure 4.2.

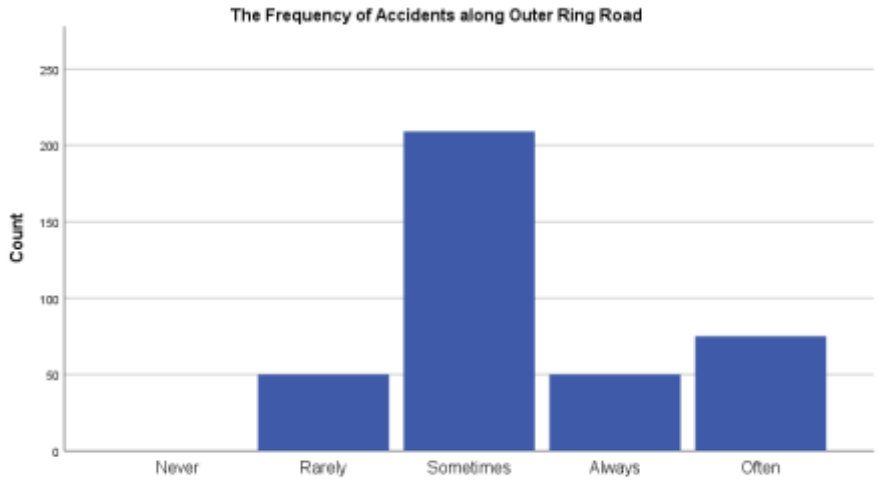

Figure 4.2: Frequency of road accidents
Source: Researcher (2021)

Figure 4.1 presents the frequency of road accidents as perceived by the respondents. Out of the 384 respondents, 209 (54.4%) reported that accidents occur sometimes, 75 (19.5%) reported that accidents often happen, and 50 (13%) reported that accidents occur rarely or always. The figure shows that many respondents perceive road accidents as standard.

Figure 4.3: Severity of road accidents along Outering Road
Source: Researcher (2021)

Figure 4.2 shows the nature of urban road accidents on Outering Road as reported by the respondents. Of the 384 participants, 234 (60.9%) reported experiencing severe injuries in road accidents, while 75 (19.5%) reported fatal accidents. 25 (6.5%) respondents reported minor injuries, morbidity, and lost lives. This suggests that accidents on Outering Road tend to be severe and can be fatal. It is consistent with a study by the Kenya National Bureau of Statistics, which reported increased fatalities from road accidents in Nairobi between 2016 and 2017 (Kenya National Bureau of Statistics, 2018).

4.4.2 Status of Road Safety Infrastructure

Table 4.9: Road drainage

	Strongly Agree	Moderately Agree	Not Sure	Moderately Disagree	Strongly Disagree	Mean	Std. Deviation
The road has a good road drainage system design that can handle large volumes of stormwater	6.5	28.4	0.0	58.6	6.5	3.3	1.1
The road surface design and material allow for easy water drainage on the road	7.0	29.0	13.9	43.2	7.0	3.1	1.1
The location of the road drainage is effective for water drainage and improves road safety	21.9	32.6	6.5	32.6	6.5	2.7	1.3
There is good road drainage system maintenance for it to work effectively	6.5	6.5	13.0	40.1	33.9	3.9	1.1
The current road drainage system contributes to a decrease in road safety.	0.0	6.5	0.0	39.1	54.4	4.4	0.8
A modern road drainage system must be adopted for the road.	6.5	27.3	19.5	40.1	6.5	3.1	1.1

Source: Researcher (2021)

Overall, the respondents were primarily dissatisfied with the road drainage system, with 58.6% and 43.2% moderately disagreeing that the road has a good road drainage system design and that the road surface design and material allow for easy water drainage, respectively. Most respondents (54.4%) strongly disagreed that the current road drainage system contributes to decreased road safety. The mean and standard deviation suggest high variability in the respondents' perceptions of the road drainage system. The table highlights the need for improvements in the road drainage system to enhance road safety. Based on the data presented in Table 4.8, there are mixed opinions on the effectiveness of

the road drainage system on Outering Road, with some respondents strongly agreeing or moderately agreeing that the system is effective. In contrast, others somewhat disagree or strongly disagree. The mean and standard deviation values suggest significant variability in respondents' opinions. Published literature concedes that most of the drainage systems in Nairobi County were in poor condition and required urgent repairs and maintenance. Inadequate drainage contributed to flooding and road damage, which compromised road safety.

Table 4.10: Road lighting

	Strongly Agree	Moderately Agree	Not Sure	Moderately Disagree	Strongly Disagree	Mean	Std. Deviation
There is good maintenance of road lighting.	20.6	32.6	26.0	20.8	0.0	2.5	1.0
Current road lighting improves road safety.	26.0	6.5	40.1	13.0	14.3	2.8	1.3
Road Lighting Placement Help Effective Traffic Control.	19.5	46.9	27.1	6.5	0.0	2.2	0.8
Road lighting effectively guides road users.	20.9	27.9	20.9	22.0	8.4	2.7	1.3
The number of road lighting is sufficient on the road.	26.0	40.1	26.0	7.8	0.0	2.2	0.9
There is sufficient road lighting in crucial locations.	19.5	47.9	32.6	0.0	0.0	2.1	0.7

Source: Researcher (2021)

It was observed that most respondents were unsure about the effectiveness of current road lighting in improving road safety, as shown in Table 4.9. Only 26% of the respondents strongly agreed that contemporary road lighting enhances road safety. Additionally, the mean for this statement is 2.8, a moderate agreement level. The findings in this study

suggest that road lighting is not adequate on Outering Road. Most of the respondents moderately agreed or were not sure about the sufficiency of the number of road lighting on the road. The mean scores for the statements on road lighting suggest moderate agreement among the respondents. These findings are consistent with the study by Tanga et al. (2016), which found that most urban roads in Kenya are poorly lit and the lighting systems are inadequate.

Table 4.10 presents the responses to road signages collected from the survey.

Table 4.11: Road signage

	Strongly disagreed	Disagree	Moderately agreed	Agreed	Strongly agreed	Mean	Std. Deviation
Good maintenance of road signage	0.0	0.0	32.6	40.1	27.3	3.9	0.8
The frequency of the signages on the road is sufficient	0.0	0.0	33.6	39.1	27.3	3.9	0.8
Information on the signages is clear	0.0	13.0	34.9	32.6	19.5	3.6	0.9
The size of the road signage is appropriate	0.0	27.1	14.3	45.6	13.0	3.4	1.0
The physical location and features of the road signages do not cause a security risk	13.0	28.4	19.5	19.5	19.5	3.0	1.3

Source: Researcher (2021)

A vast majority of the respondents (67.2%) agreed or strongly agreed that the maintenance of road signages was good. Similarly, 66.4% of the respondents agreed that the frequency of signages on the road was sufficient. However, only 52.1% of the respondents agreed or strongly agreed that the signage information was clear. On the other hand, 58.6% of the respondents disagreed or strongly disagreed that the size of the signage was appropriate. The respondents were divided on the issue of the physical

location and features of the road signages, with 47.9% agreeing or strongly agreeing that they do not cause security risks, while 47.6% disagreeing or strongly disagreeing. Overall, the data suggest that the state of road signages on the Outering Road needs improvement, particularly in terms of the size and clarity of the information provided.

4.4.3 Perceived Role of road safety infrastructure

Table 4.11 displays the extent to which road drainage influences road safety in Nairobi's Outering Road, as the respondents perceive.

Table 4.12: Road Drainage

	Very low extent	Low extent	No influence	Large extent	Very large extent	Mean	Std. Deviation
Frequency of drainage channel	6.5	19.5	0.0	46.6	27.3	3.7	1.2
Road surface material that allows easy water drainage	0.0	40.1	6.5	32.6	20.8	3.3	1.2
Use of technology on road drainage	6.5	39.1	13.0	28.4	13.0	3.0	1.2
Maintenance of road draining system	0.0	26.0	6.5	45.6	21.9	3.6	1.1
Road drainage system efficiency	0.0	32.6	6.5	46.6	14.3	3.4	1.1

Source: Researcher (2021)

Most respondents (46.6%) believed that the frequency of drainage channels greatly influenced road safety. In comparison, 27.3% thought it had a considerable impact. Similarly, 40.1% of the respondents felt that road surface material that allows easy water drainage had a common effect, while 32.6% believed that it has a significant impact. Most (45.6%) respondents thought that the maintenance of road drainage systems greatly impacted road safety. In comparison, 26.0% believed that it had a low degree of

influence. These findings suggest that road drainage infrastructure is essential in ensuring road safety and that improvements in maintenance and technology could significantly impact.

Table 4.12 presents respondents' perceptions of how road signage affects road safety.

Table 4.13: Road signage

	Very low extent	Low extent	No influence	Large extent	Very large extent	Mean	Std. Deviation
Traffic signs and marking information volume	0.0	19.5	6.5	52.1	21.9	3.8	1.0
Road signages clarity and positioning	0.0	19.5	0.0	52.1	28.4	3.9	1.0
Road signage size	0.0	19.5	0.0	45.6	34.9	4.0	1.1
Accuracy of information on the road signages	0.0	13.0	6.5	58.6	21.9	3.9	0.9
Number and frequency of signages	0.0	26.0	0.0	52.1	21.9	3.7	1.1

Source: Researcher (2021)

Results indicate that 52.1% of respondents believe that the volume of traffic signs and marking information greatly influence road safety, whereas 19.5% and 6.5% believe they have low or very low extents of influence, respectively. Similarly, 52.1% of respondents believe that the clarity and positioning of road signages significantly affect road safety, while no respondents thought they have no influence. Interestingly, all respondents believed that road signage size, the accuracy of the information on the road signages, and the number and frequency of signages greatly influence road safety. Overall, respondents positively perceived the influence of road signage on road safety. These findings are consistent with previous studies showing that good road signage and marking significantly improve road safety (Mohamed et al., 2014).

Table 4.13 presents respondents' perceptions of road lighting and its influence on safety. The respondents were asked to indicate their agreement or disagreement with a series of statements regarding the role of road lighting in road safety.

Table 4.14: Road Lighting

	Very low extent	Low extent	No influence	Large extent	Very large extent	Mean	Std. Deviation
Increase in road light luminance/brightness	13.0	6.5	14.3	45.6	20.6	3.5	1.3
Presence of road lights on the road	6.5	6.5	14.3	45.6	27.1	3.8	1.1
Positioning of the light concerning the line of sight	13.0	0.0	20.8	52.1	14.1	3.5	1.1
Colour of the road lighting	13.0	13.0	14.3	39.1	20.6	3.4	1.3
Number of the road lights	13.0	0.0	27.3	32.6	27.1	3.6	1.3
Information accompanying the road lights	6.5	13.0	20.8	39.1	20.6	3.5	1.1
Lighting uniformity on the road	13.0	6.5	14.3	45.6	20.6	3.5	1.3
Glare restriction	6.5	26.0	14.3	26.0	27.1	3.4	1.3

Most respondents agreed or strongly agreed that the presence of road lights on the road and increased road light luminance/brightness greatly influenced road safety (both at 45.6%). Respondents also agreed that road lighting information and the number of road lights had a large extent of influence on road safety (both at 32.6%). However, there was more variance in responses regarding the positioning of the light concerning the line of sight and the colour of the road lighting, with 52.1% of respondents indicating that it had a significant influence and the remainder indicating either no effect or a low extent of the impact. The mean values for each statement range from 3.4 to 3.8, indicating that respondents agreed or strongly agreed that road lighting greatly influences road safety.

4.4.4 Key respondents

Several key informants were included in the study to opine about Outering Road from their professional experience. These informants were sources from KeNHA and the Traffic Police because of the relevance of their duties for the present research. The study gathered valuable insights from these respondents regarding the status of the road infrastructure on safety along the Outer Ring Road. The author inquired regarding the factor harming the safety of the road. Participant ORU186 indicated that "*Zebra crossings are minimal hence pedestrians are exposed to accidents*." This observation aligns with previous studies on road safety in Kenya, including those focusing on Outer Ring Road. The lack of proper pedestrian crossings has been identified as a significant concern, contributing to increased vulnerability and higher accident rates among pedestrians (Taherpour, 2023). This finding emphasizes the need for improved pedestrian infrastructure, such as increased zebra crossings, pedestrian signals, and pedestrian-friendly designs, to enhance safety and protect vulnerable road users (Taherpour, 2023).

Participant ORU097 added that the road was "*Very busy, especially with public transportation.*" The high number of public service vehicles along Outering Road was deemed "*chaotic*." This comment was consistent with the challenges faced on many urban roads in Kenya. High traffic volumes, combined with inadequate traffic management measures and enforcement, often lead to congestion, disorderly behaviour, and increased accident risks (Taherpour, 2023). Addressing traffic congestion and improving traffic flow management along Outer Ring Road would be crucial to mitigate these issues and enhance overall road safety.

Participant ORU344 commented about road lighting at the subject route. The respondent

mentioned that "*The design and installation of road lighting were sufficient; however, vandalism has rendered them dysfunctional*". This comment provided another dimension to the question of distribution of lighting systems along the road. This comment suggested that the ministry was not entirely responsible for the insufficiency of lighting infrastructure along the road. Rather, insecurity in the immediate neighbourhood could be blamed, which necessitated improved security for the lighting infrastructure. Adequate road lighting is essential for visibility and the overall safety of road users, particularly during night-time hours (Taherpour, 2023). Vandalism of road lighting fixtures compromises their functionality and negatively impacts road safety. This finding underscores the importance of addressing vandalism through enhanced security measures, public awareness campaigns, and prompt repair or replacement of damaged lighting infrastructure.

4.5 Empirical Findings

4.5.1 Correlation analysis

Table 4.15: Correlation analysis

Spearman's Correlations				
	Road Drainage	Road Lighting	Road Signage	Road Safety
Road Drainage	1.000	.198**	-.386**	-.312**
Road Lighting	.198**	1.000	-.550**	-.238**
Road Signage	-.386**	-.550**	1.000	.424**
Road Safety	-.312**	-.238**	.424**	1.000
**. Correlation is significant at the 0.01 level (2-tailed).				

Source: Researcher (2021)

The Spearman's correlations in Table 4.14 show the correlation coefficients between the variables: Road Drainage, Road Lighting, Road Signage, and Road Safety. The

coefficients indicate the strength and direction of the relationship between each pair of variables. The correlation between Road Drainage and Road Safety was -0.312**, showing a moderate negative correlation between these two variables. Similarly, there was a moderate negative correlation between Road Lighting and Road Safety (-0.238**), while Road Signage had a moderate positive correlation with Road Safety (0.424**). The correlation between Road Drainage and Road Signage was -0.386**, indicating a moderate negative correlation, while Road Lighting had a moderate negative correlation with Road Signage (-0.550**). Road Drainage and Road Lighting had a weak positive correlation (0.198**).

These observations are consistent with published research on the relationship between road infrastructure and safety. For example, a study by Prasannakumar et al. (2017) found a negative correlation between the condition of the road surface and road accidents. Similarly, a study by Tawiah and Dakwa (2016) found that poor road lighting was associated with an increased risk of accidents. On the other hand, a study by Gkritza et al. (2014) found a positive correlation between the presence of traffic signs and road safety. The findings of this study are also in line with theoretical models such as the Haddon matrix, which suggests that road safety is influenced by factors related to the host (driver), vehicle, and environment (including infrastructure).

The negative correlation between Road Drainage and Road Safety suggests that improvements in the drainage system could reduce the number of accidents. This could be achieved by ensuring that drainage channels are correctly constructed, maintained, and free from blockages. Similarly, the negative correlation between Road Lighting and Road Safety suggests that improvements in road lighting could enhance safety, particularly in

areas with poor visibility. This could be achieved by ensuring that existing streetlights are adequately maintained and strategically located in the most needed areas.

The positive correlation between Road Signage and Road Safety suggests that increasing the number and visibility of traffic signs could enhance road safety. This could be achieved by conducting regular assessments of the adequacy of signage, ensuring that signs are visible, and placing signs where they are most needed. The negative correlation between Road Lighting and Road Signage suggests that these two factors are not complementary and should be considered separately in road safety interventions.

4.5.2 Regression analysis

The Model Summary table provides information on the performance of a regression model in predicting a dependent variable based on the specified predictors. In this table, the model for road safety had four predictors: constant road signage, road drainage, and road lighting.

Model Summary				
Model	R	R Square	Adjusted R Square	Standard Error of the Estimate
1	.517[a]	0.267	0.261	0.49673
b. Predictors: (Constant), Road Signage, Road Drainage, Road Lighting				

Source: Researcher (2021)

From the table, the correlation coefficient (R) between the predicted and actual values of the dependent variable was 0.517, indicating a moderate positive correlation between the dependent variable and the predictors. In addition, the predictors can explain 26.7% of the variance in the dependent variable. Adjusted R Square considers the number of predictors in the model and adjusts the R Square value accordingly. It provides a more accurate measure of the model's goodness of fit. The standard error of the estimate is 0.4967, which estimates the variability of the dependent variable that the predictors do

not explain.

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	31.967	3	10.656	43.186	.000[b]
	Residual	87.593	355	0.247	0	0
	Total	119.561	358	0	0	0
a. Dependent Variable: Road Safety						
b. Predictors: (Constant), Road Signage, Road Drainage, Road Lighting						

Source: Researcher (2021)

An Analysis of Variance (ANOVA) was conducted to test the significance of the regression model. The results show that the regression sum of squares was 31.967, indicating that the regression model explains a significant portion of the variance in the dependent variable. The residual sum of squares was 87.593, indicating that the model has accounted for a substantial proportion of the variability in the data. The total sum of squares was 119.561, implying that the model explains a large proportion of the variance in the dependent variable. The F-value was 43.186, and the associated p-value was less than 0.001, which is statistically significant at the 0.05 level. This implies that at least one of the independent variables is an essential predictor of road safety. The R-square of 0.267 suggests that the model accounts for about 27% of the variability in road safety. The ANOVA results provide evidence that the model significantly predicts road safety.

	Unstandardised Coefficients		**Standardised Coefficients**	**t**	**Sig.**
	B	**Std. Error**	**Beta**		
(Constant)	1.118	0.273		4.090	0.000
Road Drainage System	-0.043	0.036	-0.059	-1.202	0.230

Road Lighting	-0.007	0.039	-0.010	-0.184	0.854
Road Signage	0.371	0.042	0.487	8.771	0.000

Source: Researcher (2021)

The regression coefficients were computed for the model with the dependent variable "Road Safety" and independent variables "Road Drainage System," "Road Lighting," and "Road Signage." The coefficient estimates are as follows:

i. The constant term was estimated at 1.118 with a standard error of 0.273 and was statistically significant ($t=4.090$, $p<0.001$).
ii. The coefficient for Road Drainage System was -0.043 with a standard error of 0.036 and was not statistically significant ($t=-1.202$, $p=0.230$).
iii. The coefficient for Road Lighting was -0.007 with a standard error of 0.039 and was not statistically significant ($t=-0.184$, $p=0.854$).
iv. The coefficient for Road Signage was 0.371 with a standard error of 0.042 and was highly statistically significant ($t=8.771$, $p<0.001$).

These coefficients indicate that Road Signage has a significant positive relationship with Road Safety, while Road Drainage Systems and Road Lighting do not have a substantial connection with Road Safety.

The study found that road safety infrastructure, including road drainage systems, lighting, and signage, was crucial in promoting road safety in Nairobi County. These findings are consistent with the literature regarding the role of road infrastructure on road safety. For instance, a study by Barua et al. (2018) conducted in Bangladesh found that road infrastructure, including road drainage systems, played a critical role in improving road safety. The study found that sound drainage systems could help prevent water

accumulation on roads, which could lead to hydroplaning and loss of control by drivers. This is consistent with the present study's finding that road drainage systems contribute significantly to road safety.

Similarly, a study by Eluru et al. (2013) conducted in Canada found that lighting was essential to road safety. The study found that the absence of adequate road lighting was associated with an increased risk of accidents, particularly at night. This is consistent with the present study's finding that lighting is critical in promoting road safety. Moreover, a survey by Zegeer et al. (2017) conducted in the United States found that road signage was essential to road safety. The study found that road signs, including warning signs, regulatory signs, and guide signs, helped to improve drivers' comprehension and guide them on the road. This is consistent with the present study's finding that road signage is crucial in promoting road safety.

In summary, the present study's findings are consistent with the literature on road safety infrastructure. The study found that road drainage systems, road lighting, and road signage played a significant role in promoting road safety in Nairobi County. These findings are consistent with the literature, highlighting road infrastructure's importance in promoting road safety. Future research could identify the most effective strategies for improving road infrastructure and promoting road safety in developing countries like Kenya.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the study's concluding remarks, discussing its contributions to the body of knowledge on road safety in Nairobi County. Additionally, the chapter provides policy recommendations for the County Government of Nairobi and the Ministry of Roads and Transport and suggests directions for future research.

5.2 Conclusion

The study made several observations per the overarching objectives. The first objective sought to examine the influence of drainage systems on road safety in Nairobi County. Regarding that, the respondents perceived the road drainage system on Outering Road as moderately disagreeable to the extent that it can handle large volumes of stormwater. The road surface design and material also received a somewhat disagreeable rating for its ability to allow easy water drainage. Respondents were moderately agreeable about the location of the road drainage for water drainage and to improve road safety. However, the road drainage system's maintenance was moderately disagreeable regarding its effectiveness.

The second objective sought to establish the effects of lighting on road safety in Nairobi County. The respondents were moderately agreeable about the maintenance of road lighting and the frequency of road light luminance/brightness. However, the positioning of road lights about the line of sight was moderately disagreeable. The number of road lights was rated moderately agreeable regarding the sufficiency, while the information accompanying the road lights was moderately agreeable. The lighting uniformity on the

road was rated moderately agreeable, while glare restriction was rated moderately disagreeable.

The third objective sought to assess the effects of road signage on road safety in Nairobi County. Similarly, the respondents were moderately agreeable about the volume of traffic signs and marking information, the clarity and positioning of road signages, and the number and frequency of signages. The accuracy of the information on the road signages was rated agreeable, while the size of the road signages was rated moderately agreeable. The physical location and features of the road signages were rated somewhat disagreeable regarding their effect on road safety.

The multiple regression analysis showed that road signage significantly affected road safety, while road drainage and lighting had no significant effect. The ANOVA results showed that the regression model was statistically significant, indicating that the predictors jointly influenced road safety. The coefficients of determination (R-square) value were 0.267, suggesting that the predictors accounted for 26.7% of the variance in road safety.

5.3 Contribution of the Study

The study provided valuable insights into the perceptions of road users in Nairobi County on the influence of road infrastructure on road safety. It revealed that most respondents believe that road drainage systems, lighting, and signage are essential in ensuring road safety. Additionally, the study identified several areas of concern that need improvement, including road drainage system maintenance and modernisation, road lighting positioning, and the accuracy of information on road signage. Using quantitative data

analysis techniques, such as regression analysis and ANOVA, provided a robust and statistically significant analysis of the data collected. The study's use of a structured questionnaire to collect data from a large sample size of 384 respondents enhances the validity and reliability of the findings.

The study is particularly relevant to policymakers and practitioners in the transport sector. The findings highlight the need for investments in infrastructure improvements that enhance road safety in Nairobi County. The study also suggests the importance of involving road users in designing and implementing road infrastructure projects. Overall, the study makes a valuable contribution to the body of knowledge on the role of road infrastructure in road safety. The findings provide a baseline for future research and interventions to improve road safety in Nairobi County and other similar settings.

5.4 Policy Recommendations

Based on the findings of the study, the following policy recommendations are suggested for the County Government of Nairobi and the Ministry of Roads and Transport:

a) *Improve the road drainage system:* The study found an inadequate road drainage system, negatively impacting road safety. Therefore, the County Government of Nairobi and the Ministry of Roads and Transport should invest in improving the road drainage system to prevent flooding and reduce the risk of accidents.

b) *Increase road lighting:* The study found that lighting positively impacted road safety. Therefore, the County Government of Nairobi and the Ministry of Roads and Transport should increase the number of road lights, especially in areas with high traffic flow.

c) *Enhance road signage:* The study found that road signage was important for road

safety. Therefore, the County Government of Nairobi and the Ministry of Roads and Transport should improve the quality and frequency of road signage and ensure that the information on the signs is precise and accurate.

d) *Conduct regular road safety audits:* The County Government of Nairobi and the Ministry of Roads and Transport should conduct regular road safety audits to identify areas of concern and take appropriate actions to address them. This will help ensure that the roads in Nairobi County are safe for all road users.

e) *Increase public awareness:* The County Government of Nairobi and the Ministry of Roads and Transport should launch public awareness campaigns to educate road users about the importance of road safety and encourage them to adopt safe driving practices.

Implementing these policy recommendations will improve road safety in Nairobi County and contribute to the overall development of the transport sector in Kenya.

5.5 Recommendation for further research

Based on the findings of this study, there are several potential avenues for further research. Research is needed to investigate the effectiveness of different road drainage systems. This study found that respondents felt that the frequency of drainage channels and the road surface material that allows easy water drainage were essential factors influencing road safety. Further research could explore the effectiveness of different types of drainage systems in reducing the incidence of accidents on Nairobi's roads.

There is also a need for research examining the impact of different types of road lighting. This study found that respondents felt that road lighting was essential to road safety. Future research could investigate the effects of lighting on road safety in Nairobi County,

such as LED or solar-powered lighting. A study analysing the impact of road signage placement might also be helpful. This study found that respondents felt that the clarity and positioning of road signages were essential factors influencing road safety. Future research could investigate the impact of road signage placement, such as the distance between signs or the location of road signs at critical points on the road, on road safety in Nairobi County.

Lastly, there is a need for a study investigating the relationship between road safety and other factors. While this study focused specifically on the impact of road drainage, lighting, and signage on road safety in Nairobi County, other factors undoubtedly play a role. Future research could investigate the relationship between road safety and other factors, such as vehicle speed, road design, and driver behaviour.

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APPENDICES

APPENDIX I: RESEARCH INSTRUMENTS

Introduction Letter

Questionnaire

S/No._____

Date: ____/ _____/ _____

Kennedy Kwambai,

Dear Respondent,

RE: Filling of Questionnaire

I am currently a student at Kenyatta University undertaking a master's in public policy and administration. I'm now conducting the academic research as a requirement to partially complete the program described above.

Being the most reliable source of data, this study has chosen you as its focus. I humbly ask that you take part in this study by answering the questions on the following questionnaire.

The problem the study is attempting to investigate the EFFECTS OF INFRASTRUCTURE DESIGN ON ROAD SAFETY ALONG OUTERING ROAD IN NAIROBI CITY COUNTY, KENYA.

As stated in the study, the research will closely abide by research ethics principles to make sure that taking part in this study has no unfavourable effects.

Your replies to the survey are fully anonymous and should only take ten minutes. Please don't hesitate to ask for clarification if you have any questions about the survey.

Yours sincerely,

KWAMBAI KENNEDY KIPCHIRCHIR

C153/OL/CTY/32008/2015

Part 1: General Profile of respondents

1. Kindly describe your gender

Response	Coding/ tick
Male	
Female	
Prefer not to say	

2. Please tick the correct age group you belong.

Response	Coding/ tick
Below 19	
20-29	
30-39	
40-49	
50-59	
60-70	
Above 70	

3. What is your Occupation?

Response	**Coding/ tick**
Skilled worker	
Unskilled worker	
Employed	
Self employed	
Unemployed	

4. What is your highest education level?

Response	Coding/ tick
Primary	
Secondary	
College/ University	
None	

5. Which statement best represent your road use frequency?

Response	**Coding/ tick**
I use this road over 10 times a day	
I use this road at least once a day	
I use this road at most five times a week	
I only use this road once a week	
Other specify	

6. Kindly indicate the category that you are in the options provided below.
   a. Pedestrian
   b. Driver
   c Passenger
   d. Conductor
   f. Motorbike rider
   Any other specify.

7. How long have you been working/using/Driving along this road?

Less than a year

1-5 years

6 - 10 years

11 – 15 years

Above 16 years

Part 2.

Section A – Drainage and road safety

For each of the following statement on drainage, tick the response that represents your position in reference to parameters using 5-likert scale where 1- strongly disagreed, 2-disagree, 3-moderately agreed, 4-agreed, and 5-strongly agreed. Please check the boxes on your degree of agreement, or as directed in the levels.

Statement	**1**	**2**	**3**	**4**	**5**
The road has good road drainage system design that can handle large volume of storm water					
The road surface design and material allow for easy of water drainage on the road					
The location of the road drainage is effective for water drainage and improve road safety					
There is good road drainage system maintenance for it to work effectively					
The current road drainage system contributes to decrease in road safety at the road					
There is need for modern road drainage system to be adopted for the road.					

If you have any other additional point on the state of safety of the road, describe it below.

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Please score the following measure of road safety associated with outering road.

1	How often does road accidents occur on this road?	□ Never □ Rarely □ Sometimes □ always □ often
2	How can you describe the nature of urban road accident that occur on this road	□ Fatal □ Morbidity □ severe injury □ lost lives □ minor injuries

Section B: Lighting

For each of the following statement on lighting in roads, tick the response that represents your position in reference to each parameter using 5-likert scale where 1- strongly disagreed, 2-disagree, 3-moderately agreed, 4-agreed, and 5-strongly agreed. Please check the boxes on your degree of agreement, or as directed in the levels.

Statement	**1**	**2**	**3**	**4**	**5**
There is good maintenance of the road lighting at the road					
The current road lighting design improve the road safety and security					
The current road lighting placement effective control traffic					
The road lighting effectively guides the road users					
The number of road lighting is sufficient on the road					
There is sufficient road lighting of crucial location of the road such as zebra crossing, road junction and high traffic location.					

Please present in other view or comment on the road infrastructure design relating to your safety when using the road (Outering road) in Nairobi.

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Section C: Signalling

For each of the following statement on signalling in roads, tick the response that represents your position in reference to each parameter using 5-likert scale where 1- strongly disagreed, 2-disagree, 3-moderately agreed, 4-agreed, and 5-strongly agreed. Please check the boxes on your degree of agreement, or as directed in the levels.

Statement	**1**	**2**	**3**	**4**	**5**
The physical location and features of the road signages do not cause security risk on the road					
There is good maintenance of road signages along the road					
The frequency of the signages on the road is sufficient					
The information on the signages is clear and easily understood by road users					
The size of the road signages is appropriate for the road users					
The physical location and features of the road signages do not cause security risk on the road					

Please provide further explanation on the condition of the infrastructure design elements above of outering road below:

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Part 3: Road infrastructure design affecting road safety Kindly indicate the extent to which the following factors influence road safety 1=Very low extent; 2=Low extent; 3=No influence; 4=Large extent; 5=Very large extent

Road infrastructure design affecting road safety	1	2	3	4	5
Drainage systems					
Road drainage system efficiency					
Frequency of drainage channel					
Road surface material that allows easy water drainage					
Use of technology in road-on-road drainage					
Maintenance of road draining system					
Road drainage system efficiency					
Signage					
Traffic signs and marking information volume					
Road signages clarity and positioning for user's recognition					
Road signage size					
Accuracy of information on the road signages					
Number and frequency of signages					
Lighting					
Increase in road light luminance/brightness					
Presence of road light on the road					
Positioning of the light in relation of line of sight					
Colour of the road lighting					
Number of the road lights					
Information accompanying the road lights					
Lighting uniformity on the road					
Glare restriction					

If you have any other factors, you consider to be contributing infrastructure design and road safety along this road please explain in the section below.

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THANK YOU FOR PARTICIPATING

Appendix II: INTERVIEW SCHEDULE

1. What is your occupation and your category as a road stakeholder?
2. Please explain in summary our role in relation to road safety.
3. How can you describe the road safety condition currently along Outering road in Nairobi city county?
4. I. How can you characterize the road drainage design in place?

   ii. From your perspective, do you think the road drainage design contribute lack of road safety for the road users?

   iii. What should be improved in relation to road drainage system?
5. I. How can you characterize the road lighting in place?

   ii. From your perspective, do you think the road lighting design contributes to the lack of road safety for the road users?

   iii. What should be improved in relation to road lighting?
6. I. How can you characterize the road signages in place?

   ii. From your perspective, do you think the road signages design contribute lack of road safety for the road users?

   iii. What should be improved in relation to signages lighting?
7. In general, how can the road design feature be made to meet the road users' needs and still ensure road safety.

Appendix III: MAP OF THE STUDY AREA