Infrastructure Design on Road Safety Along Outering Roads in Nairobi City County, Kenya

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DOI: https://dx.doi.org/10.47772/IJRISS.2023.7713

Received: 05 June 2023; Revised: 20 June 2023; Accepted: 24 June 2023; Published: 16 July 2023

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 an exploratory 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 and the importance of involving road users in designing and implementing road infrastructure projects.

BACKGROUND INFORMATION

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 around the world, 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. In addition, according to WHO (2021), road users provide crucial information that enables the management of existing road infrastructure to promote safety by providing safer routes for pedestrians and cyclists, traffic-calming measures, low-cost remedial measures, and crash-protective roadsides, as well as by giving crash-protective roadsides. Public education and information campaigns also help the police improve traffic enforcement.

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 ofpublic-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). Research has identified several risk factors for road traffic accidents. Some of these require drivers' education, and the first step in this process is to assess perceptions of these risk factors to determine the current level of awareness.

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.

1.1 Problem Statement

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. 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.

The government has made efforts to address the problem through initiatives and laws implemented by competent agencies but with inconsistent results. There is existing literature on the contributing factors to road accidents, including human factors, road design, and law enforcement. However, there is no clear consensus or recommendations regarding the role of road infrastructure design in urban road safety, specifically in Nairobi County, Kenya. Despite the available literature on road safety factors, there is a lack of in-depth understanding regarding the influence of road infrastructure design on urban road safety in Nairobi County. The existing studies do not provide conclusive evidence or suggestions on how road infrastructure design can contribute to reducing road carnage and improving road safety in Kenya. Therefore, there is a need for a comprehensive review and exploration of the relationship between road infrastructure design and road safety, as well as the identification of potential solutions to address any negative aspects that may exist.

LITERATURE REVIEW

Theoretical Literature

This study was be premised on the human factor theory (HFT). This theory 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 (Y?lmaz & 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..

Empirical Literature

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.

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.

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).

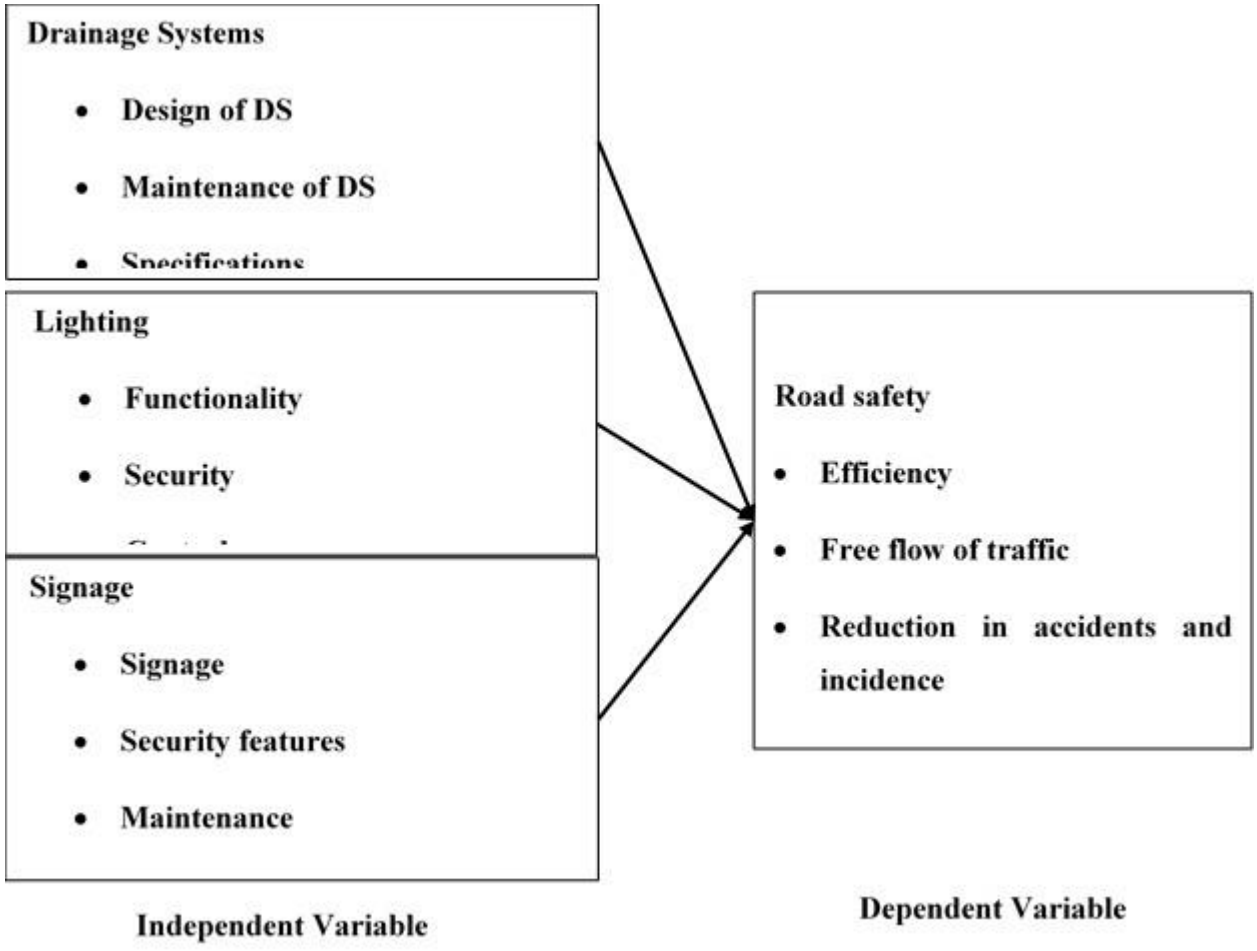
Lighting on the road is considered crucial to facilitate road users to effectively utilize the roads. Consequently, effective road design is expected to incorporate road lighting design. An increase in road light luminance is associated with a decrease in the percentage of night crashes in the urban 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). Road lighting designs at road intersection are considered to influence the 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 a need for the implementation of user-centredtred 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.

Conceptual Framework

A conceptual framework refers to a written or a visual presentation of key variables so as to give a narrative or graphical presentation of their relationship in a study. The conceptual framework for this study guides how the study was conducted with respect to the underlying aim and objectives.

Figure 1: Conceptual Framework



Source: Authors (2021)

RESEARCH METHODOLOGY

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 explanatory research design.

Target Population and Sampling

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 highwaywas 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.

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.

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 where is the sample, is the population size and 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

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.

Data analysis

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, depicts Road Drainage System, depicts road lighting while depicts road signages). The epsilon () denotes the error term while denotes the coefficients of the model. represents the interval of the model. Data analysis was actualized using version 24 of the Statistical Package for Social Science (SPSS) and Microsoft Excel.

RESULTS AND ANALYSIS

Demographic profiles

Information regarding the demographic characteristics of the respondents was collected to provide the researcher with deeper information of the participants. The study examined the gender of the respondents to ensure an equal representation of the opinions among the target 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. 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. The study examined the duration the respondents have been using the Outering Road. 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 4.1.

Table 4.1: Demographic profile of the respondents

		Frequency	**Percentage**
Gender	Male	279	72.5
	Female	105	27.3
Age group	25 to 34 Years	100	26
	35 to 44 Years	230	59.7
	45 to 54 Years	54	14
Level of education	Bachelor's Degree	229	59.5
	Diploma	75	19.5
	Master's degree	80	20.8
Duration using Outering Road	1-5 years	134	34.9
	11 – 15 years	25	6.5
	6 – 10 years	175	45.6
Category of Employment	Above 16 years	50	13
	Employed	309	80.3
	Self-employed	75	19.5
Category of Respondents	**Passengers**	284	73.8
	Driver/Conductor	100	26

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. 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.

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. 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.

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 4.2: 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.

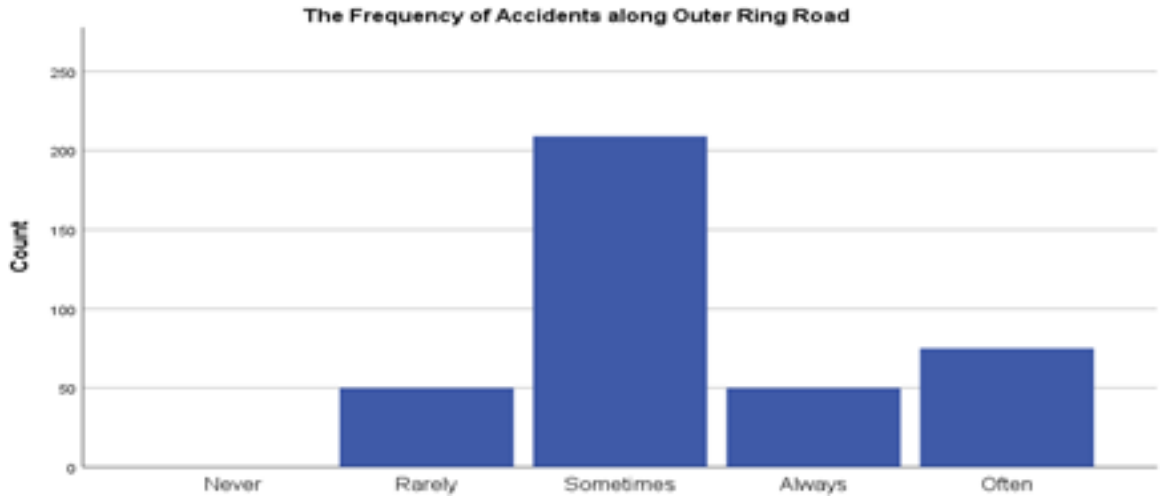
About 27.1% reported using the route five times a week, while 13.0% reported using it over ten times daily. Only 6.5% of respondents specified other frequencies of road use.

Descriptive Statistics

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.

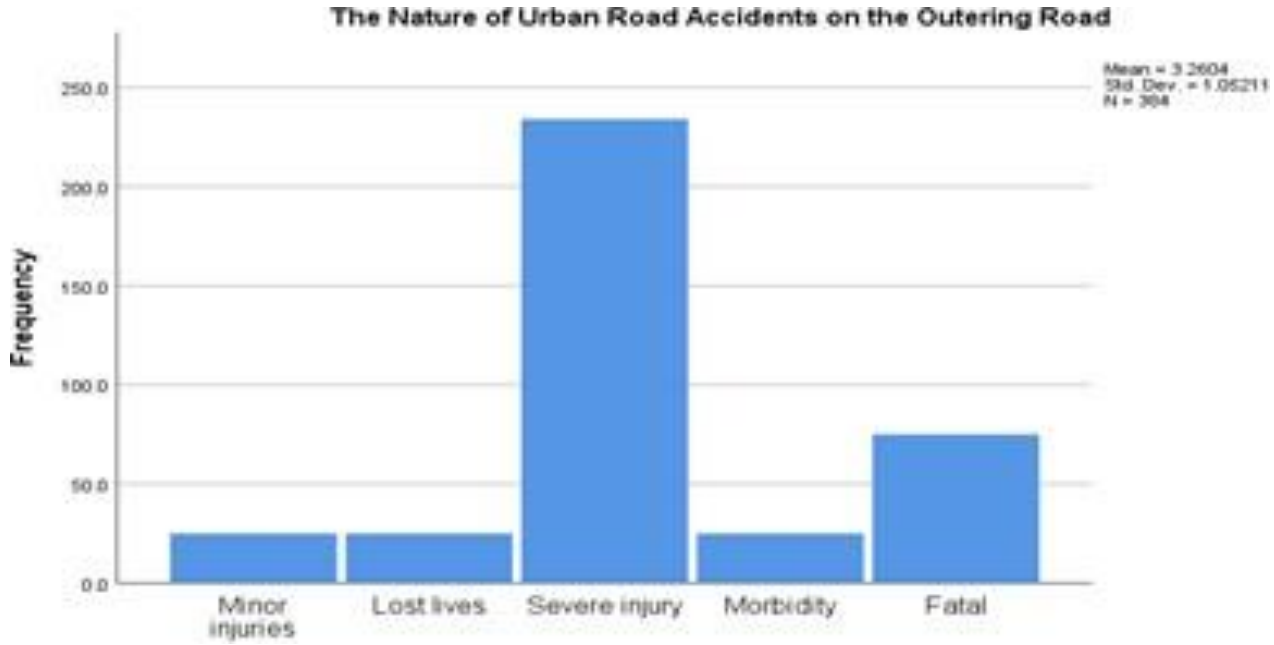
Figure 4.1: Frequency of road accidents



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 4.2: 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).

Status of Road Safety Infrastructure

Table 4.3: 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)

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.

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..

Empirical Findings

Table 4.4: 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)

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VII Issue VI June 2023

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.

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:

1. The constant term was estimated at 1.118 with a standard error of 0.273 and was statistically significant ($t=4.090$, $p<0.001$).
2. The coefficient for Road Drainage System was -0.043 with a standard error of 0.036 and was not statistically significant ($t=-1.202$, $p=0.230$).
3. 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).

4. 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.

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.

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.

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:

1. *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.
2. *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.
3. *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.
4. *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.
5. *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.

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