Effects of Mixed Traffic on Road Traffic Deaths in Kenya

Grace Wangui Muhoro
Private Sector Development Division
Kenya Institute for Public Policy
Research and Analysis

KIPPRA Discussion Paper No. 172
2014

KIPPRA in Brief

The Kenya Institute for Public Policy Research and Analysis (KIPPRA) is an autonomous institute whose primary mission is to conduct public policy research leading to policy advice. KIPPRA's mission is to produce consistently high-quality analysis of key issues of public policy and to contribute to the achievement of national long-term development objectives by positively influencing the decision-making process. These goals are met through effective dissemination of recommendations resulting from analysis and by training policy analysts in the public sector. KIPPRA therefore produces a body of well-researched and documented information on public policy, and in the process assists in formulating long-term strategic perspectives. KIPPRA serves as a centralized source from which the Government and the private sector may obtain information and advice on public policy issues.

Published 2014

Bishops Garden Towers, Bishops Road
PO Box 56445-00200 Nairobi, Kenya
tel: +254 20 2719933/4; fax: +254 20 2719951
email: admin@kippra.or.ke
website: http://www.kippra.org

ISBN 978 9966 058 42 3

The Discussion Paper Series disseminates results and reflections from ongoing research activities of the Institute's programmes. The papers are internally refereed and are disseminated to inform and invoke debate on policy issues. Opinions expressed in the papers are entirely those of the authors and do not necessarily reflect the views of the Institute.

This paper is produced under the KIPPRA Young Professionals (YPs) programme. The programme targets young scholars from the public and private sector, who undertake an intensive one-year course on public policy research and analysis, and during which they write a research paper on a selected public policy issue, with supervision from senior researchers at the Institute.

KIPPRA acknowledges generous support from the Government of Kenya, African Capacity Building Foundation (ACBF), and the Think Tank Initiative of IDRC.

Abstract

This study seeks to establish the significance of mixed traffic on road traffic deaths in Kenya. Eradication of road traffic deaths is a priority for the Government of Kenya because it imposes socio-economic costs on individuals and the society, including loss of source of livelihood, grief and suffering, loss of productivity, and diversion of resources.

The role of mixed traffic in exposure to risk is less analyzed in developing countries. The study used cross-sectional data obtained from a survey conducted by the Kenya Institute for Public Policy Research and Analysis in 2012. Multinomial logit results for a sample of 612 observations established that buses, lorries, motor cycles and pedestrians increase incidences of death in road traffic crashes. In addition, alcohol, night time and higher speed limits increase incidences of deaths in road traffic crashes. On the other hand, road junctions and use of seat belts reduce incidences of deaths in road traffic crashes.

This study recommends establishment of Public Service Obligation and Level of Service arrangements in the public transport system; tightening compliance on use of safety belts in both public and private vehicles; redesign of roads and intersections; continuous review of speed limits; establishment of rescue centres along road traffic crash hot spots; revocation of driving licenses; and introduction of in-vehicle alcohol interlocks to deter drunken driving.

Abbreviations and Acronyms

ADF	Augmented Dickey Fuller
GoK	Government of Kenya
IMT	Intermediate Means of Transport
INTP	Integrated National and Transport Policy
KENHA	Kenya National Highway Authority
KERRA	Kenya Rural Roads Authority
KNBS	Kenya National Bureau of Statistics
KRB	Kenya Roads Board
KURA	Kenya Urban Roads Authority
NRCS	National Road Safety Council
NRSAP	National Road Safety Action Plan
NTSA	National Transport Safety Authority
PP	Philips Peron
PSV	Public Service Vehicle
SUV	Sport Utility Vehicles
WHO	World Health Organization

Table of Contents

Abstract iii
Abbreviations and Acronyms iv

1. Introduction 1
   1.1 Background 1
   1.2 Motorization and Traffic Mix 3
   1.3 Problem Statement 6
   1.4 Research Objectives 7
   1.5 Research Questions 7
   1.6 Justification and Policy Relevance 7
   1.7 Legal and Institutional Reforms Towards Road Safety in Kenya 8

2. Literature Review 10
   2.1 Theoretical Literature 10
   2.2 Empirical Literature 10
   2.3 Critique of Literature 12

3. Methodology 14
   3.1 Conceptual Framework 14
   3.2 Model Specification 1 15
   3.3 Model Specification 2 16
   3.4 Estimation Technique 17
   3.5 Data Type, Source and Variables 20

4. Results and Discussion 22
   4.1 Results and Discussions for Model 1 22
   4.2 Results and Discussions for Model 2 24

5. Conclusion and Policy Recommendations 30
   5.1 Conclusion 30
   5.2 Policy Recommendations 30
   5.3 Limitations and Areas for Further Study 32

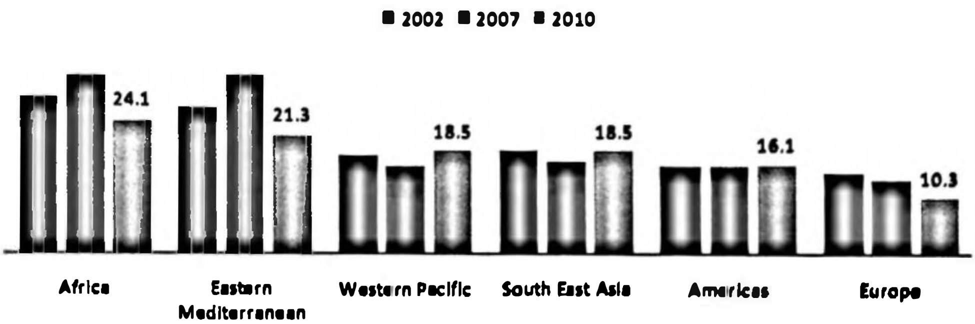
References 33
Appendix 37

1. Introduction

1.1 Background

According to WHO (2004), a road traffic death is commonly defined as a death recorded within 30 days[1] of a road traffic crash; that is, a collision of at least one moving vehicle that may lead to death or injury. Road traffic injuries are a global public health problem; constituting 12 per cent of disease burden. The United Nations (UN) predicts that road traffic injuries will become the fifth cause of death[2] globally by 2030 (WHO, 2009). Accordingly, the UN declared the Decade of Action for Road Safety (2011-2020) aimed at reducing road traffic deaths from 1.3 million to 0.9 million annually. Also, a resolution to have road safety in the post-2015 agenda was recently adopted. The global road traffic death rate is 18 deaths per 100,000 persons. It, however, differs between regions and countries within the same region. Africa has the highest rate at 24.1 deaths per 100,000 persons (16% of global deaths), while Europe has the lowest at 10.3 (WHO, 2013a).

Figure 1.1: Road traffic deaths per 100,000 persons by region, 2002-2010



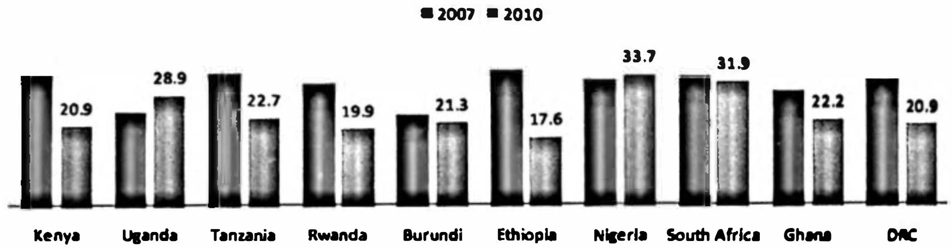
Data Source: WHO (2004, 2009, 2013a)

Figure 1.1 shows the trend in road traffic deaths (RTDs) per 100,000 persons across regions. It shows a decline between 2002 and 2007, with exceptions in Africa, Eastern Mediterranean and Americas. Africa and Eastern Mediterranean registered a rise of 13.78 per cent and 22.43 per cent, respectively, while that of Americas was negligible. In 2007-2010, Africa and Eastern Mediterranean reduced their RTDs per 100,000 persons by 25.15 per cent and 33.85 per cent, respectively, while Europe reduced further by 23.13 per cent. In Africa, Nigeria leads with 33.7 deaths per 100,000 persons. Kenya, Uganda, Tanzania, Ethiopia,

[1] There are definition differences. For example, Greece, Portugal, Spain use 1 day; France, 6 days; Italy, 7 days; Kenya at crash site.

[2] After ischemic heart disease, cerebrovascular disease, chronic obstructive pulmonary disease, and lower respiratory infections.

Figure 1.2: Road traffic deaths per 100,000 persons by country, 2007-2010



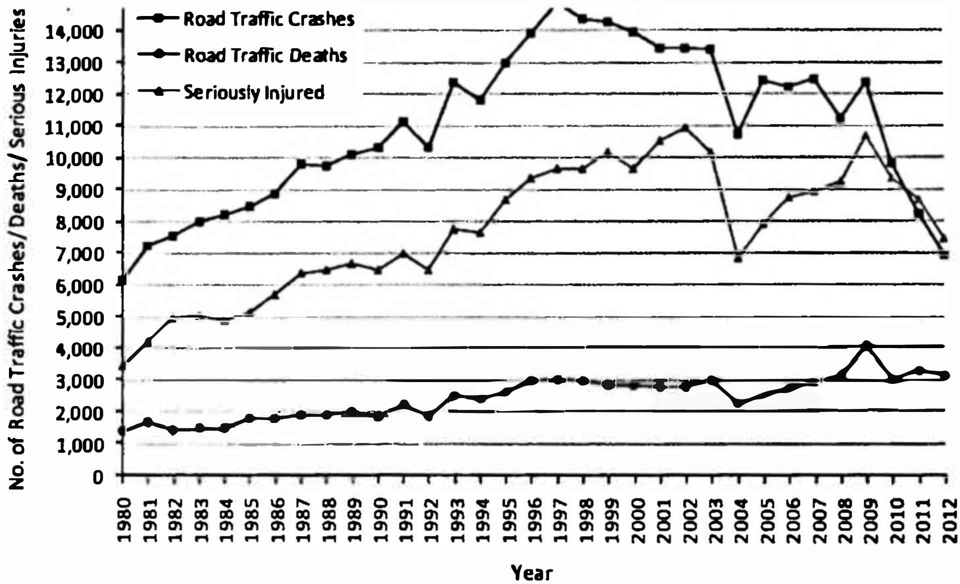
Data Source: WHO (2009, 2013a)

South Africa and Democratic Republic of Congo (DRC) account for 64 per cent of road traffic deaths in the region (WHO, 2013b).

Figure 1.2 shows RTDs per 100,000 persons in selected African countries. From the figure, all countries other than Uganda and Nigeria have made strides in reducing their RTDs per 100,000 persons. The reduction rate differs from country to country. with Ethiopia, Kenya, Rwanda, DRC, Tanzania and Ghana registering the highest declines in that order. Burundi and South Africa had slower reduction rates. Even though Ethiopia is more populated than Kenya, it reduced its RTDs per 100,000 persons by 49.7 per cent, while Kenya reduced its own by 39.2 per cent. Kenya's road traffic death rate of 20.9 is lower than the region's rate of 24.1, but higher than the global rate of 18.0. These numbers are, however, much higher than those from police records (for example, Kenya's 7.74 deaths per 100,000 persons) because the WHO figures are adjusted for the 30 days definition, and and any under reporting of road traffic deaths.

Kenya recognizes road traffic deaths as a huge challenge facing the country and needs urgent intervention. About 3,000 people die annually in Kenya from road traffic crashes at the productive age of 15-44 years (Bachani *et al.*, 2012). An average of 3 per cent and 5 per cent increase in road traffic deaths was recorded annually in the 1980s and 1990s, respectively. In 2000 to 2011, road traffic deaths increased at an annual rate of 2 per cent. Although the percentage increase declined, the actual number of road traffic deaths increased each year (Figure 1.3). In 2010, road traffic crashes accounted for 1.98 per cent of all deaths (Department of Civil Registration, 2010). They are also estimated to have an economic cost of 5 per cent of GDP in form of injuries, disabilities and deaths (Ministry of Transport, 2010). These costs arise from medical treatment, lost production, damage to property, insurance, and traffic administration. Road traffic crashes are a hindrance to social and economic development. They affect the emotional,

Figure 1.3: Road traffic crashes and road traffic deaths, 1980-2012



Data Source: KNBS (Various), Statistical Abstracts, 1981-2013

mental, physical and economic well being of the society in terms of grief, suffering and diversion of resources from productive economic activities.

In light of this, various initiatives (Section 1.7) have been implemented in an effort to reduce road traffic crashes and deaths in Kenya. Nonetheless, a mixed performance has been achieved so far in the fight against road traffic crashes, deaths and injuries (Figure 1.3).

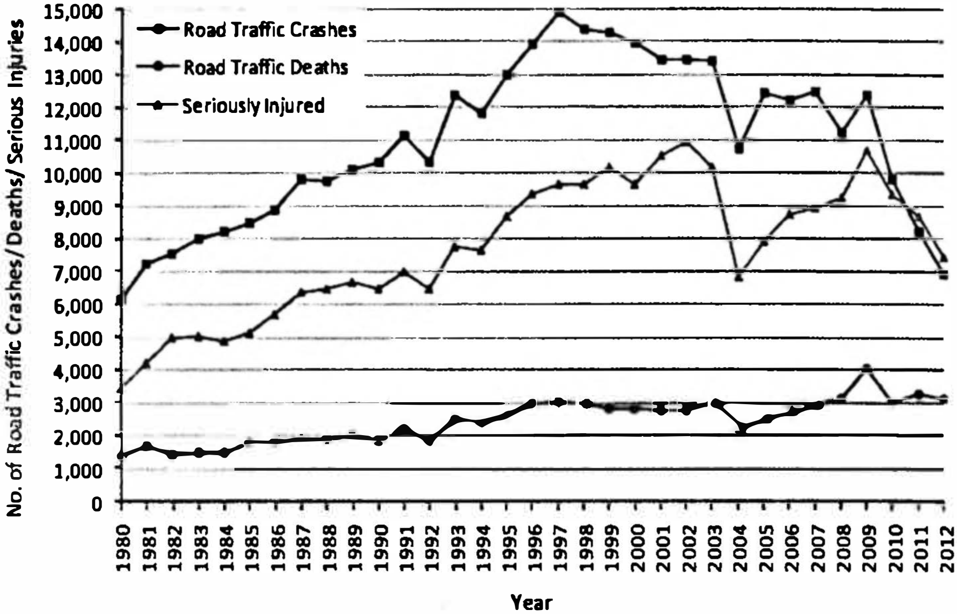
Road traffic crashes registered a downward trend from 14,849 in 1997 to 6,917 in 2012. Undesirably, road traffic deaths remained constant during 1996-2003 and have increased since then except in 2004 and 2010. The decline in 2004 is credited to the enforcement of Legal Notice No. 161. This trend means that recent road traffic crashes are increasingly fatal as indicated by the severity rates in Figure 1.4. Just like RTDs, serious injuries have been on a spiral trend after a sharp decline between 2002 and 2004, but a steady decline has been recorded in the last 3 years.

1.2 Motorization and Traffic Mix[3]

Few developing countries have been able to reduce the number of road traffic injuries in the recent past. Road traffic in such countries is more complex

[3] Traffic mix is the type and make up of various modes of travel that share the same road network (WHO, 2004).

Figure 1.4: Crash and casualty severity rates, 1980-2012



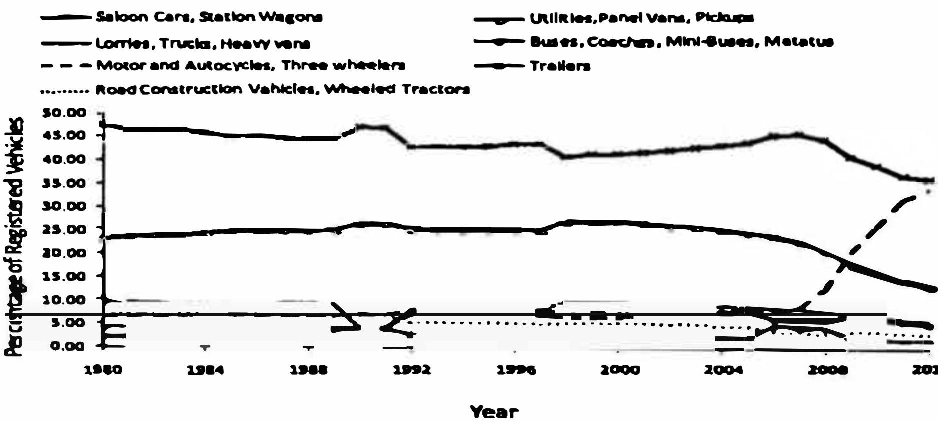
Data Source: KNBS (Various), Statistical Abstracts, 1981-2013

because diverse modes of travel share the same road network and a large number includes motorcycles, three wheelers, bicycles and pedestrians (Mohan, 2002). In developed countries, road traffic is nearly homogenous with 80 per cent of traffic being cars, while in developing countries it is highly heterogeneous with vehicles of different characteristics (Praveen and Arasan, 2013). The differences in size, mass, geometry and structure between different categories of vehicles are major injury risk factors (WHO, 2004). The interactions between fast speed and slow speed traffic increases traffic conflicts and road traffic crashes. Motorization mainly through cars and motorcycles has aggressively been promoted in developing nations, disregarding bus and railway systems (Mohan, 2002).

Cars, buses and trucks are often involved in road traffic crashes with pedestrians, cyclists and motor cyclists. In India, 50 per cent of the road traffic crashes involve buses and trucks with pedestrians (WHO, 2004). In Eastern Germany and Poland, respectively, an additional 1,000 cars caused an additional 2.5 deaths and 1.8 deaths annually between 1989 and 1991 (Vasconcellos, 2005). In Asian countries such as Cambodia, Malaysia, China and Vietnam, the rise in motorcycles and three wheelers has been linked to a drastic increase in road traffic injuries. A 29 per cent increase in motorcycles in 2001 increased road traffic deaths by 37 per cent in Vietnam (WHO, 2004). In India, Grimm and Treibich (2013) found that total road traffic deaths and motorcycle deaths increase with motorization level, but decreased with the share of four wheel vehicles. On the other hand, pedestrian deaths increase with both motorization level and share of four wheel vehicles.

In Kenya, the traffic situation is complex, with seven different categories of vehicles (Figure 1.5) competing for road space with pedestrians and cyclists. The mixed performance in road safety indicators is partly due to rapid motorization, especially in intermediate means of transport (IMT).[4] According to Smith (1999), countries with relatively high proportions of pedestrians, motor cyclists and cyclists in traffic, are expected to have high road traffic death rates compared to those with relative low proportions. Over the last decade, there has been a significant increase in the number of motorcycles and motor tri-cycles on the roads. A major reason for increased popularity is a tax waiver on the motorcycle in 2007. The zero-rating of the motorcycle by the VAT Act (2007) increased its affordability and stirred up its popularity as a means of travel. Annual registrations of motorcycles expanded from 1,136 in 2000 to 93,970 in 2012 (Kenya National Bureau of Statistics, 2002 and 2013). As at 2012, motorcycles and three wheelers constituted 34 per cent of registered vehicles after saloon cars and station wagons at 36 per cent. All other categories of vehicles registered a decline in their shares as depicted in Figure 1.5.

Figure 1.5: Trends in motorization by vehicle category, 1980-2012



Data Source: KNBS (Various) Statistical Abstract, 1981-2013

With the new face of motorization, road traffic deaths are bound to increase because the intensity of mixed traffic affects exposure, crash risk and injury risk (WHO, 2004). From Figure 1.4, the increase in severity rates from 2005-2012 coincides with the growth of motorcycles and three wheelers (Figure 1.5). Table 1.1 indicates that motorcycles and three wheelers are responsible for 10.45 per cent

[4] IMT is defined by Integrated National Transport Policy as low engine capacity vehicles such as motorcycles and three wheelers.

of road traffic crashes in 2009 compared to 2.85 per cent in 2000. Buses are also blamed for more road traffic crashes from 7.71 per cent to 12.85 per cent.

Table 1.1 Vehicles primarily responsible in road traffic crashes, 2000 and 2009

Vehicle category	2000	2009	Vehicle category	2000	2009
Cars and utilities	30.27	27.75	Bicycles	7.22	6.55
Matatus	18.85	16.97	Trailers, tankers and tractors	3.37	3.88
Buses	7.71	12.85	Not known	5.49	3.19
Motorcycles and three wheelers	2.85	10.45	Tourist vans and taxis	2.75	1.23
Persons	13.60	9.13	Animals, hand and animal carts	1.02	0.59
Lorries	6.87	7.42			

Data Source: Kenya Police Traffic Headquarters, 2000-2013

Therefore, policy makers are faced with the challenge of enforcing the best mix of traffic that reduces exposure to risk, while addressing the country's mobility. Limited studies have been undertaken on the effects of mixed traffic on road traffic crashes and injuries (Tay, 2003; White, 2004; Anderson, 2008; Cooper *et al.*, 2009; Fredette *et al.*, 2008; Schepers and Heinen, 2013). Nevertheless, these studies focus on developed countries whose nature of traffic is different from developing countries such as Kenya. This study fills the gap by examining the effects of mixed traffic on road traffic deaths in Kenya.

1.3 Problem Statement

The Government of Kenya has in the past established various legislations and policies to reduce road traffic crashes and injuries, including the National Road Safety Action Plan, Integrated National Transport Policy, Traffic (Amendment) Act 2012, Legal Notice No. 161 and 138 known as the Michuki rules and alcoblow regulations. Despite various initiatives, Kenya failed to achieve its National Road Safety Action Plan target of reducing road traffic deaths by 5 per cent annually for the duration 2005-2010 and is unlikely to realize it for the period 2009-2014. The severity rates have doubled in the recent past at 45.4 deaths per 100 crashes and 20.1 deaths per 100 casualties. In addition, the current road traffic rate of 20.9 deaths per 100,000 persons is high compared to Africa's lowest and global rates of 11.4 deaths and 18 deaths per 100,000 persons, respectively. Based on these estimates, Kenya is ranked 21st out of 44 countries (minus Algeria and Eritrea) in the African region (WHO, 2013b).

Consequently, families and the society have adversely been affected through loss of source of livelihood, mental and emotional suffering, lost productivity, and diversion of resources from productive economic activities to medical costs and funeral expenses. Since most victims are bread winners and heads of families, road traffic deaths are also associated with displacement of families, deteriorating living conditions , and orphaned and vulnerable children. Despite strides made in averting road traffic crashes, little attempt has been made to investigate the factors that have led to increased death rates, specifically the role of mixed traffic. This study seeks to provide an empirical analysis on the effects of mixed traffic on road traffic deaths in Kenya.

1.4 Research Objectives

The general objective of this study is to assess if mixed traffic has a significant effect on road traffic deaths in Kenya. Specifically, the study seeks to determine the effects of mixed traffic on road traffic deaths in Kenya.

1.5 Research Questions

The research intends to answer the following question: to what extent does mixed traffic explain the number of road traffic deaths in Kenya?

1.6 Justification and Policy Relevance

At the moment, the Kenyan government is redefining the road safety strategies and streamlining the road transport system in an attempt to reduce incidences of road traffic crashes and injuries. This creates an opportunity to provide evidence-based information to such new strategies, policies and legislations. This study is timely in the wake of the controversial alcoblow and night ban travel regulations meant to reduce road traffic crashes and injuries. The negative impacts of road traffic crashes not only affect Kenya's economic growth but also its competitiveness within the East African Community (EAC). Thus, reducing road traffic crashes is critical to unlocking resources for productive economic activities. Whereas motorization has social benefits, it is a source of social costs in form of road traffic injuries. This study explains the relationship between mixed traffic and road traffic deaths in Kenya. New knowledge on the effects of mixed traffic will guide policy makers on the best mix of traffic that reduces exposure to risk, while addressing mobility needs. The study results will contribute to the National Road Safety Programme, a flagship project of Vision 2030 that aims to reduce road traffic crashes and injuries.

1.7 Legal and Institutional Reforms towards Road Safety in Kenya

The Government of Kenya is a key player in road transport sector by virtue of legislative, regulatory, policy and financing responsibilities, through the Ministry of Transport and Infrastructure. Other key players in the sector include the Kenya Traffic Police, the National Transport and Safety Authority (NTSA), Kenya Roads Board (KRB), Kenya National Highways Authority (KENHA), Kenya Urban Roads Authority (KURA), and Kenya Rural Roads Authority (KERRA). Enforcement of traffic laws and regulations is by the Kenya Traffic Police. The role of NTSA is to register, license, inspect and certify motor vehicles; regulate public service vehicles; undertake road safety education and research; and train, test and license drivers. The KRB oversees and coordinates the development, rehabilitation and maintenance of the country's road network, while KENHA, KURA and KERRA are responsible for development, rehabilitation and maintenance of national roads, urban public roads and rural roads, respectively.

In Kenya, various reforms have been carried out to improve the management of the road transport sector as well as improve road safety; these reforms include institutional and legal reforms. In the early 1970s, the Kenya Police began traffic training and established the traffic department and highway patrol system (Asingo and Mitullah, 2007). Kenya and Finland then jointly established a road safety programme (1979-1988) that included law enforcement, driver and first aid training, accident investigation, vehicle inspection and road safety research (Odengo, Khayesi and Heda, 2003; Asingo and Mitullah, 2007). Through a Gazette Notice in 1982, the National Road Safety Council of Kenya (NRSCK) was formed to develop and implement a national road safety policy and coordinate road safety organizations (Odero, Khayesi and Heda, 2003; Asingo and Mitullah, 2007). The NRSCK developed the first National Road Safety Programme for the period 1984-1993 targeting 30 per cent reduction in road traffic deaths from 1,515 in 1983 to less than 1,000 deaths by 1993. In 1986, Legal Notice No. 361 introduced the use of seat belts in motor vehicles.

Fast forward to 2003, Legal Notice No. 161 commonly known as the "Michuki rules" required safety belts and speed governors to be fitted in commercial and Public Service Vehicles (PSVs). It also sought mandatory certification of drivers and conductors. The year 2005 saw the introduction of "alcoblow"[5] to test drivers for drunken driving but was later withdrawn for lack of legal backing. Also, the National Road Safety Action Plan (NRSAP) 2005-2010 was formulated with a target of 5 per cent reduction in road traffic deaths per annum, a total of 50 per cent by 2010. Strategies such as road safety coordination, road safety funding,

[5] Alcoblow is a breath test gadget that measures the level of alcohol concentration in the breath.

road safety research, road expansion and enhancement, traffic legislation and enforcement, and road safety awareness were implemented to try and achieve the target. Again, the NRSAP 2009-2014 was formulated with the same target of 5 per cent reduction in road traffic deaths annually. By 2010, there were 3,055 road traffic deaths (KNBS, 2011) compared to the 1,958 deaths targeted by the 2005-2010 NRSAP.

The Ministry of Transport then launched the Integrated National Transport Policy (INTP) that aims to achieve an efficient, affordable, reliable, safe, secure, integrated and sustainable road transport system (Ministry of Transport, 2009). In 2011, the 'alcoblow" was reintroduced through Legal Notice No. 138. The Government of Kenya then established the NTSA through the National Transport and Safety Authority Act 2012. NTSA aims to provide safe, reliable and efficient road transport system through implementation of road safety policies and coordination of organizations dealing with road safety. Additionally, the Traffic (Amendment) Act 2012 was enacted to address reckless driving through imposition of heavy fines to offenders.

Recently, in late 2013, Legal Notice No. 219 established new stringent conditions for licensing and operating PSVs, long distance passenger PSVs, and night time long distance passenger PSVs. These include a limit of eight working hours per day and regular salary for drivers and conductors, adoption of fleet management and data storage system, no cargo carriers, and employment of two drivers for long distance PSVs.

Reforms in the road transport sector have had most progress towards addressing road traffic crashes and least progress in reducing road traffic deaths. Like most countries, Kenya has mostly focused on road users in addressing road safety. Although this is justified on the basis that most road traffic crashes occur due to human error, the design of vehicles and roads must account for human physical vulnerability and tolerance to injury so that road traffic crashes do not result in road traffic deaths and severe injuries. This is recognized in the Decade of Action Plan, which adopts the system approach and calls for more emphasis on vehicles and roads (WHO, 2010).

2. Literature Review

2.1 Theoretical Literature

2.1.1 Systems theory

This theory was developed by John Dunlop in 1958. It propagates that road traffic crashes occur from interactions between vehicles, roads, road users and the environment (physical and socio-economic). In systems approach, road traffic crashes are a failure of the entire road traffic system and not a failure of its elements (vehicles, roads, road users or environment). It identifies the underlying causes, the role of various agents and tries to mitigate the outcomes of road traffic crashes. The systems approach recognizes human error and vulnerability to injury. The likelihood of a road traffic crash is determined by the interactions in the road traffic system. Those between vehicles and road users are man-machine factors, whereas those between roads and road users are human factors. Changes in the patterns of interactions increase or reduce the probability of a road traffic crash. Understanding the interactions is essential in improving the safety of a road traffic system.

2.1.2 Exposure, crash risk and injury risk theories

Road traffic deaths and injuries are a function of exposure, crash risk and injury risk (Al-Haji, 2007; Elvik *et al.*, 2009). Exposure is the amount of travel in which road traffic crashes may occur. It can be measured by kilometres travelled or traffic volume; and it is determined by economic factors, demographic factors, motorization level, travel mode choice, traffic volume, traffic mix and land use planning (WHO, 2004). Crash risk is the probability of a crash given exposure and it is influenced by risk factors such as age, speed, alcohol, vehicle factors, road factors, weather and illumination (WHO, 2004). Road traffic crashes result in injuries when excess energy is exchanged between roads, vehicles and road users (Schepers *et al.*, 2014). The probability of death or injury given a crash is known as injury risk or injury severity. The risk factors include tolerance factors (age, health, and physique), inadequate vehicle crash protection, non-use of vehicle crash protection (seat belts, child restraints and helmets), and insufficient roadside crash protection (WHO, 2004). In addition to exposure, crash risk and injury risk, risk factors such as availability of rescue and evacuation services, first-aid and emergency care determine the injury outcome in the post-crash phase.

2.2 Empirical Literature

Limited studies have investigated the relationship between mixed traffic and road traffic crashes, deaths and injuries. Tay (2003) found that an increase in vehicles that are less friendly to passenger cars is likely to increase fatal crashes. A 1 per cent increase in trucks, sport utility vehicles/vans, and motorcycles increases the number of fatal crashes by 1 per cent, 1.26 per cent and 1.64 per cent, respectively, while a 1 per cent increase in cars and buses reduces the number of fatal crashes by 0.30 per cent and 3.96 per cent, respectively. The Australian analysis used Ordinary Least Squares and Poisson model. Negative Binomial results of Anderson (2008) in United States showed that a 1 per cent increase in light truck share (pick ups, sport utility vehicles and vans) increases road traffic deaths by 0.34 per cent annually, of which 20 per cent occur among light truck occupants and 80 per cent among other vehicle occupants and pedestrians. Weighted Least Squares method produced a similar result, although the effect of a 1 per cent increase in light truck share on road traffic deaths reduced to 0.29 per cent.

Similar results were achieved by White (2004), Fredette *et al.* (2008) and Anderson (2008) using logistic regression. They established that light trucks increase the probability of death or serious injury to other road users or own occupants. White (2004) found that an extra 4.3 fatal crashes are reported in United States among cars, pedestrians, cyclists and motorcyclists for each fatal crash that is averted among sport utility vehicles and pick ups. In Canada, the probability of death or serious injury is higher when driving a pick up or when in a crash with a heavy truck or pick up (Fredette *et al.*, 2008). Anderson (2008) found that in the event of a road traffic crash, light trucks increase the risk of death to other road users or to own occupants by 20 per cent to 97 per cent depending on the type of crash.

Using multivariate linear approach, Cooper *et al.* (2009) found that in British Columbia, a shift from sport utility vehicles, pick ups and vans to passenger cars decreases injuries by 1 per cent but increases deaths by 3.5 per cent. Ayati and Abbasi (2011) found that passenger cars increase the likelihood of no injury crashes but are unimportant in the likelihood of serious injury and fatal crashes. On the other hand, taxis, pick ups and motorcycles increase the likelihood of no-injury, serious injury and fatal crashes, while trucks, trailers, buses, minibuses are unimportant in the likelihood of road traffic crashes. The Iran study used Poisson and Negative Binomial.

Other studies investigated the effects of motorcycles on road traffic crashes, deaths and injuries. Christie and Newland (2001) used descriptive analysis to examine the relationship between motorcycle sales and motorcyclist deaths in Australia. They established that deaths reduced for riders aged below 25, but increased for those above 25 because 65 per cent of motorcycle sales were large capacity motorcycles purchased by older riders, whose riding skills may be outdated due to infrequent riding. In a China study, Zhang *et al.* (2004) applied linear regression and established that motorcycles as a proportion of vehicle population had a positive correlation with both motorcycle deaths and motorcycle injuries as a proportion of total casualties.

According to Vasconcellos (2012), an additional 1,000 motorcycles in Brazil caused 1.24 additional deaths and 3 additional injuries annually. Thus, an additional death resulted from the sale of 809 motorcycles, while 366 motorcycles sold caused an additional injury. A multiple regression study by Aderamo and Olatujoye (2013) carried out in Nigeria found that motorcycle population had a direct relationship with motorcycle deaths and an inverse relationship with motorcycle injuries. The study also found that road length reduces both deaths and injuries.

Schepers and Heinen (2013) investigated the effect of a shift from cars to bicycles on road traffic deaths and serious injuries in Netherlands. Overall, the change in the number of road traffic deaths was insignificant, while the number of serious injuries increased with the modal shift because of single bicycle crashes. However, the number of road traffic deaths increased if the shift was among old drivers above 65 years, and decreased if the shift was by drivers aged 18-64 years. The study applied Negative Binomial models.

Other risk factors include population, unemployment rate, alcohol, safety belt use, safety belt laws, driver's age and gender, speed, time, day, location of crash and road design. Population has a direct relationship with road traffic deaths while unemployment rate has an inverse relationship (Anderson, 2008; Aderamo and Olatujoye, 2013). In addition, alcohol consumption increases the likelihood of death, while safety belt laws and safety belt use reduce its chances (White, 2004; Anderson, 2008; Fredette *et al.*, 2008). White (2004) and Fredette *et al.* (2008) found that the risk of death increases with higher speed limits, old and male drivers, but surprisingly decreases with young male drivers (White, 2004). At the same time, the risk of death or serious injury increases with female drivers and older drivers (Fredette *et al.*, 2008). On the other hand, Cooper *et al.* (2009) established that the risk of death increases with young drivers and female drivers. Road traffic crashes that occur at night, on weekends, in cities and along divided and interstate highways are likely to cause death (White, 2004; Cooper *et al.*, 2009).

2.3 Critique of Literature

Most studies focused on effects of mixed traffic on road traffic crashes and injuries in developed nations rather than developing ones. This draws attention to the limited studies on the effects of mixed traffic on road traffic deaths in developing nations, despite road traffic being highly heterogeneous in these nations. This study fills this research gap by assessing the significance of mixed traffic on road traffic deaths in the Kenyan context.

These studies used different data types, variables and methodologies. They mainly used cross-sectional and time series data, but Anderson (2008) also used panel data in addition to cross sectional data. Crash level micro data was cross sectional, while country level macro data was time series or panel in nature. Count models (Poisson and Negative Binomial) and logistic models were the main methodologies applied in the studies. Tay (2003) and Anderson (2008) also utilized Ordinary Least Squares and Weighted Least Squares methods, respectively, in addition to count models. On the other hand, some studies (Cooper *et al.*, 2009; Zhang *et al.*, 2004; Aderamo and Olatujoye, 2013) only used linear regression in their analysis. Over the years, linear regression has been found to be inappropriate in count data (non-negative integer values) analysis because road traffic crashes and injuries may not follow a normal distribution.

In general, most studies agreed that trucks, sport utility vehicles, pick ups, vans and motorcycles are the least safe vehicles on the roads to own occupants and other road users, while cars, buses and bicycles are the safest. Driving a truck, pick up, sport utility vehicle, van and motorcycle or being in a crash with them is associated with higher probability of death or serious injury.

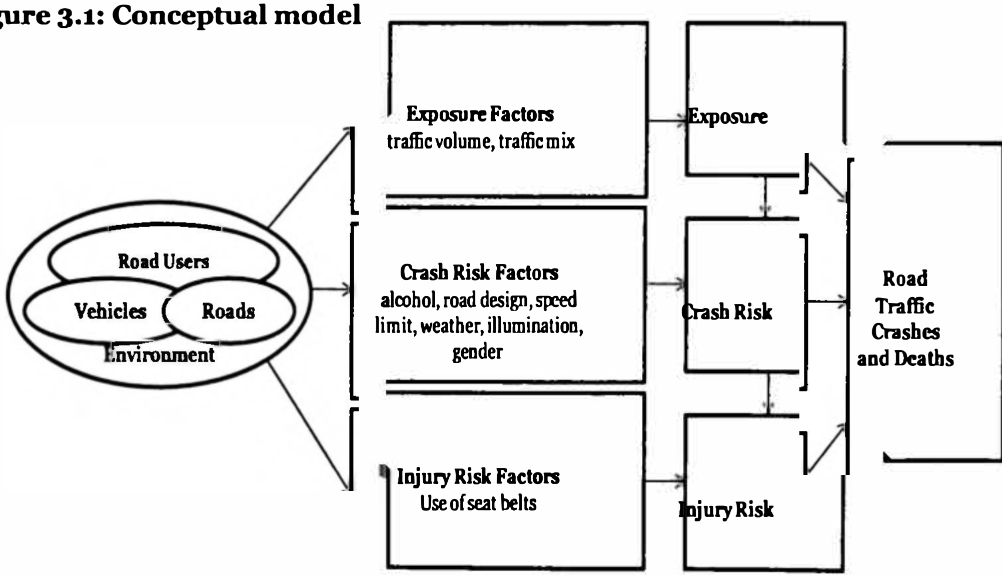
This study contributes to literature by analyzing the effects of mixed traffic on road traffic deaths in Kenya. Following Anderson (2008), this study will analyze both crash level micro data and country level macro data so as to enrich the results and policy recommendations.

3. Methodology

3.1 Conceptual Framework

The model as shown in Figure 3.1 is conceptualized from systems theory, exposure, crash risk and injury risk theories. These theories advance that factors associated to interaction of vehicles, road users, roads and environment influence exposure, crash and injury risk, which result in road traffic crashes and deaths. Road traffic crashes result in road traffic deaths when the energy transferred to the victims exceeds the human body tolerance to injury (Schepers *et al.*, 2014). Travel to work, school or for leisure exposes one to risk in road traffic. Travel mode choice, traffic volume and traffic mix determines exposure to risk in traffic (Schepers *et al.*, 2014). Alcohol consumption impairs and affects the vigilance of road users, hence increases the risk of a crash and injury. In addition, road design features such as tarmac, junctions and road width may increase or decrease the risk of a crash. On the other hand, bad weather and night time reduce visibility, hence increase in the risk of a crash, while the use of seat belts is expected to reduce the injury risk. The model excludes the post-crash phase in which availability of rescue and evacuation, first-aid and emergency care, determine the injury outcome. This is omitted due to unavailability of data to measure these variables effectively.

Figure 3.1: Conceptual model



3.2 Model Specification 1

The dependent variable is the number of road traffic deaths. The main independent variables of interest include modal traffic of saloon cars and station wagons; utilities, panel vans and pick ups; lorries, trucks, heavy vans and trailers; buses, coaches, minibuses and matatus; and motorcycles and three wheelers expressed as a percentage of total traffic. Other independent variables include monthly indicators for March, April and May, which capture seasonal effects of long rains and Easter holiday, and for October, November and December capturing seasonal effects of short rains and Christmas holiday. The model can be represented as:

$RTD = f(Q_i, x_i, \varepsilon)$ .... (1)

Where: *RTD* is the number of road traffic deaths,

Q_i is a vector of factors influencing exposure,

x_i is a vector of factors influencing crash and injury risk, and

ε is a vector of unknown factors that influence exposure, crash and injury risk.

Q_i represents modal traffic of saloon cars and station wagons (SCSW); utilities, panel vans and pick ups (UPVP); lorries, trucks, heavy vans and trailers (LTHVT); buses, coaches, minibuses and matatus (BCMM); and motorcycles and three wheelers (MACTW) expressed as a percentage of total traffic. x_i includes monthly indicators for March, April and May capturing seasonal effects of long rains and Easter holiday (MAM), and for October, November and December capturing seasonal effects of short rains and Christmas holiday (OND).

The relationship between the dependent variable and independent variables is assumed to be non-linear. This is because of Poisson distribution features of the dependent variable and the relationship between exposure and risk. Studies have shown that when traffic increases by 1 per cent, the number of injuries and fatal crashes increase by 0.8 per cent and 0.25 per cent, respectively (Elvik and Vaa, 2004). This is known as non-linearity of risk. It holds that road traffic crashes and injuries increase proportionally less with increase in traffic beyond a certain amount (Elvik, 2009). This explains the exponential relationship between Q_{it} and β_i in equation 2, such that if $\beta_i=1$, the increase in road traffic deaths is proportional to increase in traffic (linear); $\beta_i>1$, the increase in road traffic deaths is greater than the increase in traffic; $\beta_i<1$ the increase in road traffic deaths is less than the increase in traffic. Hence, road crash modeling equation 1 is expressed as:

$RTD_t = \alpha Q_{it}^{\beta i} e^{\Sigma b_j x_{jt}}$ .... (2)

where: RTD_t is the number of road traffic deaths during month *t*,

Q_{it} is a vector of exposure factors during month *t*,

α is a scaling constant,

x_{jt} is a vector of crash risk and injury risk factors during month *t*,

β_i represents effects of exposure factors on road traffic deaths,

b_j represents effects of risk factors on road traffic deaths,

i is the number of exposure variables, and

j is the number of risk factors.

Replacing Q_{it} and x_{jt} with study variables generates equation 3:

$$RTDt = \alpha SCSW_t^{\beta_1} UPVP_t^{\beta_2} LTHVT_t^{\beta_3} BCMM_t^{\beta_4} MACTW_t^{\beta_5} e^{b_1 MAM_t + b_2 OND_t} \quad \text{..................(3)}$$

Taking logarithms in equation 3 and using coefficient symbol β, it can be presented as:

$$Log\ RTD_t = \beta_0 + \beta_1 SCSW_t + \beta_2 UPVP_t + \beta_3 LTHVT_t + \beta_4 BCMM_t + \beta_5 MACTW_t + \beta_6 MAM_t + \beta_7 OND_t + \varepsilon \quad \text{....................(4)}$$

From equation 4, the model estimated is defined explicitly as:

$$RTD_t = e^{\beta_0 + \beta_1 SCSW_t + \beta_2 UPVP_t + \beta_3 LTHVT_t + \beta_4 BCMM_t + \beta_5 MACTW_t + \beta_6 MAM_t + \beta_7 OND_t + \varepsilon} \quad \text{......... (5)}$$

3.3 Model Specification 2

The dependent variable type of injury takes on three possibilities: death, serious injury or slight injury. The probability of death, serious injury or slight injury is dependent on category of person injured (driver, motor cyclist, passenger, pedestrian, pillion passenger), vehicle participants (saloon car, pick up van, bus, lorry, trailer, matatus, motorcycle, pedestrians), gender of person injured, road design (road surface, road width, road intersection), and road environment (speed limit, seat belt use, alcohol, weather, illumination). The model can be represented as:

$$I = f(Q_i, x_i, \varepsilon) \quad \text{....................(6)}$$

where: I represents the type of injury sustained (death, serious injury or slight injury),

Q_i is a vector of factors influencing exposure,

x_i is a vector of factors influencing crash risk and injury risk, and

ε is a vector of unknown factors that influence exposure, crash risk and injury risk.

Q_i represents vehicle participants (VP) including saloon car, pick up van, bus, lorry, trailer, matatus, motorcycle, other vehicles and pedestrians.

x_i includes category of person injured (CPI), namely cyclist, driver, motor cyclist, passenger, pedestrian, pillion passenger; gender of person injured (GPI); road design (road surface-RS); road width (RW); road intersection (RI); and road environment (speed limit, SL; seat belt use, SB; alcohol, A; weather, W and illumination, ILL).

Replacing equation 6 with the study variables gives equation 7 below:

$$I=\beta_0+\beta_1 CPI+\beta_2 VP+\beta_3 GPI+\beta_4 SB+\beta_5 SL+\beta_6 RS+\beta_7 RW+\beta_8 RI+\beta_9 A+\beta_{10} W+\beta_{11} ILL+\varepsilon \quad \text{.......... (7)}$$

3.4 Estimation Technique

From literature review, there are two approaches mainly used in road crash modelling. First, the application of count models (Poisson and Negative Binomial) if the dependent variable is a non-negative integer (number of road traffic crashes, deaths or injuries). Second, the use of logit models, if the dependent variable is binary (death or injury); or multinomial logit models, if the dependent variable is multinomial (death, serious injury, slight injury).

In model 1, the response variable takes non-negative integer values (number of deaths), hence it requires the use of count models such as Poisson regression model (Cameron and Trivedi, 2005). In the Poisson model, observation t of the dependent variable y_t is a random variable with Poisson distribution and mean μ_t, which must be positive (Cameron and Trivedi, 2005).

$$P(y_t)=\frac{e^{-\mu_t}\mu_t^{y_t}}{y_t!}, t=1,2..n \quad \text{.......... (8)}$$

where: e is the exponential function or the base of natural logarithms, e = 2.71828; and μ_t is the expected value of the random variable y at year t.

In this model, the conditional mean equals the conditional variance (conditional on independent variables x_t). This is known as equi-dispersion (Cameron and Trivedi, 2005). The expected value of y_t given x_t can be expressed as μ_t as a function of x_t.

$$E(y_t|x_t)=V(y_t|x_t)=\mu_t=e^{x_t'\beta} \quad \text{.......... (9)}$$

where β is a vector of unknown regression coefficients, and x_t is a vector of independent variables including a constant.

The log likelihood of the Poisson model is given by taking the logarithm of equation (8)

$$L = \sum_{i=1}^{n} ln \frac{e^{-\mu_t} \mu_t^{y_t}}{y_t!} = \sum_{i=1}^{n} [-\mu_t + y_t \, ln\mu_t - lny_t] \qquad (10)$$

The regression coefficients are estimated using the Maximum Likelihood Estimation technique. To obtain the regression coefficients by Maximum Likelihood Estimation technique, the derivative of the log likelihood with respect to β is equated to zero.

$$\frac{dL}{d\beta} = \sum_{i=1}^{n} (y_i - e^{X_i'\beta}) x_i = 0 \qquad (11)$$

In model 2, the dependent variable takes on three outcomes (value of 1 for death, 2 for serious injury, and 3 for slight injury); therefore, it requires the use of the unordered dependent models such as multinomial logit (Greene, 2000). The multinomial logit model assumes that the error components are extreme-value distributed (rather than normally distributed), and are identically and independently distributed across outcomes and observations (Greene, 2000). If there are k outcomes for the dependent variable y, the probability that the response for the i[th] observation is the j[th] outcome is given as:

$$\Pr(y_i = j) = \frac{\exp(V_i)}{\sum_{j=1}^{k} \exp(V_j)} \qquad (12)$$

Based on the injury outcomes examined in this study, equation (12) can be re-written as:

$$\Pr(y_i = j) = \frac{\exp(V_i)}{\sum_{j}^{3} = DEATH, SERIOUS, SLIGHT^{\exp(V_j)}} \qquad (13)$$

Equation (13) means that the probability of one of the injury outcomes is a function of the deterministic value of that injury, and the sum of the deterministic value of all the injury outcomes.

In practice, the deterministic component of the value takes the form $\beta'_j x_{ij}$ Therefore, the probability of any of the injury outcomes can be re-written as:

$$\Pr(ij) = \frac{e^{\beta'_j x_i}}{\sum_{j}^{3} = DEATH, SERIOUS, SLIGHT^{\beta'_j x_i}} \qquad (14)$$

The problem with estimating equation 14 is that the model is unidentified, in that there will be more than one solution to the coefficients, leading to the same probability for each of the alternatives (Greene, 2000). This problem is overcome by setting one of the coefficients equal to zero. This is equivalent to setting one of the outcomes as the reference category. In this study, the "slight injury" outcome is the reference category.

Multinomial logit is estimated by Maximum Likelihood technique. The coefficient values obtained should maximize the log likelihood function. The likelihood function is:

$$L(\beta) = \prod_{i=1}^{N} \prod_{j=1}^{k} p_{ij}^{yij} \quad \text{(15)}$$

Taking the logarithm of equation 15 gives the log likelihood function:

$$LL(\beta) = \sum_{i=1}^{N} \sum_{j=1}^{k} I_j(y_i) \ln p_{ij} \quad \text{(16)}$$

where p_{ij} is similar to equation 14 and $I_j(y_i)$ is an indicator which takes the value of 1, if $y_i = j$ and 0 otherwise.

The coefficients obtained from the multinomial logit model explain the changes in the logarithm of the ratio between the probabilities of the outcome and the base categories as a result of a unit change in each explanatory variable.

$$ln\left[\frac{\Pr(y = DEATH, SERIOUS)}{\Pr(y = SLIGHT)}\right] = \beta_0 + \beta_1 CPI + \beta_2 VP + \beta_3 GPI + \beta_4 SB + \quad \text{(17)}$$
$$\beta_5 SL + \beta_6 RS + \beta_7 RW + \beta_8 RI + \beta_9 A + \beta_{10} W + \beta_{11} ILL + \varepsilon$$

The sign of the estimated coefficient shows the direction of change in the log of the relative risk ratio. The relative risk ratio is the ratio of the probability of the outcome category and the probability of the base category. The relative risk ratio is obtained by taking the exponent of the coefficients, which removes the logarithm from equation 17 and gives the ratio of the probabilities of the outcome and base categories. Coefficients with negative signs usually have the relative risk ratio less than 1, whereas coefficients with positive signs have the relative risk ratio greater than 1. If the relative risk ratio is greater than 1, the variable favours the outcome category. On the other hand, if the relative risk ratio is less than 1, the variable favours the base category (Greene, 2000).

3.5 Data Type, Source and Variables

For model 1, the study uses monthly time series data for the period 2006-2012 from the Kenya National Bureau of Statistics (KNBS) and Kenya Police Traffic Department. The dependent variable is the monthly number of road traffic deaths (RTD), and it is collected from the Kenya Police Traffic Department. In Kenya, a road traffic death is defined as one recorded at a road crash scene (Bachani *et al.*, 2012). The independent variables include: SCSW, UPVP, LTHVT, BCMM, MACTW, MAM and OND. Like in earlier empirical studies, the study is unable to account for pedestrian and cyclist traffic in the model for lack of reliable data.

For model 2, the study uses cross-sectional data obtained from a survey conducted by the Kenya Institute for Public Policy Research and Analysis (KIPPRA) in 2012. The survey collected secondary data on road traffic crashes from the Kenya Police Traffic Department. The survey covered 711 road traffic crashes reported in 24 districts between 1991 and 2012. The districts were selected using Geographic Information Systems (GIS) based on their proximity to Class A road network and distribution of towns. The 711 road traffic crashes involved 1,071 vehicle participants and 1,273 injured persons. After merging the road traffic crashes, vehicle participants and persons injured data sets, the sample size was reduced to 612.

Table 3.1: Definition of variables for model 1

Variable	Description and measurement of variables	Expected sign
RTD_t	Number of road traffic deaths	
$SCSW_t$	Number of registered saloon cars and station wagons as a % of total number of vehicles registered	Negative
$UPVP_t$	Number of registered utilities, panel vans and pick ups as a % of total number of vehicles registered	Positive
$LTHVT_t$	Number of registered lorries, trucks, heavy vans and trailers as a % of total number of vehicles registered	Positive
$BCMM_t$	Number of registered buses, coaches, mini-buses and matatus as a % of total number of vehicles registered	Negative
$MACTW_t$	Number of registered motor and auto cycles and three wheelers as a % of total number of vehicles registered	Positive
MAM	Dummy variable for March, April, May capturing seasonal effects of long rains and Easter holiday	Positive
OND	Dummy variable for October, November, December capturing seasonal effects of short rains and Christmas holiday	Positive

Table 3.2: Definition of variables for model 2

Variable	Measurement of variable	Expected sign
Type of injury (I)	Categorical variable (death, serious, slight)	Negative
Category of person injured (CPI)	Categorical variable (cyclist, driver, motor cyclist, passenger, pedestrian, pillion passenger)	Relative risk ratio expected to be less in all other than pedestrian
Vehicles participants (VP)	Categorical variable (bicycle, bus, lorry, trailer, *matatus*, motorcycle, other vehicle, pedestrians, saloon car, pick up vans)	Relative risk ratio expected to be higher in all
Gender of Person Injured (GPI)	Categorical variable (1 if male, 0 if female)	Relative risk ratio expected to be higher in males
Use of seat belt (SB)	Categorical variable (1 if no, 2 if yes, 3 n/a)	Relative risk ratio expected to be least in seat belt use
Speed limit at road traffic crash site (SL)	Continuous variable in kilometres per hour	Relative risk ratio expected to be higher with higher speed limits
Road surface at road traffic crash site (RS)	Categorical variable (1 if tarmac, 0 if earth or murram)	Relative risk ratio expected to be higher in tarmac roads
Road width at road traffic crash site (RW)	Continuous variable in metres	Relative risk ratio expected to be less with greater road widths
Road intersection at road traffic crash site (RI)	Categorical variable (1 if junction, 0 if no junction)	Relative risk ratio expected to be least in junctions
Alcohol consumption detected (A)	Categorical variable (1 yes, 0 if no)	Relative risk ratio expected to be highest in alcohol
Weather at the time of the road traffic crash (W)	Categorical variable (1 if cloudy or foggy or rainy, 0 if clear)	Relative risk ratio expected to be highest in cloudy, foggy or rainy weather
Illumination at the time of the crash (ILL)	Categorical variable (1 if night, 0 if day)	Relative risk ratio expected to be highest in night time

4. Results and Discussion

4.1 Results and Discussions for Model 1

4.1.1 Summary statistics

The average number of road traffic deaths is 264 deaths per month for the period 2006-2012, with a standard deviation of 51. The highest number of deaths is 417 in December 2007, and the lowest is 172 deaths in October 2007. In terms of modal share, saloon cars and station wagons have the highest mean (41.58%), while buses, coaches, mini-buses and *matatus* have the lowest mean (7.06%). The minimum and maximum motor and auto cycle share is 7.68 per cent (January 2006) and 33.39 per cent (December 2012), respectively. The standard deviation is relatively high at 9.24 per cent. Looking at the dispersion, the motor and auto cycle share has grown by 4.35 times. All the variables have skewed distributions as indicated by the skewness measure in Table 4.1.

4.1.2 Unit root test

Time series data leads to spurious regressions and erroneous inferences, if analysis is conducted on non-stationary series. Non-stationarity means that the series has a trend (increasing or decreasing), volatility or is shock resistant, implying that the mean and variance change over time. Augmented Dickey Fuller and Phillips Peron are used to test for stationarity of the variables. These tests give the null hypothesis as non-stationary (variable has a unit root). The ADF test indicates that MACTW is not stationary. MACTW must be differenced twice to become stationary I(2). The PP test confirms this, except that MACTW must be differenced. Differencing is transforming a series to a new series of changes between consecutive values of the original series. The study adopts I(2) for MACTW. The results are shown in Appendix Table 1.

Table 4.1: Summary statistics

	Mean	Median	Maximum	Minimum	Standard Deviation	Skewness	Kurtosis
RTD	264.37	260.50	417.00	172.00	51.01	0.72	3.48
SCSW	41.58	42.40	44.99	36.43	3.06	-0.48	1.67
UPVP	19.23	19.22	24.48	13.56	3.70	-0.06	1.54
LTHVT	9.90	10.14	11.17	8.13	1.13	-0.34	1.53
BCMM	7.06	7.31	8.08	5.24	0.97	-0.52	1.78
MACTW	18.30	17.11	33.39	7.68	9.24	0.31	1.56

4.1.3 Correlations

Correlation analysis (Appendix Table 2) was carried out to establish the relationships between the variables. The variables of interest (SCSW, UPVP, LTHVT, BCMM and MACTW) are highly correlated at 0.96, 0.98, 0.99 and 1. SCSW is positively correlated with UPVP by 0.96, and with LTHVT and BCMM by 0.99. The correlation between UPVP and LTHVT is also 0.99. A 1 per cent point increase in BCMM is associated with a 0.98 per cent increase in UPVP and a 0.99 per cent increase in SCSW and LTHVT. Similarly, the reverse applies. On the other hand, MACTW is negatively correlated with all of them.

4.1.4 Regression results

Road traffic deaths and traffic mix

A one percentage point increase in saloon cars and station wagons share increases the monthly road traffic deaths by 0.06 per cent. Similarly, LTHVT and BCMM had positive coefficients, though not statistically significant. On the other hand, a one percentage point increase in utilities, panel vans and pick ups reduces the monthly road traffic deaths by 0.09 per cent. MACTW was found to have a small negative insignificant coefficient. Interestingly, the coefficient of increasing the share of saloon cars and station wagons is positive, while that of increasing utilities, panel vans and pick ups is negative. These study findings deviate from Tay (2003) results of a negative coefficient for cars and buses, and a positive coefficient for sport utility vehicles and motorcycles.

Road traffic deaths and seasonal effects

The dummy variables capturing the rainy and holiday seasons have significant positive coefficients of 0.0494 and 0.1015. This means that the number of road

Table 4.2: Poisson maximum likelihood results

Variable	Coefficient	Z-statistic
Saloon cars and station wagons (SCSW)	0.0605*	1.75
Utilities, panel vans and pick ups (UPVP	-0.0919***	-4.39
Lorries, trucks, heavy vans and trailers (LTHVT)	0.0073	0.06
Buses, coaches, minibuses and *matatus* (BCMM)	0.1110	1.17
Motor and auto cycles and three wheelers (MACTW)	-0.0148	-0.87
March, April and May (MAM)	0.0494**	2.85
October, November and December (OND)	0.1015***	6.09
Constant	3.92***	8.32
Significant at 1%***, 5%** and 10%*		

traffic deaths increase by 4.9 per cent in March, April and May and by 10 per cent in October, November and December. These months represent the short and long rain seasons, hence agrees with that of White (2004) and Anderson (2008), who found that incidences of road traffic deaths increase with rainy or foggy weather.

4.1.5 Serial Correlation Test

After the regression analysis, the residuals were tested for serial correlation usually in time series data. Serial correlation was tested using Ljung Box Q statistics and no serial correlation was found. The probabilities were not significant as shown in Appendix Table 3.

4.2 Results and Discussions for Model 2

4.2.1 Summary statistics

Table 4.3 shows that most of the injuries sustained are either fatal or serious at 46.90 per cent and 32.19 per cent, respectively. The distribution for category of person injured is highest for pedestrians and passengers, each at 31.05 per cent. Of the persons injured, 80.23 per cent were male. *Matatus*, saloon cars, lorries and pick up vans dominate in road traffic injuries at 16.34 per cent, 15.20 per cent, 12.91 per cent and 11.60 per cent, respectively. Majority of the road traffic injuries occurred on tarmac roads (85.78%), roads with no junctions (76.47%), in daylight (56.70%) and clear weather (79.90%). Non-seat belt use and alcohol accounted for 31.70 per cent and 21.41 per cent of road traffic injuries, respectively. Speed limits range from 20 to 110km/hr with a mean of 72km/hr, while road width ranges from 0 to 20m with a mean of 6.2m.

Table 4.3: Summary statistics

Variable	Frequency	Percentage
Type of injury		
Death	287	46.90
Serious	197	32.19
Slight	128	20.92
Category of person injured		
Cyclists	72	11.76
Drivers	131	21.41
Motorcyclists	15	2.15
Passengers	190	31.05
Pedestrians	190	31.05

Pillion passengers	14	2.29
Vehicle participants		
Bicycle	48	7.84
Bus	31	5.07
Lorry	79	12.91
Trailer	51	8.33
Matatu	100	16.34
Motorcycle	47	7.68
Other vehicle	36	5.88
Pedestrian	56	9.15
Pickup van	71	11.60
Saloon car	93	15.20
Gender		
Female	121	19.77
Male	491	80.23
Seat belt use		
No	194	31.70
Yes	106	17.32
N/A-bicycles, motorcycles, pedestrians	312	50.98
Road surface		
Earth or murram	87	14.22
Tarmac	525	85.78
Road intersection		
No junction	468	76.47
Junction	144	23.53
Weather		
Clear	489	79.90
Cloudy or foggy or rainy	123	20.10
Illumination		
Day	347	56.70
Night	265	43.30
Alcohol		
No	481	78.89
Yes	131	21.41
Mean		
Speed limit		72.04
Road width		6.29

4.2.2 Regression results

Multinomial logit results are reported using 'slight injury' as the base outcome. The results show that buses, lorries, motorcycles and pedestrians are strong predictors of deaths.

Table 4.4: Multinomial logit relative risk ratio results (z-statistics in parantheses)

Variable	Type of injury (base outcome-slight injury)	
	Death	**Serious injury**
Category of person injured (reference group-cyclists)		
Drivers	0.80 (-0.27)	0.59 (-0.55)
Motorcyclists	0.08** (-2.65)	0.58 (-0.68)
Passengers	0.90 (-0.13)	0.66 (-0.46)
Pedestrians	1.15 (0.31)	1.15 (0.27)
Pillion Passengers	0.19** (-2.06)	0.39 (-1.26)
Vehicle participants (reference group-bicycle)		
Bus	6.15** (2.23)	2.82 (1.17)
Lorry	3.51** (2.02)	2.42 (1.35)
Trailer	2.63 (1.50)	2.26 (1.27)
Matatu	2.24 (1.44)	2.37 (1.48)
Motorcycle	3.82* (2.10)	3.46* (1.82)
Other vehicle	3.43* (1.72)	2.39 (1.16)
Pedestrian	3.38* (1.86)	2.23 (1.08)
Pickup van	1.06 (0.10)	0.55 (-0.91)
Saloon car	1.00 (-0.00)	1.60 (0.80)
Gender (reference group-female)		
Male	1.16 (0.47)	1.40 (1.03)
Seat belt use (reference group-no seat belt)		
Yes	0.46** (-2.15)	0.89 (-0.35)
N/A-bicycles, motorcycles, pedestrians	1.97 (0.97)	1.05 (0.06)
Road surface (reference group-earth or murram)		
Tarmac	1.07 (0.19)	0.73 (-0.87)
Road intersection (reference group-no junction)		
Junction	0.45*** (-2.97)	0.56** (-2.11)
Weather (reference group-clear weather)		
Cloudy or foggy or rainy	1.23 (0.60)	2.64***(2.92)
Illumination (reference group-day)		

Night	1.70**	(2.13)	0.97	(0.12)
Alcohol (reference group-no alcohol)				
Yes	1.74*	(1.72)	1.90*	(1.98)
Speed limit	1.01*	(1.92)	1.01	(1.57)
Road width	1.05	(1.07)	1.01	(0.13)
Constant	0.22	(-1.49)	0.47	(-0.67)
No. of observations	612		612	
Significant at 1%***, 5%** and 10%*				

Category of person injured

For motorcyclists compared to cyclists, the relative risk of death to slight injury reduces by 0.08 times. Being a pillion passenger (motorcycle) compared to a cyclist reduces the probability of death over slight injury by 0.19 times. Though not statistically significant, the relative risk of death to slight injury is 1.15 times higher for pedestrians compared to cyclists. Contrary to these findings, White (2004) and Anderson (2008) found that the probability of death in crashes with cars, light trucks or heavy trucks is higher for motor cyclists than cyclists and pedestrians. In contrast, the category of the person injured is not important in the serious injury outcome.

Vehicle participants

Buses and lorries compared to bicycles increase the probability of death over slight injury by 6.15 times and 3.51 times, respectively. Motorcycles compared to bicycles increase death and serious injury outcomes relative to the base outcome by 3.82 times and 3.46 times, respectively. The probability of death over the base outcome is higher by 3.38 times when travelling by foot, compared to travelling by bicycle. From the findings, buses, motorcycles, lorries, pedestrians, trailers, matatus, pick up vans, saloon cars and bicycles increase the risk of death in that order. A study by Fredette *et al.* (2008) found that the risk of death increases when in a crash with a bus, heavy truck, pick up, sport utility vehicle and mini-van compared to a car. Schepers and Heinen (2013) found no significant change in road traffic deaths due to a shift from cars to bicycles.

Gender

Gender is not important in death and serious injury outcomes relative to the base outcome. This finding is contrary to studies by Fredette *et al.* (2008) that the risk of death increases with male drivers but the risk of death or serious injury increases with female drivers, and Cooper *et al.* (2009) that the risk of death increases with female drivers.

Seat belt use

The use of seat belt is an important determinant in the probability of death over slight injury. Vehicle occupants who fasten their seat belts are less likely to die in a road traffic crash by 0.46 times compared to those who do not. The finding is supported by previous studies conducted by White (2004), Anderson (2008) and Fredette *et al.* (2008), who found that safety belt use reduces the likelihood of death. However, the relative risk of serious injury to slight injury is statistically insignificant.

Road surface, road intersection and road width

Road surface is unimportant in death and serious injury outcomes meaning that the likelihood of death and serious injury relative to slight injury is the same for tarmac, earth or murram roads. The presence of a road junction is negatively associated with death and serious injury outcomes relative to the base outcome. A road that has a junction reduces death and serious injury outcomes by 0.45 times and 0.56 times, respectively, compared to one without a junction. On the other hand, road width is not an important determinant in death and serious injury outcomes relative to the base outcome.

Speed limit

The maximum speed at which vehicles can travel is positively related to the probability of death over slight injury. A higher speed limit increases the probability of death relative to slight injury by 1.01 times. This finding agrees with that of White (2004), Fredette *et al.* (2008) and Anderson (2008) who found that the risk of death increases with higher speed limits. On the other hand, speed limit is unimportant in the serious injury outcome.

Weather and illumination

Weather is not an important determinant in the probability of death over slight injury. This finding is contrary to studies that found that the risk of death increases with rainy or foggy weather compared to clear weather (White, 2004 and

Anderson, 2008). However, cloudy, foggy or rainy weather increases the relative risk of serious injury to slight injury by 2.64 times compared to clear weather. This finding is partly supported by White (2004) who found that foggy weather increases the risk of serious injury, but rainy weather decreases it. On the other hand, night time compared to day time increases the relative risk of death to slight injury by 1.70 times, but is unimportant in serious injury. This finding is similar to the study by White (2004), who found that road traffic crashes that occur at night are likely to cause deaths.

Alcohol

Consuming alcohol increases death and serious injury outcomes relative to the base outcome by 1.74 times and 1.90 times, respectively. This finding supports the studies by White (2004) and Anderson (2008) who found that alcohol consumption increases the likelihood of death and serious injury.

4.2.3 Diagnostic tests

The correlation analysis results (Appendix Table 4) indicate the absence of multicollinearity. Multicollinearity arises when variables are highly correlated, such that the correlation is close to 1. An assumption of multinomial logit is that the inclusion or exclusion of an outcome category does not affect the relative risks of independent variables for categories in the model. Therefore, the Hausman test of Independence of Irrelevant Alternatives (IIA) was conducted. No systematic change was found in the relative risk ratios when the 'serious' or 'fatal' category was excluded from the model, hence IIA was not violated.

5. Conclusion and Policy Recommendations

5.1 Conclusion

The role of mixed traffic in exposure to risk is less analyzed in developing countries. This study provides a deep insight into understanding the exposure and risk factors associated with road traffic deaths in Kenya. The objective is to determine the effects of mixed traffic on road traffic deaths, while controlling for relevant risk factors such as alcohol, road design, speed limit, weather, holiday seasons, illumination, gender and seat belt use. This study established that buses, lorries, motorcycles and pedestrians increase incidences of deaths in road traffic crashes. In addition, alcohol, night time and speed limits increase incidences of deaths, while road junctions and seat belt use reduce incidences of deaths in road traffic crashes.

5.2 Policy Recommendations

Impose Public Service Obligation and Level of Service

This study found that pedestrians and passengers are the highest category of persons injured at 31.05 per cent each. This finding is supported by the 2012 road crash data that indicates passengers and pedestrians as the highest category of victims at 50.9 per cent and 24.5 per cent, respectively. Again, 49.3 per cent and 23.7 per cent of road traffic deaths in 2012 are pedestrians and passengers, respectively. This means that pedestrians and passengers are overly represented in both deaths and injuries. In addition, the incidence of death was higher for a motor cyclist and pillion passenger than a cyclist. At the same time, travelling by bus, motorcycle or foot had higher incidences of death than cycling.

This study, therefore, recommends an increased role of the public sector in the public transport system by establishing Public Service Obligation arrangements for socially desirable but financially unsustainable public transport services. The National Transport and Safety Authority (NTSA) or the county governments can offer subsidies to certain companies to provide the services for a specified period of time so long as they comply and meet the levels of service. One of the levels of service is safety. Public Service Obligation guarantees social inclusion in mobility access and safety, hence a reduction of passengers, pedestrians and motor cyclists in road traffic deaths.

Tighten compliance on safety belt use

The use of safety belts was found to have a positive impact in reduction of incidences of death. Non-seat belt use accounted for 31.70 per cent of road traffic injuries. The NTSA and Kenya Traffic Police should tighten enforcement of the seat belt law and seat belt use. The seat belt law requires all vehicles to be fitted with driver and passenger seat belts. The County Transport and Safety Committees under the NTSA should frequently sensitize the public on the benefits of seat belt use. In addition, NTSA should compile a time series database on seat belt violations country wide to inform future policies and legislations.

Redesign roads and revision of speed limits

A road junction was found to be negatively associated with incidences of death and serious injuries because it slows down travel speeds and improves the safety of pedestrians and cyclists. This study found that 76.47 per cent of road traffic injuries occurred on roads with no junctions. On the other hand, speed limits were found to be positively associated to incidences of deaths. Therefore, reduction of travel speeds can be achieved through redesign of roads and intersections. Road speed limits were found to vary between 20km/h and 110km/h. This reflects a huge variance and it means that some roads have speed limits beyond the recommended driving speed of 80km/hr. The Kenya Traffic Police needs to continuously review road speed limits to reduce incidences of deaths and improve the co-existence of vehicles, pedestrians and cyclists.

Encourage establishment of rescue centres

This study found that night time is associated with higher incidences of death as 43.3 per cent of road traffic injuries occur then. This can be associated with delayed emergency rescue in the night. Rescue centres can be introduced along road traffic crash hot spots to reduce the time taken for victims to receive medical assistance.

Revocate driving licenses and introduce alcohol interlocks

Alcohol consumption was found to be positively associated to incidences of death and serious injuries despite being detected in only 21.41 per cent of road traffic injuries. Public sensitization on the dangers of drunken driving should be complemented by deterrent measures such as revocation of driving licenses, especially for repeat offenders. The NTSA should also experiment with in-vehicle alcohol interlocks in addition to alcoblow. Alcohol interlocks are electronic breath test gadgets that prevent the start of a vehicle if the breath test is failed.

5.3 Limitations and Areas of Further Study

The study has limitations that need to be highlighted. First, pedestrian and cyclist volumes, and speed and seat belt violations were not included in the time series analysis due to unavailability of data. Continuous knowledge of pedestrian and cyclist numbers is critical in the management of traffic mix aimed at reducing pedestrian and cyclist injuries. In addition, data on speed and seat belt violations (or rates of seat belt use) is crucial in informing policies aimed at reducing these risk factors. This study recommends countrywide collection of such information by the NTSA. Secondly, road safety measures that aim at reducing exposure to risk are least implemented, yet factors influencing exposure to risk have significant effects. Land use planning is important in managing exposure to risk. Future research needs to consider land use planning as it affects traffic volume, travel mode choice and road infrastructure.

References

Aderamo, J. A. and Olatujoye, S. (2013), "Trends in Motorcycle Accidents in Lokoja, Nigeria", *European International Journal of Science and Technology*, 2, 6: 251-261.

Al-Haji, G. (2007), "Road Safety Development Index: Theory, Philosophy and Practice", Department of Science and Technology, Linkoping University, SE-601 74, Norrköping, Sweden.

Anderson, M. (2008), "Safety For Whom? The Effects of Light Trucks on Traffic Fatalities", *Journal of Health E*conomics, 27: 973-989.

Asingo, O. P. and Mitullah, V. W. (2007), "Implementing Road Transport Safety Measures in Kenya Policy Issues and Challenges", Working Paper 545, Institute for Development Studies, University of Nairobi.

Ayati, E. and Abbasi, E. (2011), "Investigation on the Role of Traffic Volume in Accidents on Urban Highways", *Journal of Safety Research*, 42: 209-214.

Bachani, M. A., Koradia, P., Herbert, K. H., Stephen Mogere, S., Daniel Akungah, D., Nyamari, J., Eric Osoro, E., Maina, W. and Stevens, A. K. (2012), "Road Traffic Injuries in Kenya: The Health Burden and Risk Factors in Two Districts", *Traffic Injury Prevention*, 13, 1: 24-30.

Cameron, C.A. and Trivedi, K.P. (2005), "Microeconometrics: Methods and Applications", New York: Cambridge University Press.

Christie, R. and Newland, R. (2001), *Motorcyclist Fatality and Motorcycle Sales Patterns in Australia*, Road Safety Research Policing and Education Conference, Melbourne, November.

Cooper, J. P., Zheng, Y., Andersen, L. and Pellegrini, N. (2009), "The Impact of Replacing Heavy Passenger Vehicles (LTVs and SUVs) in the British Columbia Fleet with Lighter Versions", *Traffic Injury Prevention,* 10, 5: 458-466.

Elvik, R. and Vaa., T. (2004), *The Handbook of Road Safety Measures*. Emerald Group Publishing Limited, UK.

Elvik, R., Vaa, T., Hoye, A. and Sorensen, M. (2009), *The Handbook of Road Safety Measures*, Second Revised Edition. Emerald Group Publishing Limited, UK.

Elvik, R. (2009), "The Non-Linearity of Risk and the Promotion of Environmentally Sustainable Transport," *Accident Analysis and Prevention*, 41, 4: 849-855.

Fredette, M., Mambu, S. L., Chouinard, A. and Bellavance, F. (2008), "Safety Impacts Due to the Incompatibility of SUVs, Minivans, and Pickup Trucks in Two-Vehicle Collisions", *Accident Analysis and Prevention*, 40: 1987-1995.

Government of Kenya (1986), The Traffic Act (Cap. 403): Legal Notice No. 361. Nairobi: Government Printer.

Government of Kenya (2003), The Traffic Act (Cap. 403): Legal Notice No. 161. Nairobi: Government Printer.

Government of Kenya (2007), Kenya Vision 2030: A Globally Competitive and Prosperous Kenya. Nairobi: Ministry of Planning and National Development and National Economic and Social Council of Kenya (NESC).

Government of Kenya (2007), The Value Added Tax Act (Cap. 476) and the Subsidiary Legislations (Revised Editions, 2007). Nairobi: Government Printer.

Government of Kenya (2010), Constitution of Kenya 2010. Nairobi: Government Printer.

Government of Kenya (2012), The National Transport and Safety Authority Act 2012. Nairobi: Government Printer.

Government of Kenya (2012), The Traffic (Amendment) Act, 2012. Nairobi: Government Printer.

Government of Kenya (2013), Legal Notice No. 219: National Transport and Safety Authority (Operation of Public Service Vehicles) Regulations. Nairobi.

Greene, W. (2000), Econometric Analysis, 4th Ed., Upper Saddle River, N. J.: Prentice Hall.

Grimm, M. and Treibich, C. (2013), "Determinants of Traffic Crash Fatalities across Indian States," *Health Economics*, 22, 8: 915-930.

Kenya National Bureau of Statistics (2011), *Economic Survey*, Nairobi.

Kenya National Bureau of Statistics (2002), *Economic Survey*, Nairobi.

Kenya National Bureau of Statistics (2013), *Economic Survey*, Nairobi.

Kenya National Bureau of Statistics (Various), *Statistical Abstract*, Nairobi.

Kenya Police Traffic Headquarters (2013), Monthly Traffic Accident Statistics Running Totals for the Year 2000 to 2013: Vehicles and/or Others Primarily Responsible, Nairobi.

Ministry of State for Immigration and Registration of Persons (2010), National Totals on Registered Deaths by Causes: Deaths by Cause and Year of Registration from Year 2000 to 2010, Nairobi: Department of Registration.

Ministry of Transport (2005), National Road Safety Action Plan (2005-2010). Nairobi: Ministry of Transport.

Ministry of Transport (2009a), National Road Safety Action Plan (2009-2014). Nairobi: Ministry of Transport.

Ministry of Transport (2009b), Integrated National Transport Policy: Moving A Working Nation. Nairobi: Ministry of Transport.

Ministry of Transport (2010), Sessional Paper on Integrated National Transport Policy. Nairobi: Ministry of Transport.

Mohan, D. (2002), "Road Safety in Less-Motorized Environments: Future Concerns," *International Epidemiological Association*, 31: 527-532.

Odero, W., Khayesi, M. and Heda, P.M. (2003), "Road Traffic Injuries in Kenya: Magnitude, Course and Status of Intervention," *Injury Control and Safety Promotion*, 10, 122: 53-61.

Praveen, P. S. and Arasan, V. T. (2013), "Influence of Traffic Mix on PCU Value of Vehicles under Heterogeneous Traffic Conditions," *International Journal for Traffic and Transport Engineering*, 3, 3: 302-330.

Schepers, J. P. and Heinen, E. (2013), "How Does a Modal Shift from Car Trips to Cycling Affect Road Safety?" *Accident Analysis and Prevention*, 50: 1118-1127.

Schepers, J. P., Hagenzieker, M., Methorst, R. and Wee, B. (2014), "A Conceptual Framework for Road Safety and Mobility Applied to Cycling Safety", *Accident Analysis and Prevention*, 62: 331-340.

Smith, I. (1999), "Road Fatalities, Modal Split and Smeed's Law," *Applied Economics Letters*, 6, 4: 215-217.

Tay, R. (2003), "Effects of Changing the Vehicle Mix on Fatal Crashes", *Journal of Transport Economics and Policy*, 37, 3: 439-450.

Vasconcellos, A. E. (2005), *Traffic Accident Risks in Developing Countries: Superseding Biased Approaches*, ICTCT Extra Workshop, Campo Grande, Brasil.

Vasconcellos, A. E. (2012), "Road Safety Impacts of the Motorcycle in Brazil", *International Journal of Injury Control and Safety Promotion*, 1-8.

White, J.M. (2004), "The "Arms Race" on American Roads: The Effect of Sport Utility Vehicles and Pickup Trucks on Traffic Safety", *Journal of Law and Economics*, 47, 2: 333-355.

World Health Organization (2004), *World Report on Road Traffic Injury Prevention*.

World Health Organization (2009), "Global Status Report on Road Safety: Time for Action". Geneva: World Health Organization.

World Health Organization (2010), *Global Plan for the Decade of Action for Road Safety 2011-2020*. Geneva: World Health Organization.

World Health Organization (2013a), *Global Status Report on Road Safety 2013: Supporting a Decade of Action*. Geneva: World Health Organization.

World Health Organization (2013b), *Road Safety in the African Region: The Facts 2013*. Geneva: World Health Organization.

Zhang, J., Norton, R., Tang, KC., Lo, S.K., Jiatong, Z. and Wenkui, G. (2004), "Motorcycle Ownership and Injury in China", *International Control and Safety Promotion*, 11, 3: 159-163.

Appendix Table 1: Augmented Dickey Fuller (ADF) and Phillips Peron (PP) tests

Variable	Augmented Dickey Fuller			I(d)	Phillip Peron			I(d)
	Level		No intercept and trend at level/ Difference		Level		No intercept and trend at level/ Difference	
	Intercept and trend	Intercept			Intercept and trend	Intercept		
RTD	-6.281330***	-6.055906***		I(0)	-6.450050***	-6.193813***		I(0)
SCSW	-2.497664	0.518194	-2.170152**	I(0)	-2.59028	1.214063	-2.985277***	I(0)
UPVP	-1.487383	-1.025127	-2.392876**	I(0)	-2.210865	0.430573	-8.001430***	I(0)
LTHVT	-2.265046	-0.482842	-1.768997*	I(0)	-2.439849	0.947055	-4.527888***	I(0)
BCMM	-2.437292	0.542093	-2.072387**	I(0)	-3.005857	2.892949	-4.294640***	I(0)
MACTW	-2.253805	-0.510704	-9.447109***	I(2)	-2.870359	1.367772	-2.680973*	I(1)

Critical values at 1%***, 5%** and 10%* significance levels: None [-2.59, -1.95, -1.61], Intercept [-3.51, -2.90, -2.59],
Intercept and trend [-4.07, -3.47, -3.16]

Appendix Table 2: Correlation matrix

	RTD	SCSW	UPVP	LTHVT	BCMM	MACTW	MAM	OND
RTD	1.00							
SCSW	-0.13	1.00						
UPVP	-0.25	0.96	1.00					
LTHVT	-0.19	0.99	0.99	1.00				
BCMM	-0.16	0.99	0.98	0.99	1.00			
MACTW	0.20	-0.99	-0.99	-1.00	-0.99	1.00		
MAM	0.00	0.03	0.05	0.05	0.05	-0.05	1.00	
OND	0.25	-0.07	-0.09	-0.08	-0.09	0.08	-0.33	1.00

Appendix Table 3: Test for serial correlation: Q statistics

	AC	PAC	Q-Stat	Prob		AC	PAC	Q-Stat	Prob
1	0.047	0.047	0.184	0.668	19	-0.14	-0.071	11.742	0.896
2	0.231	0.229	4.6628	0.097	20	0.185	0.207	15.497	0.747
3	-0.023	-0.045	4.7096	0.194	21	0.017	0.027	15.529	0.795
4	0.008	-0.044	4.7158	0.318	22	0.079	-0.041	16.242	0.804
5	0.076	0.099	5.2253	0.389	23	-0.106	-0.13	17.538	0.782
6	0.034	0.035	5.325	0.503	24	-0.076	-0.025	18.21	0.793
7	-0.01	-0.06	5.3344	0.619	25	0.002	0.093	18.211	0.833
8	0	-0.006	5.3344	0.721	26	0.027	0.019	18.299	0.865
9	-0.015	0.009	5.3558	0.802	27	0.085	0.009	19.203	0.862
10	0.076	0.074	5.8937	0.824	28	0.102	0.098	20.516	0.845
11	0.041	0.031	6.0514	0.87	29	-0.112	-0.091	22.132	0.815
12	0.037	0.001	6.1839	0.907	30	-0.067	-0.136	22.718	0.827
13	-0.12	-0.141	7.6052	0.868	31	-0.151	-0.157	25.789	0.731
14	-0.1	-0.099	8.5987	0.856	32	-0.046	-0.053	26.075	0.76
15	0.012	0.084	8.6123	0.897	33	-0.158	-0.075	29.558	0.639
16	0.081	0.119	9.2806	0.901	34	-0.17	-0.076	33.665	0.484
17	-0.053	-0.115	9.5735	0.921	35	-0.163	-0.074	37.546	0.353
18	0.022	-0.004	9.6247	0.943	36	0.124	0.181	39.848	0.303

Appendix Table 4: Correlation matrix

	Person injured	Vehicle participant	Gender	Seat belt	Speed limit	Road surface	Road width	Road intersection	Weather	Illumination	Alcohol
Person Injured	1.00										
Vehicle Participant	0.20	1.00									
Gender	-0.27	-0.00	1.00								
Seat Belt	0.25	-0.08	0.06	1.00							
Speed Limit	0.01	-0.02	-0.05	-0.11	1.00						
Road Surface	-0.01	0.02	-0.03	-0.10	0.13	1.00					
Road Width	-0.05	0.02	-0.03	-0.10	0.13	0.18	1.00				
Road Intersection	-0.05	-0.02	0.02	0.06	0.03	0.03	0.04	1.00			
Weather	-0.01	-0.01	0.07	-0.06	-0.04	-0.03	-0.04	-0.17	1.00		
Illumination	0.06	0.02	0.03	-0.04	0.02	-0.03	-0.09	-0.01	0.20	1.00	
Alcohol	0.07	-0.02	0.05	0.02	0.04	-0.00	-0.03	0.00	-0.04	0.09	1.00