

## **Analysis of Effects of Environmental Factors on Road Traffic Accidents in Nairobi, Kenya**

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### **Abstract**

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*The study investigated the effects of environmental factors on road safety in Nairobi. The objectives of the study were to (a) assess the effect of environmental factors on road traffic accidents (RTAs) in Nairobi (b) analyse how lack of road signs and road crossing points contribute to motor and pedestrian road traffic accidents (RTAs) on the roads. Two (2) hypotheses were formulated and tested using collected data. They were (a) 'there is no significant difference between wetness of the road and the number of RTAs', (b) 'there is no significant difference between pedestrian RTAs and lack of road signs and pedestrian crossings points'. Data was collected using questionnaires administered to randomly selected drivers and traffic police officers. Data was also obtained from Traffic police records. Data was analyzed using descriptive statistics. Hypotheses were tested using chi-square test.*

*The main findings of the study were that; (1) road conditions did not contribute significantly to RTAs. (2) lack of adequate pedestrian road crossing facilities and fences at black spots led to traffic crashes (3) pedestrians tend to ignore designated pedestrian traffic ways and safe road crossing points thereby being involved in RTAs, (4) absence of speed limit signs and speed limit bumps at black spots increases the occurrences of RTAs. The key recommendations of the study are: (a) road safety should be recognized as a national disaster and adequate funds allocated to deal with it (b) there should be enforcement of traffic rules (c) road designs should incorporate pedestrian crossing.*

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**Key Words:** Road safety, Road traffic accidents, Road accident black spots, Pedestrian ways, Environmental factors,

### **1.0 Introduction**

This study was motivated by the alarming statistics of death and injuries resulting from road traffic accidents (RTAs) in the world as a whole and in Kenya in particular. For example, according to the World Health Organization (WHO) global status report on road safety, annually road traffic accidents (RTAs) injure about 50 million people and kill as many as 1.2 million people worldwide (Peden et al, 2004; Lankarani et al, 2014). World Health Organization (WHO) strategy of 2001 reports that currently road traffic injuries are the leading cause of deaths and injuries, the 10th leading cause of all deaths and 9th leading contributor to the burden of disease worldwide based on disability adjusted life years.

The report further projects that RTAs will be third leading cause of deaths by the year 2020. The number of deaths resulting from road traffic crashes has been projected to reach 8.4 million in the year 2020 (WHO, 2000). Worldwide, road traffic accidents lead to death and disability as well as financial cost to both society and the individuals involved (Bundi 2015).

Road traffic accidents (RTA) are a preventable scourge. With man's invention of the wheel, the death knell has continued to toll for many, who are often innocent, but who may happen to be at the wrong place at the wrong time. Statistics has shown that mortality in road traffic accidents is very high among young adults in their prime and who constitute the work force. These are usually the breadwinners in many cultures. Innocent children are often direct victims of road mishaps and many become orphaned from these accidents. This imposes harsh social conditions made much worse in countries without social security services. The essential factors involved in RTAs include the person, the machine and the road. Most tragic accidents often involve all three. Often the person is involved with only one of the other two. A critical appraisal of factors involved in RTAs is necessary to identify and apportion responsibility for their prevention and redress to victims (Bundi, 2015).

The overall objective of this study was to analyse the environmental factors that directly or indirectly contribute to RTAs thus leading to road safety problems. The specific objectives of the study were (1) to discuss the effect of weather and road conditions on road traffic accidents (RTAs) in Nairobi and (2) to examine and analyse how environmental features contribute to road traffic accidents (RTAs) on the roads. In order to achieve the objectives stated above, two null hypotheses were formulated and their validity tested using the data collected empirically. These hypotheses were (1) there is no significant difference in road traffic accidents between wet and dry road surfaces and (2) there is no relationship between pedestrian accidents and lack of pedestrian road crossing points and road sidewalks.

## **1.1 Theoretical and Conceptual Perspectives**

### **1.1.1 Literature Review**

Many studies have examined the causes of traffic road accidents the world over. But, there is no consensus on their causes. This section reviews the existing literature on the effect of environmental factors on road traffic accidents. The main findings of the reviewed literature and any research gaps identified are discussed below.

According to the study by Shankar et al (1995), rainfall plays a significant role in road traffic accidents. They argued that higher rates of fatalities resulting from road traffic crashes in poor weather could be explained by (a) poor visibility due to rainy or snowy weather (b) the road surface which may be more slippery thereby reducing the vehicle-roadway friction. Previous study by Hajar et al (2000) in Mexico tended to support the findings of the study of Shankar et al (1995). Hajar et al (2000) showed a definite association of adverse environmental conditions such as rain, fog, and wet pavement as well as driving in daylight with traffic crashes. However, Kashani et al (2012) revealed that weather and road surface conditions, shoulder type and road width, lighting as well as location type are less important variables, influencing the injury severity by traffic crashes than the use of seat belt, cause of crash and collision type.

A study of traffic accidents at hazardous locations of urban roads in Jordan indicates that road accidents represent a major social and economic problem that causes a lot of losses in lives and injuries (Mohammed. & Thanaa 2012). This study found that logarithmic and linear statistical models could efficiently and practically predict the expected number of accidents, injuries, fatalities and their associated types as functions of numerous independent variables. It was found that the most important contributing factors to traffic safety issues at urban roads were geometrical, behavioral, traffic condition and environmental factors. The most contributing factors to accidents at hazardous locations on urban roads were speed, degree of curvature, road surface type, traffic properties, number of horizontal and vertical curves, lighting conditions and roadway geometry. The traffic accidents study in Jordan adopted an engineering approach to examine the causes of road accidents in the hazardous locations of urban areas in Jordan. The present study adopted a geographical approach to analyse the effect of environmental factors on road accidents at black spots in the City of Nairobi

Lankarani et al (2014) in a study in Iran revealed that environmental factors are major causes of road accidents. It was established that dusty weather had the highest death rate compared to other weather conditions. The study found that winding uphill/downhill road was the roadway geometry with the highest rate of RTAs. This roadway geometry limits the driver's vision and causes difficult control of vehicle at crash time with subsequent increase in fatal RTAs risk.

Well-designed roads with separate lines for pedestrians and cyclists are much safer than those without such facilities. Sometimes barriers to discourage pedestrians to motor roads reduce the rate of injuries. Road signs should be clear by themselves and should convey an unmistakable message to the driver. It has also been observed that accidents mostly occur on broader roads than narrower ones (Majumder et al 1996). In Nigeria it was reported that better roads have resulted in excessive speed and reckless driving resulting in an increase rather than reduce death toll on national roads (Asogwa 1992). There is also a relationship between seasonality; weather and time factor in road traffic accident occurrence (CSA 1983, Jegede, 1988, Zhang et al 1998). Fatal accidents have been reported during winter season. For instance, a study carried out by Kong et al (1996) has revealed that most of the accidents occur at night or in weekends during the Northern winter (e.g. October to December). Shibata et al. (1994) observes that informal tertiary sector activities along the road side tend to increase exposure risk to traffic accidents. In addition, improved road quality may lead to behavioral adjustments in terms of more risk prone driving (Jorgensen and Abane; 1999).

According to Agoki (1992) the major causes of RTAs were behavioural, environmental, vehicular and governance factors. Agoki (1992) further noted that these factors influenced one another and a single solution or an arbitrary set of un-researched measures cannot resolve the complex issues in RTAs particularly in urban areas like Nairobi. The present study examined to a large extent how environmental factors cause RTAs. The study does not consider how the inter-dependence of the social, environmental and governance factors causes RTAs.

In Kenya, Irandu (1996) observes that development and expansion of road transport system has been revolutionary promoting efficient and quick exchange of goods and services between distant places which would not be accessible by any other cheaper and convenient mode of transport. This development has led to increased road traffic accidents in Kenya. Among the key recommendations proposed by Irandu (1996) are that drivers of Matatus and their proprietors should be well trained and informed on traffic management and made aware of road safety issues. He recommends that roads should be regularly maintained to make them motorable and to reduce road traffic accidents and all road users should be made aware of the importance of road safety in order to minimise RTAs. The recommendation by Irandu (1996) takes cognisance of the fact that there are some environmental and governance factors that to a larger extent affects road safety on our roads in one way or another. The present study examines the environmental factors which affect road safety at road black spots in the City of Nairobi. This is a major departure from studies reviewed so far.

### **1.1.2 Theoretical framework**

This study applies the systems theory in analyzing RTAs. According to Muhlrad et al (2005), explanations of the systems theory are based on human-environment adjustments and maladjustments. Krug et al (2000) distinguish three main components of the systems theory. They are: environmental factors, the means of transport (vehicles) and the behavior of driver (human factors). The environmental component comprises the natural and the built environments and road networks. The means of transport component comprises the volume and quality of vehicles on the road. The behavior of driver/human factors component consists of demographic characteristic of road users (age, sex, education, socio-economic status, stage in life cycle), people's perceptions of risk and people's general behavior on the streets. Integrated in the systems theory is a system of highway codes and enforcement mechanisms designed to ensure that road users adhere to the controls and regulations of traffic flow for maintaining road traffic safety. According to Button (1993) and Haur (1995) comprehensive traffic management should be sufficient to maintain road traffic safety.

A good control of the vehicles on the road depends very much on behavior (which is very complex) and skills of the drivers (CSA1983). Accidents may be due to judgement errors, ignorance, incompetence, rule violation, lapses or carelessness, all of which are human errors. The human factor contributes to the majority of road traffic accidents in many parts of the developing world. Lack of driver training, drug abuse, fatigue and speeding have been reported in literature as contributory factors to RTAs (Orsay et al 1994: .Shibata et al 1994, Zhang et al 1998). Odero (1995) in a study carried out in Kenya also found out that human factors were responsible for 85% of all causes. Available literature points to the fact that adolescents or young drivers are frequently involved in traffic accidents than other age groups (Leon et al, 1996; Bjornskau, 2000).

Vehicle characteristics and vehicle use are also frequently cited in the literature as being potentially important factors contributing to high motor vehicle related fatality rates. Nelson et al (1991; Bener et al (1992). Design of the vehicle, well breaking system of the vehicle, better tyres and extended visibility due to improved lighting of the vehicle reduce risk of accidents.

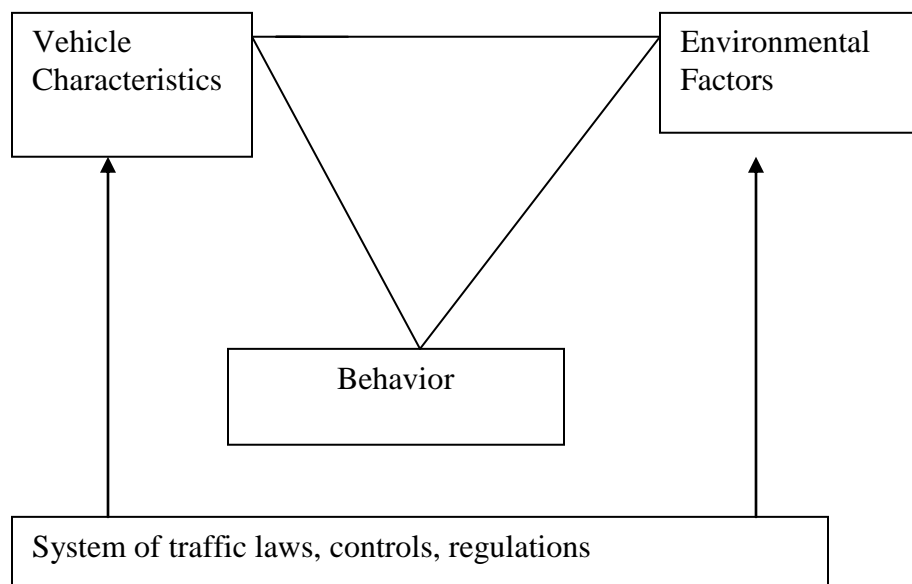
Defects in design or manufacture of vehicle can threaten occupants' safety. Improvement of the interior of the vehicle tends to increase the safety of the occupants (Graham 1993).

Bener et al (1992), (1992), Moen et al (2005) and Lankarani et al (2014) argue that environmental parameters are important contributory factors to RTAs. For example, the physical environment, various climatic threats and geo hazards like heat, fog, high winds, snow, rain, ice, flooding, tomadoes hurricanes, and avalanches have effects on roads hence on traffic accidents. The weather (e.g. heavy tropical rain) also threatens surface transport and impacts road way safety, mobility. It affects road safety through increased crash risk as well as exposure to weather related hazards. Weather impacts roadway mobility by increasing travel time delay, reducing traffic volumes and speeds and reducing roadway capacity. Weather and road conditions in terms of road qualities therefore have a role in the causes of traffic accidents (Komba, 2006).

### 1.1.3 Conceptual framework

The conceptual framework adopted in this study is a multilevel based framework which attempts to address the ways in which the physical or environmental factors influence road traffic crashes (Fig.1). The framework is used to aid understanding of the multiple causes and prevention of traffic accidents that occur in developing cities such as Nairobi. Available literature identifies the causes of traffic accidents in a place as being caused either by physical factors in the road network (environmental factors), the vehicle characteristics or behavior and how they interact with enforcement regulations in unique settings. The conceptual framework investigates risky driving behaviours

**Figure 1: Conceptual Framework**



Source: Modified from Jørgensen and Abane (1999).

## 2.0 Research Methodology

### 2.1 Research design

The methodology for data collection used in the study was based on both qualitative and quantitative methodologies within a framework of a case study approach. Interviews, focus group discussions, observations and review of secondary data, were also done. The study used triangulation to obtain data from multiple sources to adequately address the research objectives from different points of view. Triangulations strengthen reliability and validity of the research.

### 2.2 Study Area

This study was carried out in Nairobi, the capital City of Kenya. It was founded in 1899 as a supply depot for the Uganda Railway which was being constructed between Mombasa and Uganda.

Since then, the city has grown rapidly to become the largest urban centre in East Africa with an estimated population of 4 million people (RoK, 2009). The City has two physiographic regions. The western side is on a higher ground with slightly rugged topography having some river tributary channels, and the eastern side which is generally low-lying and fairly flat. The western side has steep slopes and sharp bends that can affect traffic flow and road safety. The city of Nairobi also experiences some flooding due to poor urban development. These developments tend to reduce infiltration rate and increases surface runoff resulting in flooding. According to Nyambok (1992) flooding affects road conditions which to a large extent increase road accident risk. The road accident black spots in Nairobi are shown in table 1.

**Table 1: Road Accident Black spots in the City of Nairobi**

No.	Road Accident Black spots	Location( Road)	Traffic control (police station)
1	Kasarani GSU stretch	Thika Road	Kasarani Police station
2	Westlands Museum hill roundabout	Waiyaki Way	Parklands Police station
3	Westlands kabete road	Kabete Road	Kasarani Police station
4	Mombasa road between Kencell Headquarters and Cabanas hotel	Mombasa Road	Industrial Area Police station
5	Jogoo road near Maziwa stage	Jogoo Road	Jogoo/Buruburu Police station
6	Waiyaki way near Kangemi fly over	Waiyaki Way	Parklands Police station

Source: Modified from Kenya police website, 2011.

### 2.3 Data collection

The methods of data collection in this study included on-site observations and study of accident scenes and environmental features of road accident black spot sites. The Kenya Police Traffic Department keeps records of traffic accidents in Nairobi. These records provided useful data on road accident black spots in the City. According to the police website, road accident black spots in the City are six, namely Kasarani GSU stretch, Westlands Museum hill roundabout, Westlands kabete road, Mombasa road between Kencell Headquarters and Cabanas hotel, Jogoo road near Maziwa stage and Waiyaki way near Kangemi fly over. The six (6) accident black spots formed the basis for this study. Three black spots were selected using systematic sampling method. Every second black spot was picked for study from the list of six black spots. The road accident black spots are distributed throughout the City which made it difficult for the researcher to cover all of them. But the ones selected were considered representative enough.

Interviews were also held with key informants in the City such as Traffic Commandant in the City and Ministry of Transport and Infrastructure officials. Key informants were selected using purposive sampling. Focus Group discussion (FGD) involving representatives of key stakeholders such as traffic police, PSVs/Matatus drivers, PSV SACCOs, Private vehicle drivers and Traffic police officers in the respective police bases within the sampled road accident black spots. provided additional information on possible black spots and causes of traffic crashes in Nairobi. Focus group discussion group was made up of between 10-15 members.

Questionnaires for public transport operators were administered at the route termini to avoid rushing the respondents. This was done mostly for PSV drivers. The private car drivers were interviewed at road side parking bays and supermarkets parking yards within the road accidents black spot areas. In order to get adequate data from PSV drivers questionnaires, the PSVs CBD Bus tops where driver Interviews were to be done were randomly chosen. These were chosen from the sampled Road Accident Black spots and road locations.

### 2.4 Data analysis

Data was analyzed using Pearson chi-square goodness of fit test. This inferential statistical technique was also used for testing the two hypotheses formulated for the study. Data on observations of the presence of road side activities and their encroachment on the pedestrian sidewalks was also analyzed using descriptive statistics.

### 2.5 Results and Discussion

From table 2, it can be seen that all the 65 respondents interviewed (100 percent) reported that road accidents at black spots in Nairobi occurred during dry weather conditions.

Chi square test cannot be applied where there are cells with zeros in contingency tables. The hypothesis was simply tested using cross tabulation as shown in table 2. Therefore, the null hypothesis was rejected and the alternative hypothesis was accepted. This finding is intriguing because it is not consistent with findings of other similar studies reviewed in this study (Kong et al 1996; Hijar et al, 2000; Mohammed. & Thanaa 2012). It would appear that drivers in Nairobi unlike in other parts of the world are more careful when they encounter wet and slippery road surfaces than dry ones (Bundi, 2015).

**Table 2: Reported Frequency of road traffic accidents based on weather conditions**

Weather condition	Number of accidents	Frequency	Percentages
Wet	0	0	0
Dry	65	65	100
Total	65	65	100

Source: Bundi, 2015

The second hypothesis was tested using Chi-Square test. The results of the chi square test are summarized in table 3. Therefore, the null hypothesis that there is no significant difference between pedestrian accidents and lack of pedestrian road sidewalks was rejected and the alternative hypothesis that there is a significant difference between pedestrian accidents and lack of pedestrian road sidewalks accepted. Results are considered significant at  $p < 0.05$  or 5% of Chi square test of goodness-of-fit.

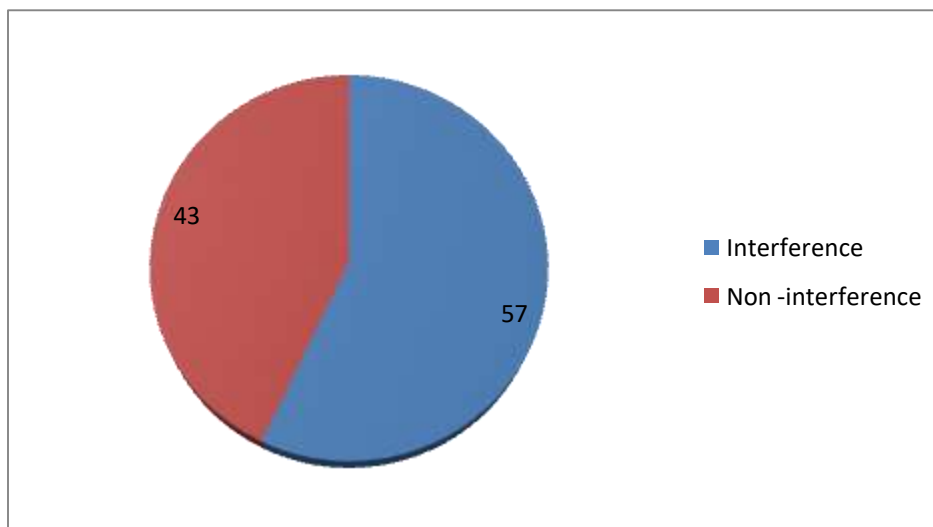
**Table 3: Combining the variables in Pearson chi-square model:**

	Value	df	Assymp.sig (2 sided)
Pearson Chi-Square	.549	2	.760
Likelihood ratio	.956	2	.620
Linear by linear association	.210	1	.647
Number of valid cases	60		

Source: Bundi, 2015

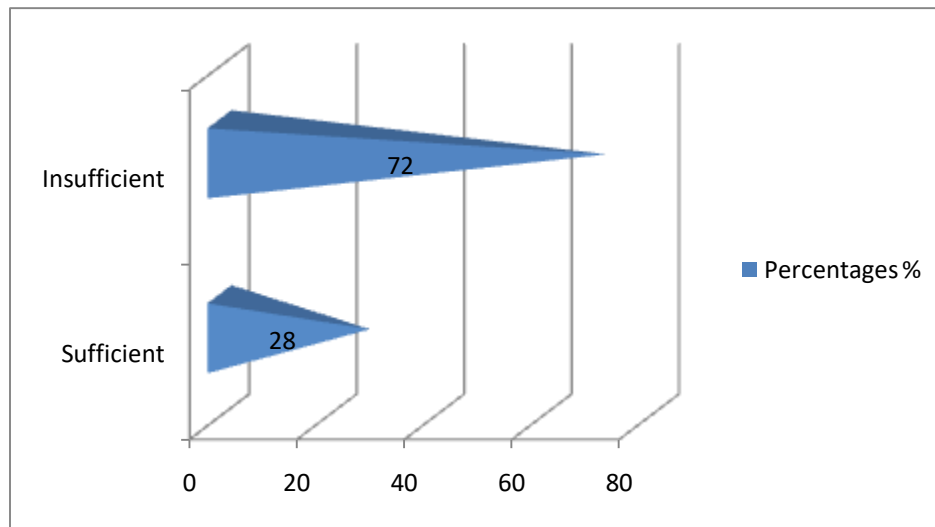
Further analysis shows that in over 56% of the observed occurrences, various road side activities were interfering with motor vehicle flow and in effect interfering with pedestrian walk ways and in 43% of the occurrences there were no interferences (Fig.2). Observations of the availability of pedestrian road crossing facilities along the road black spots are shown in Fig.3. The analysis shows that in 72% of the observed cases, there were no pedestrian fences to channel pedestrians to safe crossing points along the road black spots and in 28% of the cases there were pedestrian fences to channel pedestrians to allow for safe passage. This could be one of the causes of the pedestrian road crashes.

**Figure 2: Road side activity interference with motor vehicle Flow**



Source: Bundi, 2015.

**Figure 3: Available pedestrian crossing facilities situations**



Source: Bundi, 2015.

## 2.6 Conclusion and policy implications

This study used the systems theory as its theoretical framework. The theory was complemented by the conceptual framework, which too was founded on the interrelationships of the main components of RTAs: environmental, behavior and governance factors. These are the key factors identified in literature that are likely to cause RTAs in any place including the City of Nairobi.

In this study, the analysis of the causes of RTAs in the City of Nairobi has revealed that there are some physical/ environmental factors that contribute to road accidents. Some of these environmental factors include poor signage, narrow or wide roads and so on. An important finding in this study is that contrary to conventional knowledge, more road accidents occur on dry road surfaces than on wet road surfaces. This can be attributed to the nature of driving behavior during the wet season when road surfaces become not only wet but slippery. It has also been established that lack of pedestrian facilities and presence of vendors on roadsides tend to contribute to occurrence of road accidents.

The interaction of human road users, the motor vehicles and the prevailing physical environmental conditions if not harmoniously managed can lead to road traffic accidents which in effect contribute to road safety problems and challenges. From the results of this study, it is evident that effective enforcement of traffic rules and regulations is a major governance factor which with strict implementation can reduce RTAs on our roads. But, governance factors are outside the scope of this study.

In order to reduce the exposure to RTAs for road users, the results of this study show that visible road signs, driver speed controls, removal of motorists obstructions of road view and election of road bumps also referred to as ‘sleeping policemen’ are some of the observed physical/ environmental control features that can reduce RTAs on the roads. The results of this study have also shown that pedestrian motor conflicts on the roads and roadsides increases pedestrian road traffic accidents. This is mainly due to the encroachment of roads side activities onto the roads and pedestrian road side walks. This pushes pedestrians onto the roads and makes them prone to road accidents. On the basis of these research findings, some key recommendations have been proposed and are discussed below.

To control pedestrian- motor vehicle conflicts on the roads, the researcher recommends that road infrastructure planners should be giving due consideration to pedestrian walk ways and pedestrian road crossings when planning the roads. This calls for participatory involvement and consultations in road transport planning by all stake holders. This would take care of all road safety issues in the initial planning period and avoid the effects of future road traffic accidents.

Road traffic engineers should take stock of all road accident black spots in the City and identify the areas most prone to RTAs. Some of the recommended measures to address this scourge of RTAs include separation or median separation of incoming traffic with wide central hatching to reduce road collisions, improved road markings and proper signage in accident prone locations. Although expensive to implement, roundabouts are an effective way of reducing the speed of traffic at intersections reducing the likelihood of high speed right-angle collisions.

In this study, no attempt was made to examine the effect of driving behavior or governance factors on road traffic accidents. These can form the basis for further academic research. It would be important to examine the relationship between driving behavior and occurrences of RTAs and whether enforcement of traffic regulations would reduce traffic crashes.

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