RISK FACTORS ASSOCIATED WITH SERIOUS AND FATAL ROAD TRAFFIC ACCIDENTS IN MANZINI CITY, SWAZILAND

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Ten Keywords:

Road traffic accident, deaths, serious injuries, Swaziland, developing countries, pedestrians, drivers, drunk-driving, public transport, environmental factors

ABBREVIATIONS

BBC – British Broad Casting Corporation

ER – Emergency Room

FRSC - Federal Road Safety Commission

GOV.UK – Government of United Kingdom

SOPD – Surgical Out Patient Department

RFM hospital - Raleigh Fitkin Memorial hospital

RTA – Road Traffic Accident

UNECE – United Nations Economic Commission for Europe

UK – United Kingdom

WHO – World Health Organization

DEFINITIONS OF KEY TERMS

Operational Definitions

Road Traffic Accidents (RTAs)

Defined as an event occurring on a street, road or highway, in which at least one motor vehicle in motion is involved by collision or losing control, and which causes physical injury or damage to property.

Fatal road traffic accident

Defined as a road traffic accident in which one or more persons died as a direct result of the RTA within 30 days of the RTA.

Serious road traffic accident

Defined as a road traffic accident in which one or more persons were injured and required hospitalization for a period of more than 24 hours.

Minor injury

Defined as an injury of a minor character such as sprain, bruise, a cut or laceration which is not judged to be severe and does not require in-patient treatment.

Property damage

It is defined as all collisions that did not result in injuries or deaths.

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DECLARATION

I declare that, "Risk Factors Associated with Serious and Fatal Road Traffic Accidents in Manzini City, Swaziland" is my own work, that it has not been submitted for any degree examination in the university and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Full Name: Motuma Demissie

Signed: ______________________ Motuma Demissie __________ Date: 11/11/2016

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ABSTRACT

Background

Road Traffic Accidents (RTAs) are an important cause of morbidity and mortality worldwide, especially in low and middle-income countries. Traffic police reports indicate that RTAs are amongst the commonest health challenges Swaziland faces. Assessing the magnitude of the challenge, understanding the impact on public health and gaining more insight into the actual risk factors involved in RTAs, and especially RTAs that result in serious injuries and fatalities, is important for the road transport authority, the traffic police and for public health planners, in order to improve road safety, to develop effective countermeasures and to improve preparedness for effective health care, respectively.

There is an insufficiency of studies on risk factors associated with RTAs, and particularly those associated with serious and fatal RTAs, in Sub-Saharan countries in general and Swaziland specifically. Manzini, a busy small city in Swaziland with a population of 61000 and an estimate of approximately 12000 vehicles on its roads daily is the setting for this study. RTAs in Manzini, are considered as a major public health problem with many people either seriously injured or killed on the roads annually.

Aim

The aim of this study was to determine the human (e.g. age, gender, speeding and drunk driving), vehicle (e.g. vehicle types and vehicle defects), infrastructural (e.g. type of roads, road surface defects and road lighting) and environmental risk factors (e.g. rain and darkness) associated with serious and fatal RTAs in Manzini city and surrounding suburbs in Swaziland.

Methodology

A case control study, based on data collected from RTA records at Manzini Traffic Police Station, was conducted. The study population was all RTAs in Manzini, with cases being RTAs that resulted in serious or fatal injuries, while RTAs with no injuries (vehicle and property damage only) and minor injuries were categorised as controls. A sample size of 294 consisting of all 143 RTAs with fatal and serious injury that occurred from July 2013 to June 2015 in Manzini city as cases and a random sample of 151 controls from amongst the minor injury and property damage only RTAs, was selected. A standardised data extraction tool was used to collect data from routine traffic police records on all RTAs.

Frequencies were calculated for categorical variables. Numerical variables were summarised mathematically, via their central tendencies and distribution as well as collapsed into meaningful categories. Bivariate analysis to ascertain odds ratios was undertaken and all risk factors that showed a significant association with severe and fatal RTAs were further assessed via multivariate logistic regression analysis. Ethical approval for the study was secured from the Swaziland National Ethics Committee and the University of the Western Cape Research and Ethics committee.

Results

Factors that had an unconfounded association on multivariate analysis with serious/fatal RTAs, compared to minor RTAs, were: male drivers (AOR = 5.48; 95% CI = 1.63 – 18.43); drivers not wearing a seatbelt (AOR = 5.07; 95% CI = 2.39 – 10.74); pedestrian error (AOR = 2.66; 95% CI = 1.46 – 4.86); accidents occurring on weekends (AOR 3.62; 95% CI = 2.07- 6.33); and accidents occurring between 18:00 – 23:59 time of the day (AOR = 11.68; 95% CI = 4.49 - 30.39).

Other factors such as: age of driver, no driver's license at the accident scene, drunk-driving, seasons of the year, driver error, vehicle type, vehicle defect, road surface type, road surface condition, weather condition, street light condition and urban/rural location were not found to be associated with serious/fatal RTAs in our study.

Limitations

Limitations of the study were that some data collected at the scene of the accident were incomplete and not collected in a standardised manner (alcohol use, speeding, vehicle defects, road defects and environmental factors) and that there was probable misclassification of some serious/fatal RTAs as minor ones and under-reporting of minor RTAs. Also several variables which may affect the severity of RTAs, such as educational level, socioeconomic status, medical illness, marital status and emotional status of the driver, were not routinely collected by the traffic police department and hence were not assessed.

Conclusions and Recommendations

Modifiable risk factors that had an unconfounded positive association with serious/fatal RTAs were not using a seatbelt, night-time driving, weekend driving and pedestrian error, while male gender might be a proxy for reckless driving. Hence, education programmes for drivers and the public on behavioural change encouragement, improving pedestrians' road safety by provision of pedestrian sidewalks and crossing sites, coupled with increased traffic law enforcement at critical days and times, may result in reduction of serious/fatal RTAs.

INTRODUCTION

Road traffic accidents (RTAs) are one of the major global public health and development problems (WHO, 2004). It is stated that the number of traffic fatalities globally is estimated to be around 1.24 million per year (around 3,397 per day), and the number of people injured annually as a result of road traffic crashes are as high as 50 million (Nantulya et al., 2002; WHO, 2004). Developing countries while having only 48% of the world's vehicles are reported to account for about 90% of the road traffic accidents. The majority of such RTAs and resultant deaths are currently among "vulnerable road users" – pedestrians, pedal cyclists and motorcyclists (WHO, 2009; WHO, 2013a).

The RTA casualty rate is decreasing in the developed world as a result of determined vehicle accident counter measures that were put in place, such as improved education and training programmes for drivers, increased public awareness about RTAs, enforcement of traffic laws such as seat belt safety laws, enforcement of speed limits, prohibition of driving under the influence of alcohol and safer design and regular maintenance of vehicles and roads (Population Research Bureau, 2006). However, in developing countries less attention has been given to RTAs and road safety measures even though vehicle usage is increasing, and as a result RTAs are escalating (WHO, 2013a; Kopits and Cropper, 2003). For example, between 1975 and 1998, road traffic deaths per capita increased by 44% in Malaysia, 79% in India, 192.8% in Lesotho and by over 200% in Colombia and Botswana (Kopits and Cropper, 2003). Furthermore, a large number of people die each year as a consequence of RTAs globally and a majority of these deaths occur in low-income and middle-income countries. If no action is taken RTAs are predicted to result in the deaths of around 1.9 million people annually by 2020 (WHO, 2013a).

On the same note it is reported that traffic crashes are predicted to further decrease by 27% in countries of the developed world by 2020, but they are estimated to increase by an average of 83% in low income and middle income countries (Nantulya et al., 2002; WHO, 2004).

Currently, road traffic injuries is in ninth position in terms of the magnitude of effect it has on the public health burden of disease globally and it is among the leading causes of disability adjusted life years lost (Jacobs et al., 2000). Jacobs et al. (2000) further stated that by the year 2020 projections suggest that road traffic accidents as a cause of 'disability-adjusted life years'

(DALYs) will move up to the third place globally. However, in developing countries the problem is increasing at a faster rate due to rapid urbanization, rapid increase in motorized vehicles and yet lagging road infrastructure development (Jacobs et al, 2000). WHO reports show that the African region has the highest road traffic fatality rate (WHO, 2013a). In low- and middle-income African countries the annual road accident fatality rate is 32.3 deaths per 100,000 people, while America has 15.8 deaths per 100,000 people, Europe has 13.4 deaths per 100,000 people and South East Asia has 16.6 deaths per 100,000 people (Eshbaugh et al, 2012; WHO, 2013a). The proportionally higher burden of mortality from RTAs in low- and middle-income African countries are even greater than they appear, as these countries have lower vehicle to population ratios than the more developed countries (WHO, 2004).

Abdulgafoor et al. (2012) stated that a road traffic injury in Sub-Saharan African countries is a growing serious public health problem. The authors listed Kenya as one of the Sub-Saharan African countries with an escalating problem of road traffic accidents. In this regard the authors indicated that in Kenya fatalities due to road traffic accidents increased at an annual rate of seven percent (95% CI: 6–8) for the period 2004 to 2009.

At present, in developing countries road traffic accidents kill more people than malaria or tuberculosis. If this trend continues, then by 2030 the RTAs fatality rate will be more than the other two put together and greater even than HIV/AIDS (Reinventing the wheel, 2014).

The World Health Organization reported that road traffic accidents have multi-factorial causes – human factors (road users), road and other infrastructure defects, policing inadequacies, environmental elements and vehicle defects (WHO, 2013a). They report that the road user is usually primarily responsible for accidents. As reviewed by Downing et al., (1991) studies in different developing countries demonstrated human error estimated to account for between 64% and 95% of all causes of road traffic accidents (Downing et al., 1991). Among the developing countries mentioned to have human error as a main cause of road accidents in the 1980s were: Iran 64%, Afghanistan 74%, India 80%, Ethiopia 81%, Philippines 85%, Malaysia 87%, Zimbabwe 89 %, Botswana 94% and TRRL 95% of all causes of traffic crashes. Similar review showed that in African countries human factor account for more than 85% of the traffic crashes and injury based on the reports by police (Chen, G. 2010).

It appears that if the road user always maintained their vehicles adequately and behaved correctly within the limitations required for good and bad road infrastructure, traffic and environmental circumstances, then accidents would indeed be reduced (Norman, 1962; WHO, 2013a). Road users include drivers, passengers, pedestrians and cyclists.

The study was conducted in Manzini district in Swaziland. It is one of the four districts in the country. In general Swaziland is a mountainous landlocked country covering 17,364 square kilometers and located in the south-eastern corner of Africa. Three quarters of its area is bordered by South Africa and one quarter by Mozambique. According to the 2007 population census, the population of Swaziland was 1,018 449 inhabitants with about 78.9% residing in rural areas (Swaziland Census, 2007). According to the World Bank report (2009), Swaziland’s national per capita income is USD 2,470 and is regarded as a lower middle income country.

The country is divided into four administrative regions: Hhohho (where the capital City, Mbabane, and government ministries are located), Manzini (which contains the largest commercial and industrial sites in the country), Lubombo and Shiselweni.

Manzini is the most populous district. Its capital city is called Manzini as well. The city is the country's second largest urban centre behind the capital city Mbabane. Manzini city is situated in the heart of the country, 30 kilometers from the capital city (Mbabane). It is an industrial town and a business centre as well. In 1997 the population of Manzini city was 25,571 and it has more than doubled since then. The population of Manzini district was 319,530 and the population of Manzini city was 54,946 in 2007(Swaziland Census, 2007). This shows that the population of the urban centres is increasing rapidly, creating a situation which increases the risk of RTAs.

On the other hand, according to Swaziland Road Transportation Department 2013 annual report the number of registered vehicles in the country had increased dramatically from 160,000 in 2010 to 350,000 in 2013. The increased numbers of vehicles in the country would equally be mirrored in Manzini city as well, which could be another contributing factor to the RTAs.

As shown, in the map in the appendix (Appendix figure A), amongst its road networks the most important highway in Swaziland which starts at the border with South Africa - passes through Mbabane - before coming to Manzini and thereafter connecting to the border with Mozambique.

Exports and imports by land mostly use this road and therefore it has a high volume of trucks as well as other vehicles (Mpata et al., 2005).

The stretch of highway from the South African border to Manzini was upgraded to a 4-lane dual carriageway and this has facilitated a significant reduction in vehicle operating costs, travel time and road accidents (African Development Bank, 2004). However, this highway continues from Manzini as a two-lane highway until it connects with the Mozambique border. On this stretch of the highway traffic flows in both directions, with no barrier between the vehicles travelling in opposite directions. This scenario contributes to the high risk of RTAs along this road. This important highway traversing Manzini is a tarred road, but it has inadequate sidewalks for pedestrians and has no cycle paths. It has inadequate pedestrian crossing points and traffic lights. The inadequate pedestrian crossings apply equally to other roads in Manzini, therefore it is not surprising that pedestrians are often observed jay walking in Manzini city. All vehicle types such as heavy trucks, buses, minibuses, motorbikes and bicycles are obliged to use this road as there are no parallel roads which vehicles could use instead to travel along this popular route. This means that many vehicles pass through Manzini city and thus Manzini city is congested with a heavy flow of traffic, particularly at the rush hours, i.e. in the morning between 7:00 am to 9:00 am and in the evening from 5:00 pm to 7:00 pm. At these particular occasions people travel to/from work/business, students to/from school and others according to their need to travel at that time.

The traffic congestion is and will continue to be a rising challenge, as the population is increasing rapidly with equally increasing numbers of vehicles. The community's need to travel for daily social activities in life is also rising. Particularly migration from rural to urban areas to look for jobs is increasing. An equally important fact is that mostly, because of the economic challenges, people tend to travel on foot or use cheaper means of public transport like minibuses, trucks or buses, which are considered to increase the probability of RTAs. The main means of transportation in Swaziland is by using public transport and walking. According to the UNEP (2009) report, Swaziland had 32.6 cars per 1000 people in 1996. However, the report indicated that vehicle ownership roughly increased to 140 vehicles per 1000 people in 2013 (Swaziland Transport Master Plan, 2013). The road infrastructure development is not compatible with the increased population and increasing registered vehicle numbers. As a result, there is frequent jamming of vehicles and pedestrians using public roads in the Manzini district which is particularly bad during the rush hours.

The police station in Manzini city is the one responsible for ensuring traffic safety and traffic control by ensuring traffic rules and regulations are adhered to. They also record and evaluate the causal factors of all traffic accidents that occur in the area.

According to the WHO data issued in April 2011, road traffic accidents deaths in Swaziland reached 422 or 2.63% of total deaths and it is ranked ninth among the leading cause of deaths (WHO, 2011a). Based on age adjusted death rates Namibia has the highest in the world and Swaziland follows with an age adjusted death rate of 48.24 per 100,000 populations (WHO, 2011a).

Based on the Manzini Traffic Police Periodical Statistical reports (2008-2012), road traffic accidents is a major public health problem. As shown in the appendix (Appendix table A) the traffic police reports from 2008 to 2012 revealed that many people were injured and killed on Manzini's roads, although there seems to be a decrease in all grades of severity of RTAs since 2009. However, even though the trend appears to be decreasing it is still higher than other places with similar circumstances, such as Kibaha District, Tanzania which had an average of 640 traffic accidents per year in 2007 (Komba, 2007).

As shown in the appendix (Appendix table B) the commonest broad causes of road traffic accidents and the associated morbidity and mortality is drivers' error, followed by pedestrians' error as the second highest cause. As the result of the road traffic accidents problem many people die each year and man spend long weeks in hospital after severe road traffic accidents and may never be able to live, work or play as they used to do. Despite the efforts made to address road safety in Manzini district, there is still a large degree of human suffering due to road traffic accidents. The impact on human suffering is not only due to physical and psychological harm but also has and socioeconomic dimensions.

According to a report from Raleigh Fitkin Memorial (RFM) hospital (Surgical Department Annual Report, 2012) out of 9,225 trauma cases seen at the casualty department, 1,203 (13%) of the cases were reported to be due to RTAs. It is the second highest cause of admission to the trauma emergency unit at RFM regional hospital (Surgical Department Annual Report, 2012).

On the same note 25 (78%) cases out of 32 patients who arrived dead and those who died during resuscitation at the RFM hospital from January 1 to December 31, 2012 were due to motor vehicle accidents (Surgical Department Annual Report, 2012). Even though the number of fatal accidents reported by Manzini traffic police in 2012 was eight the number of cases who died in each accident could be many. In addition, since RFM hospital has postmortem examination service, those who died due to RTAs at other districts are brought to this hospital too. So the number of deaths attended at RFM hospital may not reflect the real scenario of Manzini city RTAs.

Noting that road traffic accidents have physical, social, emotional and economic impacts, it was stated that the global economic impact of road traffic accidents is enormous and the cost was estimated at $518 billion per year in 2003 with $100 billion of that occurring in developing countries (Peden et al., 2004). In developing countries, the cost to the economy due to RTAs is approximately 1% to 2% of a country's gross domestic product (Manyara et al., 2013).

Consequently, one may reasonably infer that the economic impact of road traffic accidents in Swaziland could be comparable to that of the other developing countries.

In view of the findings shown above, road traffic accidents is a growing problem globally which leads to a large public health burden, with Jacob et al. emphasising that it needs to be addressed as a public-health priority (Jacobs et al., 2000).

The population of Manzini city is increasing fast. It doubled within 10 years from 1997 to 2007 (Swaziland Population census, 2007). In addition, the number of registered vehicles also doubled in 10 years' time from 2001 to 2011 (Ministry of Public Works and Transport Master Plan Report, 2013). However, infrastructure development and improvement has been much slower than the population and vehicle growth.

Therefore, with the increasing number of vehicles, increasing population of Manzini city, lack of matching infrastructure improvements and low road safety awareness, road traffic accidents are inevitably expected to rise even higher in the future, unless preventive measures are put in place. That there has paradoxically been a decrease observed since 2009 suggests that some preventive measures are in place and are to some degree effective, but the continuing high levels of RTAs, despite the recent decrease, remain concerning.

Public transport such as bus, mini-bus taxi and individual-fare taxi are operating as private sector enterprises, but function under permits approved by the Road Transportation Board, Swaziland (Ministry of Public Works and Transport Master Plan Report, 2013). Mini-bus taxis operate like a bus but often without rigid stopping points and stopping times and they aggressively compete with each other for passengers. On the other hand, the bus service operates with relatively fixed times and identified bus stop sites.

The immediate causes of serious and fatal RTAs listed in the literature are those due to human factors such as age; speeding; drunk driving; non-wearing of helmets, seat-belts and child restraints; distracted driving and fatigue (WHO, 2013a). It may also be due to road factors such as defective road design; potholes in the road; lack of proper signage and the lack of road markings such as occurs with worn lane and pedestrian crossing stripes (WHO Road safety training manual, 2006). Alternatively, it may be due to vehicle defects such as tyre defects; brake system failures; or a design defect of the brake system (Agbonkhese et al., 2013). The final categories of immediate causes are those due to environmental/weather factors, such as foggy or rainy weather which affects visibility of the driver and also makes vehicle handling more difficult (Agbonkhese, 2013).

Rational ways of addressing these immediate causes are well known, but which mix of immediate causes are mainly operative in Manzini is unclear and the current underlying reasons for the operative immediate causes of RTAs in Manzini city are unclear as well. Even though raw data are available at traffic police stations, the immediate causes of serious and fatal RTAs are not studied and not made known to stakeholders either. The reason for this is that there was and remains inadequate analytical research capacity within the traffic police department and hence full analyses and use of these routinely recorded data has not been effected yet.

The actual measures to be taken to prevent serious and fatal road traffic accidents in the Manzini region would be easier to discern if the immediate and underlying causes of RTAs are identified.

RESEARCH PROBLEM

According to the Manzini Traffic Police Periodical Statistical reports (2008 - 2012), road traffic accidents are a major public health problem in Manzini with many people seriously injured and killed due to RTAs.

A report from RFM hospital (Surgical Department Annual Report, 2012) also shows that the intake of severe trauma cases due to RTAs is very high. The factors commonly listed in the literature which are associated with RTAs that result in serious and fatal injuries, include: various human factors, various infrastructure inadequacies, various vehicle defects, various policing constraints and various environmental/weather factors.

The potential causes of serious and fatal RTA injuries in Manzini city are undoubtedly the same as those occurring elsewhere, however the actual mix of causes operative in Manzini city are unknown.

Appropriate ways of addressing and counteracting each of these immediate causes are well-known, but which combinations of immediate causes are mainly operative in Manzini city are not yet known, therefore, identifying causes of serious and fatal RTA injuries in Manzini city are important, in order to take appropriate actions to prevent and mitigate the health and economic impact of road traffic accidents.

PURPOSE

The purpose of this study is to make available the findings on risk factors associated with serious and fatal RTA injuries in Manzini city, Swaziland to the Traffic Police Department and the Road Transportation Department, in order to assist them to formulate policy recommendations that would enhance implementation of road-safety measures to prevent such accidents from happening in the future. The study results would also be useful in developing evidence-based education around road safety for drivers and the general public. The data can in addition be used as baseline data for future RTA related research. Finally, it can be utilised by district health care professionals and health authorities to plan for improved appropriate trauma care services, which can optimally deal with likely injuries resulting from RTAs.

LITERATURE REVIEW

People use roads to move around and to transport goods from place to place. This movement plays a crucial role in economic and social development, however the increasing travel of people and goods on roads results in the risk of road traffic accidents (WHO, 2009). Although all types of road users are at risk of being injured or killed in a road traffic crash, there are notable differences in fatality rates between different road user groups, and the causes of RTAs vary substantially in varying circumstances as well (Peden et al., 2004).

Road traffic accidents are a major global problem as it places an immense burden on the national health system, frequently results in loss of lives, often results in disability, universally creates grief for the victims and the family of the victims, and almost always causes damage to vehicles and other property (WHO, 2009). Generally, as stated by Peden et al. (2004) road traffic accidents have an impact physically, emotionally, and socioeconomically on both the individuals involved and on society. In addition, Peden et al. (2004) illustrated that the economic costs of RTAs are enormous and particularly so in developing countries, where the incidence of RTAs is much higher than in developed countries. For everyone killed, injured, or disabled by a road traffic crash there are countless others deeply affected. Many families are driven deeper into poverty by the expenses of prolonged medical care, loss of a family breadwinner, or the added burden of caring for the disabled after a RTA (Peden et al., 2004).

Mohan (2002) showed in his review of the literature that among road users, pedestrians and cyclists are more often and more seriously affected by accidents in low-income developing countries. The author stated that in 1994 in Delhi, India pedestrians and cyclists respectively made up, 42% and 14% of all road users' fatalities, whereas the percentage of death was 12% for users of motorised four wheelers. Other studies in Kenya showed that passengers are the second largest group of road users injured in accidents (Odero, 2003; Khayesi, 2003).

On the other hand, in 1995 in the USA the percentage of deaths were 13% and 2% of all fatalities for pedestrians and cyclists respectively, whereas for users of motorised four wheelers the percentage of deaths was 79%. (Mohan, 2002; Odero, 2003). This difference is assumed to be due to the undeveloped or even non-existent provision of road and sidewalk infrastructure for pedestrians and cyclists in low-income developing countries.

Solving this challenge posed by RTAs requires determined prevention efforts. However, one needs to know the mix of contributing causes of RTAs in order to work on meaningful prevention efforts. It may not be possible in practice to completely eliminate all RTAs, but it is possible to reduce their incidence, their severity, and their consequences, such as the risk of death and severe injuries (Peden et al., 2004).

Road traffic accidents occur due to a combination of different factors: These factors include errors by road users, conditions of the road, weather conditions and the vehicle conditions (Peden et al., 2004). These factors might not act as isolated entities and indeed more commonly they act in combination with one another, with the result that typically RTAs are poly-causal (Robertson, 1998). However, a report from Road safety in India (2010) showed that the most common cause of RTAs was due to mistakes of the drivers 86 %, followed by bad road conditions 5 %, mistakes of pedestrians 4 %, vehicle defects 1 % and other causes 4% (Road safety in India, 2010). Similarly, a study done in New Zealand stated that even though multiple factors appear to contribute to the cause of accidents, drivers are responsible for a high proportion of road fatalities and serious injuries (Whitlock et al., 2004). It was reported in Ireland that the main contributing factor to fatalities (96%) in RTAs was the behavior of the road user. The behavior of drivers contributed to 88% of road fatalities, the behavior of pedestrians contributed to 8% of road fatalities, road factors contributed to 2% of road fatalities, while environmental factors and vehicle factors combined contributed to 2% of road fatalities (Mayo Road Safety, 2005). Similarly, a report from the United Kingdom stated that driver's actions accounted for 72% of RTAs, followed by the road environment 13%, pedestrians 13%, with vehicle defects accounting for 2% (Annual Report GB, 2011).

Thus, the studies from both a developing country and from developed countries showed that drivers are responsible for the majority of the road fatalities.

In general, as noted above in the introduction, the four major immediate factors associated with serous and fatal road traffic accidents can be categorised as shown below (Peden et al., 2004).

1. Human factors/Road Users – drivers (cars, buses, trucks, mini-bus taxis), passengers, pedestrians, cyclists, motor-cyclists.
2. Vehicle defects - Defects such as failure of brakes, unresponsive steering system, worn tyres, poor lighting system.
3. Road defects and other infrastructural defects – defects such as sliding road surface, pot holes, ruts, lack of signage, lack of sidewalks.

Road design faults - Defective geometric design such as inadequate sight distance, inadequate width of shoulders, improper curve design, improper traffic control devices and improper lighting.

4. Environmental factors/weather conditions - Unfavorable weather conditions like mist, snow, ice and heavy rainfall which restrict normal visibility and makes driving unsafe, as well as more unusual events such as dense smoke, oil spills and obstacles such as rocks on the road.

As the core of this study is centered on causes of severe and fatal RTAs, each of these potential causal categories are expanded on in the rest of the literature review, with some of them also disaggregated into sub-categories.

1. *Human factors/road users fault*

Human factors in vehicle collisions include all factors related to drivers and other road users that may contribute to a collision.

Driver factors

In Nigeria driving etiquette was reported as the single most important contributing factor to RTAs, as driver factors solely contributed to about 57 per cent of road traffic accidents and 93 per cent of RTAs were either entirely due to driver actions or due to driver actions in combination with other factors (Agbonkhese, 2013).

Peden et al., (2004) stated that both in developed and developing countries the behavior of drivers has been recognised as an important risk factor associated with RTAs. The authors further stated that among the risk factors considered to play a significant role in influencing the severity of RTAs are driver's age, gender, marital status, education, training, socioeconomic status, emotional status, fatigue and driving speed (Peden et al., 2004). Thus a better understanding of these factors associated with RTAs is essential in order to take appropriate measures to increase driving safety (Odero et al., 2003).

Accordingly, the main behavioral risk factors of the drivers resulting in RTAs (Peden et al., 2004; Burgut et al., 2010) are discussed as follows:

Age: A WHO (2013a) report indicated that young adult drivers aged between 15 and 44 years account for 59% of global road traffic deaths. The crash risks for teenage drivers are greater than those for any other comparable age group, with specifically 16-year-old and 17-year-old drivers being at particularly high risk (Williams, 2003). Vivoli et al. (2006) reviewed the literature and showed that, most accidents involve subjects under 25 years of age (35%), and that crash rates in drivers aged over 70 years are higher than those who are middle-aged and comparable to those of young subjects.

Sex: The same World Health Organization report indicated that more than three-quarters (77%) of all road traffic deaths occur among men (WHO, 2013b). Road traffic mortality rates are higher in men than in women in all regions regardless of income level, and also across all age groups. The gender difference in mortality rates is probably related to both exposure levels and risk-taking behavior amongst men as more men than women are likely to be drivers (Peden et al., 2002; Peden et al., 2004).

Alcohol use: In the Netherlands, Movig et al. (2004) found that drivers who tested positive for alcohol (blood alcohol concentration levels above 0.08 g/dl) had an increased likelihood of being injured in an accident; OR = 15.5 (95% CI:7.1- 33.9). A cross-sectional study done in Nigeria showed ninety-four percent of those involved in road accidents responded that they did consume alcohol a short while before driving, indicating that alcohol consumption has a significant impact on the likelihood of accident occurrence (Stephens and Ukpere, 2011). According to the World Report on Road Traffic Injury Prevention and other studies, drinking and driving increases both the risk of a crash and the likelihood of death or serious injury resulting from the crash (Bergen, 2010; Hingson, et al., 2003; Peden, et al., 2004). The WHO report stated that the risk of being involved in a crash increase significantly above a blood alcohol concentration (BAC) of 0.04 g/dl (WHO, 2013b). On the other hand, Plurad et al. studied the association of alcohol consumption with the type and severity of RTA injuries in the USA and of the 3025 people involved in RTAs studied in, 2013 (67%) were in the “zero blood alcohol level” group, 216 (7%) were in the “low blood alcohol level group”, and 796 (26%) were in the “high blood alcohol level group”. However, this study revealed that blood alcohol levels were not associated with RTAs injury severity, emergency department hypotension (which occurs due to blood loss), or intensive care unit length of stay (Plurad, 2010).

Speeding: A WHO report showed that speed of motor vehicles is at the core of the road injury problem (WHO, 2013a). The report further stated that an increase in average speed is directly related both to the likelihood of a crash occurring and to the severity of the consequences of the crash.

Wang, et al. (2003) showed that excessive speed was the main reported cause of road traffic crashes in China. Speeding and other driving errors such as loss of control of vehicle, misjudgment and improper overtaking, contributed to 44% of all police-reported crashes in Kenya (Odero, 2003). In a similar study speed was identified as the main contributory factor in 50% of road crashes in Ghana between 1998 and 2000 (Afukaar, 2003).

Driver fatigue: A population based case control study done in New Zealand stated that driver fatigue or sleepiness due to a range of factors including long-distance driving without rest, sleep deprivation and the disruption of circadian rhythms and stress, is associated with a high occurrence of road traffic accidents (Connor, 2002). It indicated that acute sleepiness in car drivers significantly increased the risk of a crash in which a car occupant is injured or killed.

Distracted driving: There are many types of distractions that can lead to impaired driving, but recently there has been a marked increase around the world in the use of mobile phones by drivers, which is becoming a growing concern for road safety. A WHO report concluded that using mobile phones while driving causes cognitive distraction. It further noted that drivers using a mobile phone are approximately four times more likely to be involved in a crash (WHO, 2011b). In another study it is described that mobile phones impair driving regardless of whether they are used in a hand held or hands free manner (WHO, 2011b).

Inexperienced and unqualified drivers: Unqualified drivers are less likely to be able to adequately control a vehicle and are much less likely to be both conversant with and cognizant of the rules of the road. Many Nigerian drivers reportedly do not possess the right authorisation from government authorized agencies (Agbonkhese, 2013), and they were involved in RTAs more frequently.

Non-use of safety devices: Seat belts are safety devices provided to safeguard vehicle occupants in the event of an accident, thereby potentially saving lives and reducing the severity of injury to the driver and passengers (Ogundele et al., 2013). According to a prospective study done in

Nigeria by Ogundele et al., (2013) among the 140 patients attended at the emergency department, 57% patients used seat-belts, while 42.1% did not. 13.6% patients died as a result of their injuries; 21.1% of these had used seat-belts, while 79% did not. The mortality rate of 79% for patients who did not use seat-belt was statistically significant. The injury mechanisms described in non-use of seat belts were ejection from the vehicle (27.1%), dashboard collision (21.4%), and collision with co-passengers, the vehicle seat and the body of the vehicle.

Public transport and particularly Minibus taxi drivers

The minibus taxi industry is the most important public transport sector in many underdeveloped countries. It is the most accessible and available mode of transport and is also the most affordable to the public (Alive Arrive, 2008). Minibus taxis drivers mostly operate at speeds higher than the road limit so as to cut travel time in order to secure more passengers, as their income is directly linked to the number of passengers they transport (Kapila, 1982). Passengers pay for their fares in cash without receiving a receipt therefore the minibus taxi owner cannot determine the daily income from fares and have responded to this by paying the driver exclusively via a commission system. In lieu of wages the income from the fares are split with the driver, but with the owner receiving a fixed amount per day with the driver then retaining all fare income received above that daily amount. There is therefore invariably pressure on the drivers to meet the strict daily requirements of numbers, both in trips made and passengers ferried (Govender, 2007) as after they attain the daily requirement set by the owner, they will try to earn more for themselves within the time available. In addition, in the event of brake pad or brake lining replacement, the driver would purchase the cheapest available, as this has a direct bearing on his wages (as the driver is strangely but typically responsible for wear and tear maintenance, although the owner remains responsible for other repairs), but which results in defective vehicles (Govender, 2007). All these conditions induce minibus taxi drivers into risky driving behavior, most notably speeding and overloading. While operating at these incomes induced high speeds, usually overloaded (again to maximise driver income), the stopping distance of these vehicles increases considerably from the design specification, thereby increasing the likelihood of RTAs with serious and/or fatal consequences (Chiduo, 2001).
A descriptive study done by Museru et al. (2002) in Tanzania, showed that 56% of those injured in RTAs were vehicle passengers. They conjectured that the large number of killed and injured

passengers was probably related to the large population of buses, minibuses, pickups and lorries carrying passengers that are involved in road accidents (Museru et al., 2002). As stated previously, these vehicles are often overloaded, under-maintained and poorly repaired. This is due to pressure on the operators to achieve their daily targets resulting in high casualty rates as the buses and minibuses are often involved in reckless driving while competing for passengers for their personal financial interest to make as many trips as possible per day (Chiduo, 2001).

Standard taxi drivers

Even though the existing literature is sparse on standard taxis (passenger designated destination) road traffic accidents, it is deemed to be safer means of transportation than both minibus taxis and private vehicles (Dalziel, 1997). In Swaziland they are rarely seen involved in RTAs and this is possibly due to the relatively low volume of standard taxis.

Bus drivers

The mode of transport of choice in developing countries usually depends on the socioeconomic status of individuals. For people with low socioeconomic status, the affordable means of transport are walking, travelling by bus, minibus or truck, or cycling. These all expose them to high risks for road traffic injuries. For example, in Kenya 27% of commuters who have no formal education were found to travel on foot, 55% usually used buses or minibuses, and 9% used private cars (Nantulya, 2002). Unlike the minibus taxi, the buses have specific stoppage points, and relatively less competition among themselves. However, the bus drivers sometimes do overload, speed and at times risky behaviors are displayed in an effort to increase their income (Komba, 2007).

Truck drivers

According to a study from Tanzanian, truckers drive for a long time without rest. The driving hours imposed by the fleet owners are a major challenge, as driving for so long makes drivers fatigued and inattentive, which increases the likelihood of hazardous situations or crashes (Kircher, 2013). Many truck drivers stated that driver recklessness was a major reason for crashes, followed by driving under the influence of alcohol, lacking attentiveness, fatigue, and speeding, which were all named by at least 15 percent of the drivers (Kircher, 2013).

Motor cyclists

Serious injury and deaths of motor cyclists and their pillions consequent on a motor cycle accident are more common than among 4 wheeled vehicles. Ogagaoghene (2011) speaking at the inauguration of members of the association of motorcycle riders in Oyo state, Nigeria, attested to the fact that motorcycles have a higher fatality rate per unit of distance travelled when compared with automobiles, but noted that this is because motorcycle riders are otherwise referred to as exposed road users (Ogagaoghene, 2011).

While motorcycle accident causes may be a combination of human errors, poor road signs, road defects, and vehicle defects, motor cyclist rider erroneous behavior is generally considered to be the predominant contributor to any road crash. (Odero, 1997; Lin, 2003). It was noted that the most important aspects related to the human factor are the age of the motorcyclist, failure to use a helmet, speeding, wrong overtaking, alcohol intake, fatigue, lack of a license and educational level (Shibata and Fukuda, 1994; Odero, 1997; Lin, 2003; Sexton, 2004).

In Thailand, it was reported that motorcycle-related crashes accounted for the majority of injuries and death from RTAs, with contributing factors including alcoholic consumption, invalid driver's license, inexperience and age of the drivers (Ichikawa, 2003). These driver related factors were found to be more common characteristics in motorcycle accidents than in accidents by other vehicles in Singapore as well (Haque, 2009).

A descriptive study done in Oyo State Nigeria (2012) revealed that the majority of motorcycle riders were male (94.9%) and that most of the riders (62.8%) were between the ages of 20-30 years. Furthermore, drinking and driving percentages was reported to be (49.3%) among those riders involved in motorcycle accidents (Gboyega, 2012).

Cyclists

It is reported that in Great Britain cyclist casualties increased in 2013 in concert with the increase in cycling with the majority of cyclist casualties being adults, with less than one fifth being children. Additionally, males were far more likely to be involved in cycling accidents than females, with four out of five cyclist casualties being male (RoSPA, 2013; Department for Transport, 2014). Furthermore, most cycling accidents happen in urban areas where most cycling takes place with almost two thirds of cyclists killed or seriously injured being involved in collisions at, or near, a road junction, with T junctions being the most commonly involved, but roundabouts are also particularly dangerous junctions for cyclists (Department for Transport, 2014; RoSPA, 2013).

Causes of accidents amongst child cyclists are often the result of the child playing, doing tricks, riding too fast, or losing control. For teenage and adult cyclists, accidents are more likely to involve collisions with motor vehicles, but about 16% of fatal or serious cyclist accidents reported to the police do not involve a collision with another vehicle, but are caused by the rider losing control of their bicycle (RoSPA, 2013).

According to the report from Great Britain (Department for Transport, 2014) in collisions involving a bicycle and another vehicle, the most common key contributory factor recorded by the police is 'failed to look properly' by either the driver or rider, especially at junctions. 'Failed to look properly' was attributed to the car driver in 57% of serious collisions and to the cyclist in 43% of serious collisions at junctions (Department for Transport, 2014; RoSPA, 2013).

Other common contributory factors attributed to drivers involved in vehicle/cycle RTAs are 'poor turn/maneuver' (in 17% of serious accidents involving a cyclist) and “careless, reckless, in a hurry” (17%). Cyclists are more likely to suffer serious injuries when a driver is judged to be 'impaired by alcohol', exceeding the speed limit' or 'travelling too fast for the conditions'(Knowles et al., 2009; RoSPA, 2013).

The other most common contributory factor attributed to cyclists was 'cyclist entering the road from the pavement' (including when a cyclist crosses the road at a pedestrian crossing), which was recorded in about 20% of serious collisions (and over one third of serious collisions involving child cyclists) (Knowles et al., 2009; RoSPA, 2013). The predominance of cyclist casualties in South-East Asian countries and Surinam can be attributed to the common traffic mix on the roads, characterized by the abundance of motorized and non-motorized two and three-wheeler vehicles, as well as a lack of segregated facilities for them in the road network such as specific cycle lanes (Downing, 1991).

Pedestrian factors

Several researchers reported that unsafe pedestrian behavior is a major factor in pedestrian injuries and fatalities. In a study done in Florida, it was discovered that pedestrians were at fault in 80 percent of these incidents (Lee, 2005). In a similar study, in the U.K., pedestrian behavior accounted for 90 percent of crashes where a vehicle struck a pedestrian (Teanby, 1993). It was also reported in the United States of America (USA) that although by far the biggest cause of road accidents is driver/rider error or reaction, which causes 68% of RTAs, pedestrian error was the next biggest cause contributing to 13% of all the causes of RTAs (Richard, 2014).

It was reported from a study in Ghana that pedestrian's behaviors such as inattention and distraction predisposed them to RTAs (Damsere et al., 2010). According to this report, distracted pedestrians are those wearing headphones, talking on a cell phone, eating, drinking, smoking or talking as they crossed the street. According to a "Road Casualty Report" from the UK, pedestrian fault contributed to 13 per cent of all accidents, to 18 per cent of fatal accidents and to 20 percent of serious accidents. The commonest reasons for the accident were mostly that the pedestrian failed to look properly, or crossing a road masked by a stationary or parked vehicle and failure to judge a vehicle's path or speed (Annual Report GB, 2011). Indeed, the most common types of pedestrian errors reported from other environments were failure to look properly before crossing a road, carelessness or recklessness when crossing or walking along a road, or being in a hurry and hence less vigilant, or crossing a road masked by a stationary or parked vehicle (Damsere et al., 2010).

In developing countries, it was reported that pedestrian RTAs were more common among males across all age groups (Peden et al., 2004; Nantulya and Reich 2002). According to a review of available studies done in the USA, pedestrian RTAs and fatalities were most prevalent among young children between the ages of 5 and 9 years, and the next biggest category was older adults over 70 years of age (Retting et al., 2003). According to a study done by Heinonen et al. (2007) some pedestrians might be injured or killed because they are ignorant of the risks that predisposes them to a pedestrian-vehicle crash (Heinonen et al., 2007).

Alcohol: Drunken driving is the cause of many traffic crashes throughout the world. Similarly, drinking contributes to unsafe pedestrian behaviours that result in crashes with vehicles. Pedestrians who have been drinking run an even higher risk of getting killed in traffic, constituting between 39 percent and 60 percent of all pedestrian fatalities (Carole Millar Research, 1998).

Drunken pedestrians can contribute to pedestrian-vehicle crashes because they likely have slower reaction time, have poor judgment, and are not likely to assess the safeness of walking conditions (Carole Millar Research, 1998). Vestrup et al. (1989) from Canada also reported that alcohol was a factor in 52% of male pedestrians involved in RTAs and 12% of female pedestrians.

Passenger factors

Passenger induced road traffic accidents are relatively rare. Possible causes of passenger caused road traffic accident might be due to attention distraction by talking to the driver, quarrelling with the driver or other passengers or physical interference with the driver. Another possible scenario is that a passenger may fall (or jump) out of a moving vehicle and sustain fall injuries and/or a collision with other vehicles.

The high proportion of passenger fatalities in RTAs appears to be associated with a lack of safety facilities in the car with either the vehicles being modified or the safety facilities being damaged. In Papua New Guinea, for example, a significant number of deaths occur amongst passengers riding on open-back utility vehicles which have no seats or restraints for the passengers being transported in them (Jayasuria 1991; Nelson & Struber 1991).

Road factors

Road defects such as a slippery sliding road surface, pot holes and ruts/grooves are some of the contributory factors to RTAs. In addition, road design defects such as defective geometric design resulting in inadequate sight distance, inadequate width of road shoulders, improper curve/turns design, improper traffic control devices and improper lighting can all contribute to serious RTAs.

A review of risks on the highways done in Great Britain showed that road environment factors were contributory in 28 percent of road traffic accidents (Sabey and Taylor, 1980), while a study done in the Philippines showed that damaged roads contributed by only 5% to RTAs (Tamayo, 2009). A similar study done in Kenya showed that the road environment contributed 2.9% to the RTAs (Manyara et al., 2013). Even though developing countries road infrastructure appears to have lower quality design and less maintenance, its contribution as a causal factor to RTAs appears to be much less than that of the Great Britain study. This inconsistency happened most likely due to inter-observer variation. However, in a study from Nigeria, where analysis of contributory risk factors to RTAs was done based on traffic police records from 2001 to 2008, as much as 21.1% of RTAs were contributed to by road defects (Ohakwe, 2011). So even though the quality of road infrastructure appears to be quite different than that in Great Britain, road defects contribution to RTAs seems to be equal in these two countries and this could again possibly be due to inter-observer variation.

Despite the differences in magnitude of the contribution to RTAs, both studies indicated that good road design and regularly maintained roads can greatly help in reducing the frequency and severity of RTAs, and conversely poorly designed roads can also contribute to crashes.

In particular, the UK research has shown that investment in a safe road infrastructure programme such as improved traffic lights, speed limit reduction, improved pedestrian crossings and sidewalk facilities, good road markings, advanced warning signs, junction improvements and bicycle lanes could yield a ⅓ reduction in road deaths, saving as much as £6 billion per year (Hill, 2008). Similarly, a study done in Kenya by Manyara et al. (2013) stated that well-designed and maintained roads play a crucial role in prevention of RTAs, however badly designed (narrow roads, uneven, steep slopes, and sharp turns/curves) and neglected roads with potholes and no road signs, increases the chance of RTAs.

Potholes specifically can cause severe damage to a car and hence cause car accidents and truck accidents when vehicles swerve suddenly to avoid the potholes and many roads in under-developed countries have become death traps with potholes which are dotted along the length and breadth of the roads (Eke, 2001; Hijar et al., 2000). Manyara et al. (2013) further noted that RTAs due to incorrect ways of overtaking happen usually due to lack of warning signs or centerline markers. However, when RTAs happen, the blame is usually passed on to the driver, sometimes to vehicle defects, the weather, or some other combination of factors.

Potholes can also cause the most serious motorcycle accidents because a motorcycle has less weight and only two wheels on the ground. A study in Nigeria showed that potholes may cause major problems for motorcycles because they may require sudden changes of lane position and direction and the motorcyclists may lose control of their motorcycles, resulting in collisions with oncoming vehicles. Even when wearing a helmet, a pothole induced accident on a motorcycle can cause serious injury and even death (FRSC, 2007).

A report from India on road safety (Road safety in India, 2010) showed that bad road conditions accounted for 5% of the RTAs seen there. It is stated that the road factor in Africa is even worse as there is poor road design and maintenance. In addition, a variety of traffic mixes are commonly observed on the roads such as high speed vehicles, heavy long distance commercial traffic, pedestrians, cyclists, and motorbike users, with each of these traffic types requiring different infrastructure and usually with none of them being adequately provided for (Odero, 1997). In addition, in developing countries, rapidly increasing motorisation is outpacing the development of already inadequate transportation infrastructure and this fact is also contributing to the increasing numbers and rates of motor vehicle injuries (Jacob et al., 2000).

Vehicle Factors

Vehicle defect is one of the key causes of RTAs and a report from Nigeria stated that most vehicles on the roads are poorly maintained and that this lack of maintenance affects the occurrence of RTAs (Agbonkhese et al., 2013). Defective vehicle parts such as tyres, brakes and driving lights can lead to tragic accidents by affecting the driver's ability to maintain control of her/his vehicle. Safety products designed for vehicles, such as warning lights and indicator lights that don't work properly, may also cause serious accidents by inhibiting the drivers' ability to communicate their intentions to other road users. Inspection and maintenance of tyres, lights and braking systems is crucial to ensure the safety of drivers and other road users. According to a study by the Department for Transport in the UK (2005) accidents resulting from vehicle defects accounted for only 1.5% of total accidents. In another report from the UK, it was described that vehicle defects accounted for 2.8% of fatal, 2.2% of serious and 1.9% of slight accidents. It was reported that defective tyres and defective brakes were the most common cause of the vehicle defect related accidents (Annual Report GB, 2011).

According to the Museru et al. (2002) study fifteen percent of all accidents based on Tanzanian police records were due to defective motor vehicles. Moodley et al from South Africa stated that human error was found to be the most frequent contributing factor to RTAs and vehicle defects contributed less frequently (Moodley, 2008).

In developing countries, where economic realities force the population to make use of older and less reliable vehicles that often carry many more people than they are designed to carry, the risk of accidents caused by mechanical failure increases (Odero, 1997). It is reported that the tyres and brakes were the most dominant components that contributed to the mechanical defects causing accidents, followed with overloading.

A report from Nigeria pointed out that brake failure is another factor which leads to loss of motorcycle control and thereby resulting in an accident (FRSC, 2007).

A study done in South Africa indicated that proper identification of vehicle defects and appropriate action taken by road transport authorities could help to reduce accidents on roads, hence running roadworthy vehicles is critical to keeping our roads safe for everyone (Schoor, 2001). The Driver & Vehicle Standards Agency (2014) recommendation to keep vehicles in a roadworthy condition includes: 1) The drivers should always inspect the following items: service brakes, parking brake, steering mechanism, lighting devices and reflectors, horn, windshield wipers, mirrors, tyres, wheels and rims, and emergency equipment and exits. 2) The drivers should perform preventive maintenance for the vehicle according to the maintenance intervals recommendations by the vehicle manufacturer and any safety defects noted should be corrected before the vehicle is used in service.

Most developing countries don't have effective regulations to ensure that maintenance is carried out and defective vehicles are kept off the roads.

Weather factors

Weather is one environmental risk factor that is known to affect collision rates. Weather-related collisions may vary between countries depending on the climate conditions present in the countries. Rain, hail and snow can cause slippery roads. Heavy rain, snow and fog can limit visibility for the drivers. Rain reduces road friction with resultant increased skidding, impairs visibility and makes vehicle handling more difficult with loss of control more likely, thereby creating a safety threat (Andrey, 2003).

A report prepared by Andrey et al. from Canada, a country with sub-zero temperatures in winter and extreme weather conditions, stated that seven percent of all injury collisions are attributable to weather (Andrey, 2003). In a similar report from the USA, which has less extreme weather conditions, a much higher twenty-four percent of all crashes are weather-related and each year, nearly 7,400 people are killed and over 673,000 people are injured in these crashes (Paul, 2008). In Nigeria poorly maintained vehicles used on a rainy day are most likely to cause a road traffic accident especially if the wipers are faulty and the tyres are worn, to the extent that they are not functioning adequately, as the driver will be unable to see ahead and unable to control the vehicle (Agbonkhese et al., 2013). One can assume that similar scenarios might happen in many sub-Saharan countries, whereby road defects, poorly maintained cars and bad weather conditions can combine to cause RTAs.

Underlying causes s of RTAs

An overview of the immediate causes of RTAs has been covered above however these are themselves predisposed to or caused by other more distal underlying causes. A range of underlying causes may determine the prevalence of RTAs in a particular country. Underlying causes and especially those most relevant to developing countries are discussed below.

Factors contributing to the rising magnitude and burden of RTAs are diverse and complex in nature. Nantulya et al (2001 & 2002) in their articles stated that in developing countries, such as Kenya and Nigeria, there are multiple interrelated contributing factors to RTAs which include the following conditions: rapid growth in motorization and human population; increased traffic volume and movement; deficiencies and problems in road user behavior, and a poor public transport system with special reference to minibus taxis, buses and trucks, all of which contribute to the increase of RTAs (Nantulya, 2002; Nantulya, 2001). In addition, deficiencies in road network development and maintenance; deficiencies in road safety planning, management and interventions; and inadequate resources and qualified personnel play a great role as underlying conditions for road accidents (Nantulya, 2002; Nantulya, 2001).

One of the main factors contributing to the increase in global RTAs is the growing number of motor vehicles and rapidly increasing urbanisation in developing countries (UNDP, 1994; Bekefi, 2006). The other problem is the lack of ensuring that the appropriate road infrastructure and road safety measures accompany this growth in vehicle numbers in urban areas. Without proper planning, growth in the number of motor vehicles can lead to problems particularly for pedestrians and cyclists.

It was stated that poor enforcement of traffic safety regulations in low income countries are prevalent due to inadequate resources, administrative problems, and corruption (Hijaar, 1999). Corruption is a huge problem in some countries, often creating a circle of blame—the police blame drivers and the public, while the public blames drivers and the police, and drivers blame the police (Hijaar, 1999). Corruption also extends to vehicle and driver licensing agencies. An officer with the Lagos State Inspection Unit in Nigeria said, “You wonder how most of the buses secured road worthiness certificates in the first place and when you ban the buses from the roads, they still find their way of returning to the roads” (Eniwoke, 2001).

The choice of mode of transport in developing countries is often influenced by socioeconomic factors, especially income. People with little formal education earn low incomes and therefore for them, the most affordable means of transport are walking, travelling by bus or truck, or cycling—all of which expose them to high risks for road traffic injuries (Nantulya, 2001; Kapila, 1982). As previously stated, in Kenya, for example, 27% of commuters who have no formal education were found to travel on foot, 55% usually used buses or minibuses, and 9% used private cars. By contrast, 81% of people with secondary level education or above usually travelled in private cars; 19% travelled by bus, and none walked (Nantulya, 2002).

AIM AND OBJECTIVES

Aim

The aim of this study was to determine the risk factors associated with serious and fatal road traffic accident injuries in Manzini city, Swaziland.

Objectives:

1. To describe the human factors related to serious/fatal RTAs: such as driver, passenger, and pedestrians risk factors.
2. To uncover the vehicle factors related to serious/fatal RTAs: such as vehicle types and defects.
3. To discern the infrastructure factors related to serious/fatal RTAs: such as road surface type and road surface condition.
4. To establish the environmental factors related to serious/fatal RTAs: such as weather conditions, street-light condition, time of day, day of the week and season of the year.

METHODOLOGY

Study Design

A case control study design was used to assess what mix of risk factors are associated with serious and fatal road traffic accidents in Manzini, Swaziland. A case control study is quick and economical to conduct and allows the researcher to identify many different variables at the same time, hence it allows one to determine the association of multiple exposures with serious and fatal RTA injuries.

Study population

All RTAs which occurred within and around Manzini city and were registered at Manzini Traffic Police station, were included in the study population.

An exclusion criterion from the study population were all accidents where all vehicles involved were immobile vehicles, e.g. a tree falling on an immobile car, or intentional damage to an immobile car. All accident injuries that occurred to a person while washing the car, alighting from the car, or changing a tyre, or doing any other work on the vehicle, were excluded as well. In addition, all RTAs that did not have a severity designation were excluded.

All RTAs occurring within and around Manzini city and registered at Manzini Traffic Police station as serious or fatal injuries were included in the study population as a case, while RTAs not involving in serious injuries and/or fatalities were included in the study population as controls, with the proviso that they have the same exclusion criteria involving immobile vehicles, as the cases.

Sampling

Sample size

A total sample size of 224, consisting of 112 cases and 112 controls was determined as appropriate to detect most factors associated with severe and fatal injury. Assumptions made in determining the sample size included an odds ratio of 3 for an association of drunk driving with RTAs involving severe and/or fatal injuries, with an assumption of drunk driving levels amongst drivers involved in RTAs which did not involve severe injuries or fatalities of 10%, with a power of 80% and a confidence level of 95%.

Sample Type

A time-delimited sequential sample based on including all serious and fatal road traffic accidents recorded by traffic police from the commencement of data collection and moving back in time until the desired sample size is achieved, was used. This time period, which was estimated to cover two years was used as it provided the latest picture of events and as it covered all seasonality patterns. This was important because the pattern of RTAs varies not only with the time of day and the days within the week, but also with the months within the year. For example, RTAs in Swaziland are anecdotally known to be more prevalent at night, on Fridays and Saturdays and are also common in December and January. This December/January phenomenon is possible due to more people being out on the street to celebrate the holidays and possibly because they also have a greater tendency to drink and drive. Controls were similarly selected from the same time period, however since there were likely to be many more controls than cases, all RTAs that fit the definition for a control and occurred during the same time period as the cases, were considered available for selection into the sample. An equal number of controls as cases was then randomly selected from amongst all the eligible controls.

Sampling Procedures

Written approval to access the police records of RTAs had been acquired from Royal Police Commissioner and presented to Manzini traffic police station and the data collector (the researcher) availed himself at Manzini police station to access the database. All RTAs were accessed and assessed as to whether they involved serious or fatal injuries, using the operational definitions listed above. Those RTAS designated as serious or fatal injuries were selected as cases and then all the RTAs which were classified as not involving serious or fatal injuries and that occurred during the same time period as the cases, were categorised as controls, and a random sample of them was taken.

Data Collection

Pre-prepared data extraction forms were used to draw pertinent data from traffic police office records in Manzini city by the investigator. Information collected included: severity of injuries sustained by any party in the RTA (fatal, or serious, or minor, or none), type of vehicle/s, driver age, sex, date license was issued, driver error, driver alcohol use, seat-belt worn or not, pedestrian actions, date and time of accident, vehicle defect or not, road defects, road surface condition, location of accident and environmental factors. In addition, the traffic police officers' comments on what they thought the main cause of the accident was in broad categories such as vehicle defect, road defect, human error or environmental factor were recorded. All these variables listed were potential immediate contributory factors of RTAs.

Data Analysis

Before analysis was carried out, the dataset was checked to detect if any errors occurred during data collection. For categorical variables - checking was done for missing values and any unlikely codes. For numerical variables - checking was done for missing values and to determine if the value falls within a plausible range; e.g. driver age = 27 and not driver age = 7.

Data cleaning was done via a record screen of Epi Info version 3.5.1 software, using the list command and the sort button and by cross-checking with the hard-copy questionnaire. The data were then exported to SPSS version 20 for further analysis. For categorical and numerical variables univariate analysis were done as described below. Numerical data were summarized mathematically via their central tendencies as means (averages) and medians and via their distributions as standard deviations and their interquartile ranges. Categorical variables were summarized using category proportions. Binary logistic regression analysis was done to check variables associated with the dependent variable (severe/fatal RTA). Those variables found to have P values of ≤ 0.05 were further assessed via multivariable logistic regression analysis to control the effects of confounders. Adjusted odds ratios with 95% CI were computed and variables having P values ≤ 0.05 in the multiple logistic regression models were considered significantly associated with the dependent variable.

Reliability

The data extraction tool was standardised and then piloted, with some modifications post piloting to ensure consistency. The same data collector was used to increase consistency.

Validity

The researcher collected all the data and the data was checked repeatedly for any inaccuracies, such as missing values, implausible codes, omissions and additions, during the process of extracting the information.

The data used was secondary data. Therefore, the possibility of errors in the primary database was a possibility. The primary data were checked for plausibility in the same way as the extracted data was checked. Though selection bias was unlikely, it could have occurred if RTAs were not properly classified by the traffic police, hence the categorisation of the RTAs in the primary database were carefully checked before extracting the data. As only two years of data were collected it only provided insight into current factors associated with serious and fatal RTA injuries and we were not able to assess medium and long term trends and changes in factors affecting RTAs. As speed measuring instruments were not present at the RTAs, the measurement of "speeding" relied on the subjective judgment of the police officers, based on witnesses information or drivers' reports and general observations/deductions of the accident scenario. So there is the possibility of underestimating the true magnitude and frequency of "speeding". A potential impact on validity was if the police officers failed to complete all the details in their reports, as then there could be large amounts of missing data which would limit the precision of the study, and might even effectively result in a selection bias, if particular types of RTAs are preferentially left incomplete (e.g. reports on non-fatal and non-serious RTAS are more frequently incomplete), as these reports would have to be excluded from the study. The sample size chosen was sufficient to account for any random errors in sample selection for most of the factors being assessed, except for those that are very rare.

Ethics

A formal ethics approval letter was secured from Swaziland National Ethics Committee after the University of the Western Cape Research and Ethics committee approval was obtained. Written consent was obtained from Swaziland Royal Police Commissioner. The investigator collected the secondary data from Manzini Traffic Police Station after permission to do so was granted from the management of the police station. In this process there was no harm done to anyone. The study will produce valuable information that will help from both the Manzini Traffic Police and the RFM Hospital to implement appropriate interventions to prevent and mitigate the impact of serious and fatal RTAs. No names were extracted from the traffic police records and hence confidentiality was assured. Feedback will be provided to all stakeholders.

RESULTS

In the proposal, the intended sample to obtain was 224 comprising of 112 cases and 112 controls and to get 112 cases from the registered RTAs one needed to go back for almost two years. Thus, a complete listing of RTAs that occurred from 1 July 2013 to 30 June 2015 was done and then they were stratified according to the severity of the accidents. The total number of RTAs registered within the two years was 448. Serious and fatal accidents that occurred within the study period were 148. Five accidents in this group were excluded due to incomplete data records. So the remaining 143 fatal/serious injury accidents were categorised as cases.

The total number of minor injuries and vehicle damage only accidents were 300. From these 151 controls were selected by simple random sampling. This resulted in seventy-six minor injuries and seventy-five property damage only accidents being included in the study as controls, giving a total sample size of 294.

The study assessed the effects of risk factors on serious and fatal road traffic accidents in Manzini city during the study period as stated above. Table 1 shows the age and gender distribution of the drivers involved in the road traffic accidents, as well as the gender distribution of all drivers in Manzini city from 2013 - 2015. As can be seen most of the drivers (92%) involved in the RTAs were males, while only 71% of the registered drivers in the city were males, indicating that males are more likely to be involved in RTAs. The majority (47%) of the drivers involved in RTAs were in the age band of 25-34 years, which is unsurprising as it is also the age band containing the majority of the registered drivers in the population (55%). Table 1 also indicates that only 8% of the drivers involved in RTAs were females (compared to 29% within the general driver population) and they tended to be younger than their male counterparts.

Table 1: Age and gender distribution of drivers involved in RTAs from 1 July 2013 to 30 June 2015, as well as the registered driver population in Manzini city in 2013 – 2015.

Age Band	Drivers involved in RTAs						Total Registered Drivers In Manzini city		
	Case		Control		Total in RTAs		Males	Females	Total
	Male	Female	Male	Female	Males in RTAs	Females in RTAs			
<25	22 (16%)	2 (20%%)	17 (12%)	4 (31%)	39 (14%)	6 (26%)	688 (21%)	206 (15%)	894 (19%)
25-34	66 (50%)	3 (30%)	66 (48%)	4 (31%)	132 (49%)	7 (31%)	1809 (54%)	759 (55%)	2568 (55%)
35-44	29 (22%)	3 (30%)	29 (21%)	3 (23%)	58 (21%)	6 (26%)	556 (17%)	297 (22%)	853 (18%)
45-54	12 (9%)	2 (20%)	15 (11%)	2 (15%)	27 (10%)	4 (17)	173 (5%)	88 (6%)	261 (6%)
>54	4 (3%)	0	11 (8%)	0	15 (6%)	0	84 (3%)	26 (2%)	110 (2%)
Total	133 (100%)	10 (100%)	138 (100%)	13 (100%)	271 (100%)	23 (100%)	3310 (71%)	1376 (29%)	4686 (100%)

Table 2 shows the mean, median, interquartile range and standard deviation of the age of the drivers involved in RTAs grouped by cases and controls, as well as the age distribution of all the registered drivers in Manzini city. The data is right skewed, however the medians and inter-quartile ranges of the cases and controls are very similar, with the controls being slightly older than the cases. The mean, median and interquartile range of the ages of the registered drivers in Manzini city are slightly lower than that of the drivers involved in RTAs.

Table 2: Mean, median and inter-quartile ranges of the ages of drivers involved in RTAs grouped by cases and controls, as well as the total registered drivers in Manzini city.

Description	Cases	Controls	Total in RTAs	Total in Manzini city
Mean age	32.91	35.19	34.08	31.25
Median age	31	32	32	29
Interquartile ranges				
Q1 (25^{th} percentile)	27	28	27	25
Q2 (50^{th} percentile)	31	32	32	29
Q3 (75^{th} percentile)	38	41	39	35
Range	14-62	16-76	14-76	15 – 76
Standard deviation	9.41	11.22	10.42	8.35

Table 3 shows the crude odds ratio (OR) with 95% confidence interval and P value of the bivariate analysis comparing risk factors between fatal/serious accidents and accidents involving only minor injuries and/or vehicle damage. Based on the analyses eight variables were found to be significantly associated with the risk of fatal/serious injuries in the RTAs. These risk factors include: gender of driver, driver not using a seatbelt, driver without a license at the accident scene, driver suspected of driving while under the influence of alcohol, pedestrian error, season during which the RTA occurred, day of the week and time of the day.

Table 3: Comparison between cases and controls via crude odds ratios of the socio-demographic characteristics of the drivers involved in the accidents, the actions of those drivers, the condition of their vehicles, the role of pedestrians and the environmental circumstances in which the accidents occurred.

Variable	**Variable Category**	**Cases (%) n = 143**	**Controls (%) n = 151**	**Crude Odds Ratio(OR)**	**95% CI**	**P value**
Gender of driver	Male	137 (95.8%)	134 (88.7%)	3.32	(1.20 - 9.20)	0.021
	Female	6 (4.2%)	17 (11.3%)			
Age of driver in 10-year age categories	35 – 44 years	32 (22.4%)	32 (21.2%)			
	<25 years	24 (16.8%)	21 (13.9%)	1.14	(0.53-2.45)	0.732
	25 - 34 years	69 (48.3%)	70 (46.3%)	0.99	(0.55-1.78)	0.962
	45 - 54 years	14 (9.8%)	17 (11.3%)	0.82	0.35-1.95)	0.658
	>54 years	4 (2.8%)	11 (7.3%)	0.36	(0.11-1.26)	0.111
Driver error type	None	24 (17.8%)	27 (17.0%)			
	Fatigue/Asleep	1 (0.7%)	5 (3.1%)	0.23	0.03 - 2.06	0.187
	Inattentive	48 (35.6%)	74 (46.5%)	0.73	0.38 - 1.41	0.349
	Too fast	49 (36.3%)	32 (20.1)	1.72	0.85 - 3.50	0.132
	Too close	3 (2.2)	4 (2.5%)	0.84	0.17 - 4.16	0.835
	Bad overtaking	3 (2.2%)	8(5%)	0.42	0.10 - 1.77	0.239
	Bad turning	7 (5.2%)	9 (5.7%)	0.88	0.28 - 2.71	0.817
Driver error	Any Driver error	119 (83.2%)	124 (82.1%)	1.08	(0.59-1.98)	0.804
	No driver error	24 (16.8%)	27 (17.9%)			
Produced Driver's License at accident scene	Yes	76 (53.1)	98(64.9)	0.61	(0.38-0.98)	0.041
	No	67 (46.9)	53(35.1)			
Driver suspected of driving while under the influence of alcohol	Yes	52 (36.4)	22 (14.6)	2.77	(1.60-4.79)	0.000
	No	91(63.6)	129(85.4)			
Driver used a Seatbelt	Driver did not use seatbelt	43 (30.1)	12 (7.9)	3.93	(2.03-7.60)	0.000
	Driver used seatbelt	100 (69.9)	139 (81.3)			
Pedestrian error resulted in RTA	Pedestrian error	56 (39.2)	35 (23.2)	2.13	(1.29-3.54)	0.003
	No pedestrian error	87 (60.8)	116 (76.8)			

Continuation of table 3.

Variable	**Variable Category**	**Cases (%) n = 143**	**Controls (%) n = 151**	**Crude Odds Ratio(OR)**	**95% CI**	**P value**
Vehicle type	Other types of vehicle	84 (61.8%)	80 (50.6%)	0.84	(0.32-2.18)	0.714
	Car	52 (38.2%)	78 (49.4%)			
Vehicle defect present	Vehicle defect	19(13.3)	13(8.6)	1.63	(0.77-3.43)	0.201
	No Vehicle defect	124(86.7)	138(91.4)			
Road Factor At Site of RTA						
Road surface type at the time of the RTA	Gravel/Earth	30 (21.0)	20 (13.2)	1.74	(0.94-3.23)	0.08
	Concrete/Asphalt	113 (79.0)	131(86.8)			
Road surface condition at the time of the RTA	Wet/Flooded/Muddy	25(17.5)	32(21.2)	0.79	(0.44-1.41)	0.422
	Dry	118 (82.5)	119 (78.8)			
Environmental Conditions						
Weather condition at the time of the RTA	Adverse weather condition	8 (5.6)	13 (8.6)	0.63	(0.25-1.57)	0.319
	No adverse weather condition	135 (94.4)	138 (91.4)			
Street light condition at the time of the RTA	Reduced light	45 (31.5)	50 (33.1)	0.93	(0.57-1.51)	0.763
	Daylight	98 (68.5)	101(66.9)			
Season during which the RTA occurred	Winter	51 (35.7)	41 (27.2)	2.4	1.24-467	0.010
	Spring	27 (18.9)	34 (22.5)	1.83	0.88-3.79	0.105
	Summer	42 (29.4)	33 (21.9)	2.93	1.46-5.87	0.002
	Fall	23 (16.1)	43 (28.3)			
Day of week	Friday/Saturday	85 (59.4)	45 (29.8)	3.45	(2.15-5.59)	0.000
	Rest of days in week	58 (40.6)	106 (70.2)			
Time of day	18:00 - 23:59	43 (31.1)	8 (5.3)	7.47	(3.25-17.15)	0.000
	24:00 - 5:59	9 (6.3)	6 (4.0)	2.08	(0.70-6.20)	0.187
	6:00 - 11:59	37 (25.9)	62 (41.1)	0.83	(0.49 - 1.42)	0.493
	12:00 - 17:59	54 (37.8)	75 (49.7)			
Urban/Rural location of the RTA	Urban	21(14.7)	18 (11.9)	0.13	(0.65-2.50)	0.486
	Rural	122 (85.3)	133 (88.1)			

Table 4 summarizes the backward stepwise regression analysis results, with the full results of each iteration of the model shown in the appendices (table C and table D). As shown in table 4, backward stepwise regression modeling analyses were made on those independent variables that showed significant association with the dependent variable in bivariate analysis.

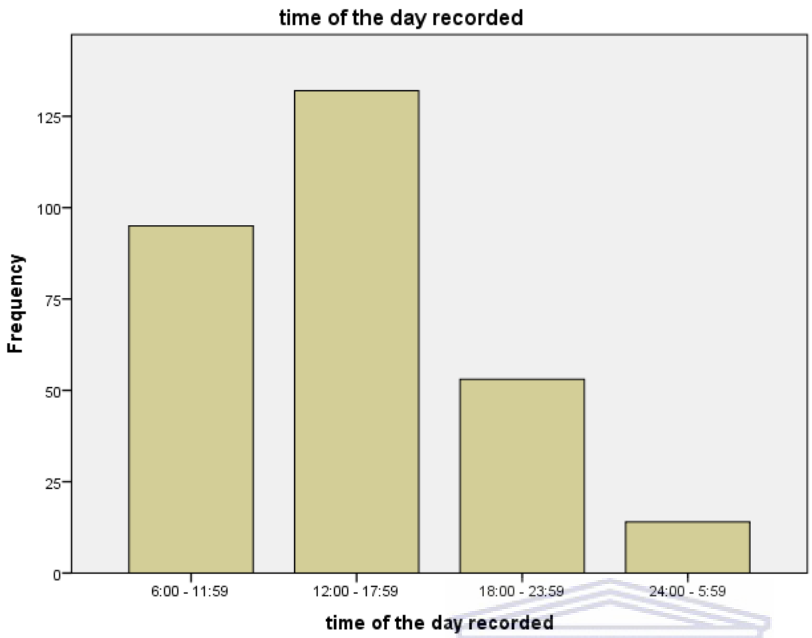
As shown in Table 4, five of the variables remained significantly associated with serious and fatal RTAs on multivariate analysis. Fatal or serious road traffic accidents in Manzini were more likely to occur in male drivers than females, when seatbelts were not used, when there was a pedestrian error, when it occurred on a Friday/ and when it happened between 18:00 - 23:59 hours during the day. However, the highest number of all RTA injuries happened between 12:00 - 17:59 hours although the proportions of severe/fatal RTAs and non-serious/non-fatal RTAs were similar (figure 1).

The age of the driver was initially inserted into the model and adjusted for as a numerical variable. However, in this study it was not found to be significant as there were minimal age differences between cases and controls and it was therefore removed from the final model.

Table 4. The backward stepwise regression modelling of the sociodemographic characteristics of the drivers involved in the accidents, the actions of those drivers, the role pedestrians and the environmental circumstances in which the accidents occurred.

Variable	Variable Category	Adjusted Odds Ratio	95% CI	P-value
Gender of driver	Male	5.48	(1.63-18.43)	0.006
	Female			
Driver used a Seatbelt	Driver did not use seatbelt	5.07	(2.39-10.74)	0.000
	Driver used seatbelt			
Pedestrian error resulted in RTA	Pedestrian error	2.66	(1.46-4.86)	0.001
	No pedestrian error			
Day of the week	Friday/Saturday	3.62	(2.07-6.33)	0.000
	Rest of days in week			
Time of the day	18:00 - 23:59	11.68	(4.49-30.39)	0.000
	24:00 - 5:59	3.15	(0.88-11.30)	0.078
	6:00 - 11:59	1.03	(0.55-1.92)	0.92
	12:00 - 17:59	1		

Figure 1. Frequency distribution of RTA injuries at the time of the day.



DISCUSSION

The discussion focusses on those variables that had an association with serious/fatal RTAs on multivariate analysis, but variables which had an effect on bivariate but not on multivariate are also commented on.

Variables that had no association but were expected to have an association with serious/fatal RTAs, such as age of driver, driver error and vehicle defect are then briefly discussed. The variable urban/rural location of RTA was difficult to assess as the study setting was mainly in Manzini city and around the city.

Gender of Driver

Ninety-two percent of drivers who were involved in all RTAs (irrespective of severity) were males, whereas males constituted only 76% of the total drivers in Manzini city, suggesting a possible association between male gender and all types of RTAs. Similarly, while 26% of drivers in Manzini city are females, only 8% of all types of RTAs involved female drivers. Male drivers had a hugely increased probability of becoming involved in a RTA involving a fatal/serious injury (adjusted OR of 5.48) compared to RTAs involving only minor injuries or no injuries (only vehicle damage occurred), than their female counterparts. Hence males in Manzini city are both possibly more likely to be involved in RTAs than females and if they are involved in a RTA then they are certainly much more likely to be involved in a fatal/serious injury RTA than females. These findings are however not universal and globally there is a diversity of effect of gender on RTAs and serious/fatal RTAs.

Our study findings are consistent with the findings of several other studies (Osoro, et al., 2011; Oder, et al., 1997; Yau, 2004; Turner, 2003; Kim, et al., 2008; WHO, 2002; Martin, 2004; Ginpil, et al., 1994), conducted in various contexts, but which all found that male drivers had a higher probability of being involved in a serious/fatal RTA than female drivers. However, it contrasts with other studies from Iran and Canada (Mehmandar, et al., 2014; Mao, et al., 1997) which found that there was no significant difference between female and male drivers in terms of severity of RTAs. Conversely a study done in the Netherlands (Ravera, et al., 2011) found that female drivers had a higher probability of being involved in serious/fatal RTAs. Despite this variability in findings in different contexts, globally males are almost three times (2.7) more likely to be involved in fatal RTAs (WHO, 2002).

Several studies conducted in varying contexts in different countries came up with comparable explanations for a higher incidence of RTAs amongst male drivers. For instance, Martin et al. (2004) from France, Odero et al. (1997) in a systematic review of studies of RTA injuries in developing countries; Osoro et al. (2011) from Kenya; Kim et al. (2004) from Hawaii; and Yau (2004) from Hong Kong; all convincingly postulated that male drivers were more likely to be at risk of being involved in RTAs as they more frequently travelled in motor vehicles for work-related activities and hence in tandem were also then at higher risk of fatal/serious RTAs. Their explanation of the higher vehicle mobility of males due to work related activities was that there are still strong socio-cultural demands on males to meet the needs of the family as breadwinners, which causes males to participate in various social and economic activities involving higher degrees of travel. These would be both due to using vehicles, whether private or public, to reach their places of work, as well as being involved in work activities which required them to drive vehicles. Other explanations they offered for the higher probability of male drivers being involved in serious/fatal RTAs were: a greater likelihood of choosing vehicles as a mode of transport; patterns of high risk-taking behaviors in males in general; and specifically, increased aggression and risk taking amongst males.

In addition to the above explanations, the Australian Federal Office of Road Safety reported that fatal and serious RTAs caused by female drivers are much less compared to those caused by male drivers, due to female drivers being less likely to get involved in drink driving or high speed driving, and females were also found to be more likely to use seatbelts than males (Ginpil, et al., 1994). These findings on drunk driving, speeding and seatbelt use however do not explain the gender differences found in our study, as although each of these factors were indeed also found to be associated with severe/fatal RTAs, the gender differences we found were adjusted for these and hence are independent of these factors. The studies from Iran and Canada which showed no significant difference between female and male drivers in terms of severity of RTAs (Mehmandar, et al., 2014; Mao, et al., 1997) provided quite different explanations as to why this was so, with the explanations linked to different gender norms prevalent in each country. Mehmandar, et al. (2014) described that females in Iran have less driving skills compared to males, as it is only recently that large proportions of females commenced driving and driving is still perceived as a quintessentially male activity. However, they noted that, as in many other countries, male drivers have higher risk taking driving behaviours and hence suggested that although the low driving skills of the females resulted in more serious/fatal RTAs, this was balanced by the higher risk taking driving behaviours of the males, with the result that the incidence of serious fatal RTAs was similar amongst the genders. Mao, et al (1997) proposed that the explanation of why males and females were equally likely to be involved in serious/fatal RTAs, in Canada, was also due to gender norms. However, they noted that in Canada one was looking at another spectrum of society, where social and economic norms and relative status, favours gender equality. Hence the risk of being involved in fatal/serious RTAs is assumed to be equal in both sexes as gendered differences and hence gender mediated behaviors, have been reduced.

In the case control study done in the Netherland (Ravera, et al., 2011) which found that female drivers were more likely to be involved in serious crashes than male drivers, the authors propose as explanation that females more frequently drive under the influence of drugs (which is legal in the Netherlands) and alcohol, than male drivers do. This phenomenon they link to cultural and socioeconomic flux, where women in developed countries such as the Netherlands become economically independent and less socially restricted and are free to do things which previously was socio-culturally linked to men mainly, hence they increasingly do so. This then applies equally to risk increasing behaviours such as drug/drunk driving as it does to all other gendered behaviours.

In our study a possible explanation for the higher mortality and morbidly could be due to a higher risk-taking behaviour of male drivers, as such behaviors are frequently observed in Manzini city (Manzini Traffic Police report, 2015). In addition, our study was done in a context where the breadwinner, from observation, is most often the male, resulting in them travelling more, and hence having more chance of using a private car and public transport. Therefore, although females constitute 26% of registered drivers in Manzini city, from Manzini police officer verbal communication, it is very likely that they drive much less than 26% of the total kilometers covered by drivers in any time period. The combination of the above, likely results in male drivers' greater predisposition to being involved in serious/fatal RTAs.

Driver Seatbelt use

Although assessing the use of seatbelts is best done by measuring use of seatbelts by all occupants of vehicles involved in RTAs, this was not possible in our study as only data on drivers' use of seatbelts are routinely collected. However, driver's use of seatbelts is a reasonable proxy measure of all occupants' use of seatbelts as the drivers' behaviour in this regard would influence the passengers (Hong, et al., 1998). In our study 30% of the drivers who were involved in serious/fatal RTAs did not use a seatbelt. Multivariate analysis showed a strong association between non–use of a seatbelt and serious/fatal RTA injuries (adjusted OR=5.07) compared with those who used a seatbelt.

Similar to our findings, in many developing countries, seatbelt use rate is very low, despite international research confirming that use of seatbelts is the most important factor affecting the risk of death, in the event of a serious collision (WHO, 2013). Several studies done in Iran reported similar or higher non-use of seat belt use rates, namely: Mohammadzadeh, et al. (2015) found seat belt non-use rates of 32%, Nabipour et al. (2014) 29% and Borghebani et al. (2013) 47%. A study done in Cape Town showed much lower seatbelt use rates of only 25% amongst vehicle occupants involved in road traffic collisions (Van Hoving, et al., 2014) and similarly in Ghana driver seat belt use rate was only 18% (Afukaar et al., 2010).

Our study is in line with several other reports that described a significant association of non-use of seat-belts with the development of serious/fatal RTA injuries (Van Hoving, et al., 2014; Abu-Zidan, eta al., 2012; Goonewardene, et al., 2010; Bener, et al., 2007; Yau, 2004; Mansuri, 2015). All these studies had given the explanation for low seatbelt use rate as being mainly due to poor traffic law enforcement. However, according to other studies done the most common reasons for not using a seat belt were: situational conditions such as alcohol/drug use, not believing the effectiveness of seat belts, underestimating the danger, over-confidence in the driver, being in traffic continuously, discomfort and not having developed the habit of doing so (Begg and Langley, 2000; Chliaoutakis et al., 2000; Fockler and Cooper, 1990). From personal observation and verbal communication with some of Manzini police officers, the non-use of seatbelt in Swaziland appears to be a combination of poor traffic law enforcement and driver's ignorance about the importance of seat belt use.

The explanations given by previous authors for the association of non-use of seatbelts with serious/fatal RTAs, were that seatbelts retain people in their seats during a crash and thereby prevent or reduce the severity of injuries. They minimise contact between the occupant and the vehicle interior and also reduce the risk of being ejected from the vehicle. So, the non-use of seatbelts removes these benefits. A WHO road traffic injury review (WHO, 2016) described that fastening seat-belts reduces the risk of a fatality among front-seat passengers by 40–50% and of rear-seat passengers by between 25–75%.

Even though the seat belt use rate seems better in our study compared to other developing countries, the association between being un-belted and severity of injuries from RTAs are high in Manzini, Swaziland.

Interventions such as focusing on traffic law enforcement and behavioral change inducement by education of drivers to wear seat belts, will probably result in a reduction in morbidity and mortality from RTAs (Valent, et al., 2002; Mohammadi, 2015).

Pedestrian Error

Thirty-nine percent of RTAs involving serious/fatal injuries are associated with pedestrian errors while 23% involving minor/property damage only were associated with pedestrian errors. It appears pedestrian errors were possibly more likely to be associated with serious/fatal RTA injuries. Both bivariate and multivariate regression analysis done showed significant association of pedestrian error with serious and fatal RTAs (adjusted OR of 2.13).

A report indicated that in developing countries pedestrian sidewalks are seldom present and frequently inadequate when present. Therefore, pedestrians opt to cross the roads in haphazard ways and to walk on the road, therefore predisposing to needless crashes. The report further stated that pedestrian faults accounted for 16% of severe/fatal RTA injuries (Damsere-Derry, 2010). In Manzini Swaziland such problems are observed daily. In addition, pedestrian behaviour such as inattention and distraction by wearing headphones, talking on a cell phone, eating, drinking or smoking and alcohol use, (Bungum et al. 2005; LasCala et al, 2001) are reported to contribute to serious/fatal RTAs. However, our study did not analyse these aspects of pedestrian behaviour, as these types of pedestrian faults/errors were not documented by Manzini traffic police officers. However, from personal observation it is highly likely there are such problems in Manzini city.

Another report from Great Britain showed that pedestrian error was a contributory factor in RTAs and were responsible for 20 per cent of fatal accidents on urban roads in 2014 (Annual report, 2014). The explanation given for the high number of pedestrian fatalities was mostly due to the high concentration of pedestrians on urban roads and also because pedestrians failed to look properly, failed to judge the vehicle speed, were careless and reckless or in a hurry, when crossing urban roads and thus were more likely to encounter RTAs.

Thus, the finding implies that road safety education needs to be reinforced amongst the public and at schools. Ameliorating measures such as raised pedestrian crossings, safe pedestrian walkways and speed humps, should be erected at pedestrian accident prone locations, to improve this situation.

Day of the week

More than fifty-nine percent of those involved in serious/fatal RTA injuries occurred on the Friday/Saturday of the week, whereas close to 30% of those involved in minor/property damage only happened on Friday/Saturday. Multivariate analysis showed an increased chance of serious/fatal RTA injuries occurrence on Friday/Saturday by about four times (adjusted OR = 3.62) compared with the rest of the days in the week.

Our study is consistent with other reports which described that a significantly higher number of accidents occurred on weekends (Odero, 1997; Pigman, et al., 1980; Hingson & Winter, 2003; Gray, 2008). All the studies described above gave the reason for the higher occurrence of serious/fatal RTA injuries on Fridays and Saturdays as possibly being due to a tendency of people to go out more towards the weekend hence increasing road usage, and the influence of additional exposure risk factors, including alcohol and possibly other intoxicating agents at these days of the week. Although our results are theoretically independent of the effect of the use of alcohol, which was adjusted for in the multivariate regression analysis, unfortunately driving under the influence of alcohol was not well measured in our study, as alcohol testing equipment is not routinely available at the RTA scenes.

Thus, to decrease serous/fatal RTAs on Fridays and Saturdays effective drink driving countermeasures such as effective enforcement and prevention of drink driving through random breath testing, public education campaigns and penalties must be implemented more frequently and comprehensively on these days.

From the Annual Report of the Surgical Department of RFM hospital (2015) and the Annual Report of the Manzini Traffic Police (2014), there is comparably increased serious/fatal RTA injuries on weekends in Manzini city, Swaziland. From personal observation, the reasons are likely to be due to people in Manzini city travelling more on weekends, as people typically visit relatives or friends and move around for recreation at the weekends. While the means of transport is mostly on foot, several others use public transport or private cars. In addition, given that recreation is the most common reason for travel on weekends it is therefore more likely that people would get involved in drinking alcohol and/or consuming mind altering substances. All these factors that increase the movement and activity of people from one place to the other over the weekend and increases associated risk factors, would contribute to the higher chance of occurrence of RTAs.

Time of day when a RTA occurred

In this study 31% of serious/fatal RTA injuries happened in the night time period between 18:00 - 23:59 hours. Multivariate analysis showed a very high association between fatal/serious RTA injuries occurrence and the night time period between 18:00 – 23:59 hours, with an increased occurrence of eleven times (adjusted OR of 11.68) compared with the day time period between 12:00 - 17:59 hours. The association of time period and severity of RTAs seems to vary from study to study.

Several studies stated that serious/fatal RTA injuries mostly happen at night time (Komba, 2007; Osoro, et al., 2011; Bates, et al., 2014) while Zhang, et al. (2013), described early morning time (which is still dark) as being associated with a higher risk of fatal/serious RTA injuries, and others such as Wang et al. (2008) found no difference. The explanations given for the night time period association with serious/fatal RTA injuries occurrence, as stated by all authors, was due to reduced visibility, faster driving at night, driving under the influence of alcohol and sleepiness. Reasons given for fatal/serious RTA injuries occurrence during the early morning were similarly suggested as being due to speeding, drunk driving, fatigue and sleepiness as significant contributory factors.

According to the Manzini traffic police (personal communication) the likely explanation for this scenario in Manzini city is assumed to be due to reduced visibility, speeding, drunk driving and fatigue.

These findings have important inferences for developing road safety promotion activities for targeted road user groups, (e.g. reducing speed during low visibility) as well as for establishing relevant regulations and policies to reduce RTA injuries severity in Manzini city (e.g. provision of street lights), and in other cities with similar settings.

Driver licence

Drivers failing to show a driver licence at the scene of a RTA when requested to by a police officer is a common occurrence in Manzini city. Perhaps it is due to carelessness that she/he left her/his driver's licence at home, or they may not have a valid driver’s licence at all. In this study 41% of the drivers involved in any accident could not produce a driver’s licence on request at the time of the accident and 47% of drivers involved in a serious/fatal road traffic accident could not produce a driver’s licence either. Bivariate analysis showed that drivers with a driver’s license were found to be less frequently involved in fatal/serious RTAs, however on adjusting for confounders in the backward stepwise regression model, the association was not found to be an independent one.

This finding is similar to a report from Western Australia that showed that 17.6% of drivers involved in fatal crashes were unlicensed drivers and interestingly and probably related to social issues, among the indigenous population 92.1% of drivers involved in fatal crashes were unlicensed (Plunkett, 2008).

Several studies provide strong evidence that unlicensed drivers are much more dangerous on the road than drivers with a valid driving licence (Watson, 2004; Singh, 2012; Brar, 2012). The reason given is that unlicensed drivers may operate outside the licensing system, and hence they are more likely to have never have had a licence, or been disqualified from holding a licence, have had their licence cancelled, or suspended, all of which suggests that they are unskillful drivers and probably inherently predisposed to risky situations.

Population-based survey on RTAs in Nigeria showed that the overall road traffic injury rate was 41 per 1,000 population, and mortality from road traffic injuries was 1.6 per 1,000 population (Labinjo, 2009). This high RTA injury was substantially contributed to by unlicensed drivers among other risk factors. Thus, many drivers without a valid driver licence or having procured a driver's licence through unauthorized means, resulted in high RTAs in Nigeria (Okafor, 2013). In Swaziland, from personal communication with the chief police officer in Manzini city, procurement of a driver's licence through unauthorized means rarely happens.

In our study the finding of a failure to show a valid driver's licence at the scene of an accident could be because they genuinely forgot the driver's licence at home, or because they do not have a valid driver's licence. In the absence of evidence, it is difficult to make a valid comment about the association of drivers without a driver's licence and severity of RTAs. This might be one of the areas where the importance of enforcement of traffic regulations and the creation of public awareness about the need for drivers to have their licence with them when driving, should be emphasized.

Suspicion of driving under the influence of Alcohol

In our study 36% of the drivers involved in serious/fatal RTA injuries were suspected of driving while under the influence of alcohol, whereas only 15% of the drives involved in minor injuries and property damage only were suspected of driving under the influence of alcohol. It appears that driving under the influence of alcohol increases the chance of being involved in serious/fatal RTAs. Bivariate analysis showed that suspicion of driving under the influence of alcohol significantly increased by almost three (OR=2.77) times the chance of being involved in a serious/fatal RTA. However, in the multivariate regression analysis there was no significant association.

In contrast to our study many other reports showed that driving while under the influence of alcohol has a significant association with severity of RTA occurrence (Peden, et al., 2004; Ahlm, K. & Eriksson, 2006; Mann, et al., 2011; McCoy, et al., 1989; Waller, 1986; Zador, et al., 2000; Hingson and Winter, 2003). All these studies, although done in different countries, agree with the assertion that alcohol influences the severity of RTAs by affecting the judgment and reasoning of the drivers, hence leading to them speeding, forgetting to wear safety belts, tending to violate traffic rules and generally engaging in reckless driving.

Our study probably did not show an independent association because we were only able to measure 'suspicion of driving under the influence of alcohol', as blood and expired air alcohol levels were not recorded by traffic officers at the scene of the accidents and hence those suspected of driving under the influence of alcohol were probably only those who were grossly intoxicated. This almost certainly resulted in an underreporting of drivers driving under the influence of alcohol. According to the information obtained from traffic police officers in Manzini city, challenges contributing to the inability to measure alcohol levels include: a shortage of breathalyzers and logistical challenges in drawing blood from the drivers. The other more relevant problem is that policy dictates that these tests are not done routinely, unless there are physical signs of intoxication observed. Therefore, if physical signs of intoxication were missed, then those drunk drivers will be missed resulting in increased underreporting. Furthermore, some drivers do not cooperate in allowing a blood test, or they might even run away after they caused an accident.

Season during which the RTA occurred

In this study 36% of serious/fatal RTA injuries occurred in winter followed by 29% in summer. Bivariate analysis showed that the risk of serious/fatal injuries were significantly higher in winter and summer. However, in backward stepwise multivariate regression analysis there was no significant association between the seasons and the severity of RTAs, suggesting that other confounding factors might have contributed to the differences in severity of RTAs seen on bivariate analysis.

The summer season in Swaziland is a festive season (Christmas and New Year) where a higher volume of holiday travelers, including a significantly higher number of alcohol-impaired drivers, are seen on the road, according to personal communication made the Manzini police department. Additionally, it is in the summer season that "marula" a locally made alcohol is brewed and used a lot. Furthermore, summer is a rainy season in Swaziland and during rainy weather RTAs are likely to increase. On the whole therefore, during the summer season serious/fatal RTAs were plausibly anticipated to rise, although it was not an independent association in our study.

In contrast to our findings other studies done in Iran and Hong Kong showed a significant association of summer season with severity of RTAs (Osoro, et al., 2011; Majdzadeh, et al., 2008; Yau, 2004). The explanations they gave were not only due to decreased visibility, but also due to slippery roads during rainy weather that could result in skidding and failure to control the vehicle.

Winter season in Swaziland is very cold and at times foggy but not a rainy season. As previously stated using backward stepwise multivariate regression analysis there was no association between winter season and severity of RTAs.

However, our finding was in contrast to other studies reported in Korea (Lee et al., 2014), in Finland (Juga, 2012), and in Canada (Andreescu and Frost, 1998) which showed that the decreased temperature during the winter season was associated with increased RTAs. Possible explanation given was that low temperatures may lead to greater braking distances by affecting the friction of roads due to snow in winter in these counties. In addition, temperature may be associated with traffic accidents via tyre conditions because temperature affects both tyre pressure and rubber flexibility (Muller et al., 2003). In Swaziland the decrease in temperature in winter is not sufficient to induce either snowfalls or tyre changes.

Drivers' Age

The pattern of driver age breakdown of those involved in all RTAs is comparable to the pattern of registered driver age breakdown of all drivers in Manzini city, except that the drivers involved in RTAs are slightly older, but not significantly so. Bivariate analysis showed no significant association between driver age and severity of RTAs.

In contrast to our study several other studies showed a positive relationship of young drivers with serious/fatal RTAs. Ramage-Morin, (2008); Clarke, (2010); Bates, (2014); Peden, et. al., (2004); Zador, et al., (2000); Qirjako, et.al., (2008); Mehmandar, et al., (2014); Yau, (2004) all reported a higher RTA risk and a higher RTA fatality rate amongst younger drivers. In these studies, it was stated that lack of driving experience, poor driving skills, high risk-taking behaviour, greater tendency to underestimate the crash risk in dangerous situations and an overestimation of their ability to avoid the threats, were possible explanations for the higher incidence of motor vehicle crashes and fatalities involving young drivers. With decreasing age in our study the risk of severe/fatal RTA increased, but the 95% confidence interval were wide and hence the lack of a statistically significant age association with severity of RTAs in our study could possibly be due to inadequate sample size to assess this variable in narrow age categories.

All Driver errors combined

All driver faults, such as fatigue, inattention, speeding, driving too close to other vehicles, incorrect overtaking and poor turning technique, were grouped under drivers' errors. Drivers' error was identified as a contributing risk factor in 83.2% of serious/fatal RTA injuries in Manzini city. The most frequent contributing factor for serious/fatal accident was found to be speeding (36.3%) followed by inattentiveness of the drivers (35.6%). It appears however that driver error equally contributed as a risk factor to serous/fatal RTAs and minor RTAs as bivariate analysis did not show a significant association between all driver errors combined and severity of RTA. Similarly, there was no significant association between any of the individual driver errors and severity of RTA.

Speeding

However, our finding is not in agreement with studies done elsewhere (Wegman & Aarts, 2008; WHO, 2015; Peden, et al., 2004; Laflamme, et al., 2007; Bedard, et al., 2002) where the authors found that driver errors, and in particular speeding, was significantly associated with serious/fatal

RTA injuries. A consistent finding was that speeding, consequent on drivers not having enough time to recognize and react to what is happening around them, is directly related both to the likelihood of a crash occurring and to the severity of the consequences of the crash (Mao, 1997; Afukaar, 2003; WHO, 2015). Commentary on other individual driver errors is provided below.

Inattentiveness while driving

In contrast to our study, and similarly as for speeding, several other studies showed that driver inattention (e.g. using cellphones, eating, drinking, adjusting radio/cassette/CD was a frequent contributing factor to serious/fatal RTAs (Klauer et al., 2006; Dingus et al., 2006; Stutts, 2001). There is a growing concern about the distraction caused by particularly cellphone use either for talking or texting messages as the use of such devices increases the probability of RTAs tremendously (Laberge-Nadeau et al., 2003). The explanation proffered for this is that using such devices while driving reduces the driver's awareness of their environment, to the extent that they are not paying attention to what is happening around them and hence are less able to respond to changing road and traffic circumstances.

In Manzini city inattention of drivers as for all other individual driver errors did not show a significant association with severity of RTAs and noting the wide 95% confidence intervals this finding can probably be attributed to the small sample size realised when assessing individual errors; or as for all errors combined it could indicate that driver error equally contributed to serous/fatal RTAs and minor RTAS.

Fatigue/falling asleep

In our study fatigue/falling asleep contributed to only one serious/fatal RTA (0.7% of cases) and therefore we couldn't assess the association of this variable with serious/fatal RTAs.

However, other researchers have shown that driver fatigue/falling asleep is a serious problem resulting in many thousands of road accidents each year (Johns, 2000; McConnell, 2003). Several other reports indicated that driver fatigue may be a contributory factor in up to 20% of road accidents with serious and fatal consequences (Brown, 1994; Sagberg, 1999; McConnell, 2003; Radun & Summala, 2004). The explanations given by these researchers for this was that sleepiness reduces reaction time (a critical element of safe driving) and it reduces vigilance, alertness and concentration, so that the ability to perform attention-based activities (such as driving) is impaired. The speed at which information is processed is also reduced by sleepiness and the quality of decision-making may also be affected.

It is extremely difficult for traffic police officers to recognize fatigue as a cause of road traffic accidents, as drivers may not disclose that they have fallen asleep because of concerns around possible legal and insurance consequences. In addition, some drivers are killed or seriously injured and therefore unavailable to provide information about this causal factor and therefore the magnitude of the challenge probably appears lower than it actually is, due to underreporting (Radun and Summala, 2004).

Hence it is unsurprising that reports of fatigue-related accidents by traffic police officers varies widely between different geographic areas. In the literature reports range from 1% for all police-reported accidents in the United States (Knipling, 1995) to 20% of fatal accidents in New South Wales, Australia (Radun and Summala, 2004).

In Manzini, Swaziland the low level of fatigue related RTAs is most probably as the result of underreporting.

Poor turning, incorrect overtaking and driving too close to other vehicles

In our study poor turning, driving too close to other vehicles and incorrect overtaking each occurred in a small proportion of serious/fatal RTAs (5.2%, 2.2% and 2.2% respectively) and as noted before bivariate analysis did not show a significant association with the severity of RTA injuries.

However, studies have shown that poor driving habits such as driving inappropriately close to another vehicle; unsafe overtaking and improper turning are driving offences that often cause serious/fatal RTA injuries (Ohakwe et al., 2011; Libres et al., 2008; Komba, 2007; Green, 2004).

Several studies showed that these errors are frequently committed by public transport drivers (i.e. minibus and taxi drivers). These drivers' primary goal is usually, and especially in developing countries, to transport as many commuters as possible in the shortest possible travel time, the "more trips, more income" reality pushes drivers to commit these offences (Nnajjuma, 2013; Ohakwe et al., 2011; Libres et al., 2008; Komba, 2007).

In Manzini, Swaziland from personal communication with Manzini police officers, the scenario is similar to other studies reported above, but the reported levels of these driver errors seem much lower than it is expected to be. The reason might be due to underreporting or a lack of proper investigation of the causes of RTAs. Therefore, refresher courses for police officers on deeper analysis of driver behavior and accident analysis in order to improve data collection and traffic accident investigation.

Vehicle factors

Vehicle type

The vehicle type most commonly involved in all severities of RTA was a car (private car), however there was no association between vehicle type and severity of RTA.

In contrast to our findings a study done in Tanzania by Komba (2007) showed that the most common vehicle involved in RTAs with severe injuries and deaths were buses (52%) followed by minibuses (29%). This difference may be due to the data source difference. Our study focused on Manzini city and the immediate surrounding rural area only, while the study done by Komba (2007) used data representing a whole district consisting of the main town and a large rural area in which buses and minibuses are the main form of road transport. Thus the opportunity for buses and minibuses to be involved in RTAs is higher than that of private vehicles. In a study in Nigeria (Ohakwe, 2011) a showed that minibuses and taxis were most frequently involved in serious/fatal RTAs and, as in Tanzania, it was ascribed to them being the major means of transport.

Vehicle defects

In this study 13% of the serious/fatal RTAs were due to vehicle defects, but on bivariate analysis there was no significant association observed between vehicle defect and severity of RTA.

In contrast to our findings, in many other developing countries road traffic accidents are commonly due to vehicle defects (Moodley and Allopi, 2008; Lagarde, 2007; van Schoor, 2001). It is probable that economic challenges force many people to have a tendency to use older, imported, second-hand and less reliable vehicles, which is exacerbated by inadequate inspection requirements and a lack of maintenance. In particular commercial and public transport vehicles are often overused to get the maximum degree of profits out of them, without giving proper attention to the maintenance of the vehicles.

According to the observations of Manzini police officers, old imported cars are widely being used in Swaziland and once the vehicles are in the country there is no guideline in place to check for ongoing road worthiness of the vehicles.

Road factors

Road surface type

In this study 79% of serious/fatal RTAs occurred on concrete/asphalt roads whereas 21% occurred on gravel/earth roads. It appears that concrete/asphalt roads have a higher proportion of fatal/serious injuries, even though there are more gravel/earth roads in the Manzini area. This paradox could be due to the higher traffic flow rate and the higher number of vehicles present on the major roads and highways (which are concrete/asphalt) at the same time. However bivariate analysis showed no significant association detected between road surface type and severity of RTAs.

In contrast to our study, Keziks and Vība (2006) in a study done in Riga and in other regions of Latvia, stated that severe RTAs tend to occur more commonly on concrete/asphalt roads. The explanation for this given by them was that on low quality road surface types, drivers tend to drive at lower speed and, consequently, this reduces the probability of severe injuries when a RTA does occur.

Road surface condition

Most of the serous/fatal RTAs occurred on dry roads (83%) and in the bivariate analysis, the surface condition of the roads had no significant association with severity of RTAs. Similarly, a study done in Riga and other regions of Latvia showed that severe RTAs occurred less frequently on wet/flooded/muddy surface conditions (Keziks and Vība, 2006). They postulated that drivers take extra care on slippery surfaces, consequently reducing accident occurrences and severity.

Environmental factors

Environmental factors impacting on RTAs and severity of RTAs include the following variables: weather conditions, street-light condition, time of day, day of the week and season of the year.

Weather conditions

Ninety-four percent of all types of RTAs happened in weather conditions which were not adverse and there was significant association of bad weather conditions with severity of RTAs. Indeed, the association between bad weather condition and severity of RTAs varies from study to study, mainly as a result of variations in weather and driving conditions.

So it is then no surprise that in contrast to our findings several studies found a statistically significant association between bad weather conditions and serious/fatal RTAs (Basagana et al., 2015; Majdzadeh, 2008; Yau, 2004; Andrey et al., 2003 and Ayuthya and Bohning, 1997). These studies found that adverse weather conditions such as rain, snow, fog, wind, hail, and freezing temperatures increased the risk of occurrence of RTAs. The commonest explanation proposed for this is that weather conditions partly determine the road conditions and the driver's inadequate response (or lack of response) to these adverse road conditions then affects driving performance, eventually leading to increased serious/fatal RTAs.

On the other hand, a study done in England, Wales and Canada showed that RTA injury severity decreased significantly in rain compared with fine weather presumably due to more careful driving on rainy days (Edwards, 1999a; 1999b; Mao et al., 1997; Zhang et al., 2000). The conflicting results of these studies on the effect of adverse weather conditions on severity of RTAs, requires further investigation, but it could be that the more severe the adverse conditions the less likely that drivers are to adequately compensate and the more likely that the frequency of severe RTAs would increase.

In Manzini, Swaziland there are no extreme changes in weather conditions and this might explain why changes in weather did not affect severity of RTAs.

Street-light condition

Our study showed that most of the RTAs (69%) occurred during daylight, however bivariate analysis found no association between severity of RTAs s and night/daylight conditions.

In contrast to our study street lighting and bad visibility were significantly associated with severity of RTAs in China and Holland (Zhang, et al.,2013; Wanvik, 2009) as well as in England and Wales (Steinbach, et al., 2015). In addition, a systematic review done covering the investigation of the effects of street lighting on fatalities and injuries from road traffic crashes also suggested that street lighting conditions significantly affects the severity of RTA injuries (Beyer and Ker, 2009). The logic is that street lighting may improve a driver's visual capabilities and ability to detect roadway hazards, particularly among older drivers, thus decreasing the severity of RTAs occurrences at night.

On the other hand, a critical review of 29 publications was done on road lighting and RTA occurrence (Vincent, 1883) which contradicts the results of the studies mentioned above. The review found no evidence to indicate that RTA reduction at night occurred due to improved street lighting.

LIMITATIONS

The limitations of our study include the following:

1. The Manzini city traffic police record is the most important official source of RTA data available, but it is only a record of data rapidly collected at the scene of the accident in a semi-standardised manner. Data collection was adjudged as being semi-standardised as although there is a standardised data collection form, the way in which that form is completed, is not standardised. Additionally, data on several variables such as the human factors (alcohol use, speeding) and vehicle defects is unavailable at the scene, and some data such as road defects and environmental factors is often not collected.

2. There was under-reporting of RTAs involving minor injuries and property damage only as these accidents are viewed as being of lesser importance than severe/fatal RTAs. This might have created a bias towards under-reporting of RTAs with the least degree of 'minor injury' and 'property damage', resulting in those RTAS classified as minor/property damage being the highest degree of 'minor injury' and 'property damage', resulting in turn in them becoming similar to severe/fatal RTAs. Therefore, any potential variable association would be driven to the null as the controls available to be selected become similar to the cases.

3. In an attempt to standardise data collection, the Manzini traffic department defines a severe RTA as one which results in an injury severe enough to require admission to a hospital ward for 24 hours or more. However, some patients were discharged from the emergency room rather than being admitted to the wards even though their injuries required admission, due to a lack of beds. However, since they were not admitted to the ward, the police officers did not label their RTA as a severe RTA even though in reality it was so. So this resulted in underreporting of severe RTAs again resulting in any potential variable association being driven to the null, as the cases become similar to the controls.
4. A limitation of the study for some of the variables investigated was that the sample size was too small to assess them adequately.

5. Data for several important variables which may affect severity of RTA, such as educational level, socioeconomic status, medical illness, marital status and emotional status of the

driver, are not routinely collected by the traffic police and hence could not be assessed in our study.

6. Group level factors potentially affecting RTAs, such as vehicle to population ratio and average distance travelled per vehicle were not assessed.

Despite these limitations, our study findings are valid and are a valuable source of information regarding the effect of the main risk factors for severe/fatal RTAs in Manzini city, Swaziland.

GENERALISABILITY

The findings can be generalised to all RTAs in Manzini city and might be generalisable to other cities and larger towns in Swaziland. The results can also be generalised, with caution, to other places with similar settings. However, generalisation to other districts of Swaziland may not be possible as they have a different urban rural mix, different road conditions and a different mix of vehicles present on the roads. Therefore, in order to have a comprehensive and comparative review of traffic accidents in other districts in Swaziland, efforts should be made to collect nationwide traffic accident data.

CONCLUSIONS

Variables that had an unconfounded positive association with serious/fatal RTAs on multivariate analysis, were, in decreasing order of strength of association: time of day 18:00 – 23:59; male gender of driver; not using a seatbelt; weekend (Friday/Saturday) driving; and pedestrian error. Increased severity of RTAs at the time of day 18:00 – 23:59 might be due to reduced visibility, speeding, drunk driving and fatigue. Similarly, weekend driving probably increased the severity of RTAs due to speeding, drunk driving and increased movement of vehicles and pedestrians over the weekends. These findings are important in developing road safety promotion activities such as street light provision, reducing speed during low visibility and exhorting drivers not to drink and drive as well as having increased checks on drunk driving and speeding during these periods.

Male drivers were probably more likely to be involved in serious/fatal RTA injuries than female drivers as there are more male drivers, they are more likely to travel due to work and leisure activities and they are more likely to engage in risk-taking behaviour. Non-use of seatbelts, which is an important injury prevention device when involved in a RTA, was high, but traffic law enforcement and behavioral change inducement by education of drivers to ensure that they and their passengers wear seat belts, might increase the prevalence of seat belt usage.

RTAs involving pedestrians are more likely to result in injury as they are less protected than people in vehicles. Pedestrians are involved in RTAS due to high concentration of pedestrians on urban roads, speeding vehicles on pedestrian dense roads, failure to look properly when crossing roads, failure to judge vehicle speeds properly, lack of sidewalks and lack of pedestrian crossings. Therefore, public education of pedestrians and pedestrian safety interventions such as provision of traffic calming measures, pedestrian sidewalks and pedestrian crossing sites should improve this situation.

Several variables such as driver suspected of driving while under the influence of alcohol, speeding, driver error and vehicle defects could not be properly assessed in this study as valid measurements of these variables were not available. Other factors such as age of driver, driver error, vehicle type, road surface type, road surface condition, weather conditions, season, street lighting and urban/rural location were not independently associated with severity of road traffic accidents.

RECOMMENDATIONS

On the basis of the findings of our study, the following five recommendations are suggested in order to reduce serious injuries and fatalities from RTAs in Manzini city and Swaziland:

Provide education programmes, particularly for male drivers, with an emphasis on increasing their vigilance of pedestrians and always using a seatbelt while driving, to decrease the severity of RTAs.

Similarly, pedestrian education on the use of sidewalks, safe road-crossing procedures, and watchfulness while crossing roads needs to be emphasized.

Improving the safety of pedestrians can be accomplished by, on busy roads, providing sidewalks, pedestrian crossings or pedestrian bridges and pedestrian barriers. Once all busy roads have these then they can be extended to the less busy roads as well.

Enhance traffic police law enforcement to reprimand drivers who are reckless, exhibit risk taking behaviour and are not using a seat belt. In particular enforcement should be stringent on weekends and between the18:00 - 23:59 hours of the day, as there are frequent serious/fatal RTAs occurrences during these time periods.

It would be advantageous to conduct research in Swaziland on important but difficult to measure variables which might be associated with severe/fatal RTAs, such as drunk driving, speeding, driver error and vehicle defects.

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APPENDICES

Appendix A

Table A. shows the traffic accident data obtained from Manzini traffic police office. The corresponding data involved fatal, serious and slight accident and property damage due to road traffic accidents which occurred in and around Manzini city in 2008-2012. A fatal accident is defined as an accident in which at least one or more people (driver, passenger or pedestrian) killed at crash. A serious accident refers to an accident in which at least one or more people seriously injured and was admitted for 24 hours or more. Slight accident refers to an accident in which at least one or more people sustained minor injuries which did not necessitate admission to hospital. Property damage accident refers to road traffic accidents with no injury.

Table A: Number of Road Traffic Accidents from 2008 to 2012 in Manzini, Swaziland

	2008	2009	2010	2011	2012
Number of fatal accidents	20	20	11	15	8
Number of serious accidents	87	102	77	68	43
Number of slight accidents	281	335	321	270	263
Number of damage to property only	1058	1118	1149	963	825
Total Number of accidents	1446	1575	1558	1316	1139

Source – Manzini Traffic Police Periodical Statistical report

Appendix Table B shows the causes of road traffic accidents in Manzini, Swaziland from 2008 to 2012. The attending traffic police officer decided the cause of RTA based on information from witness, victim and tracing the paths of the vehicles involved. In addition, the traffic officer observes visibility, condition of signs and signals, road surface condition, traffic volume, angles of view and possible distractions to decide the cause of the accident.

Appendix B

Table B: Causes of Road Traffic Accidents from 2008 to 2012 in Manzini, Swaziland

	2008	2009	2010	2011	2012
Accident caused by drivers	1251(86.5%)	1395(88.6%)	1386(89.0%)	1108(84.2%)	986(86.6%)
Accident caused by Pedestrians	92(6.4%)	102(6.5%)	70(4.5%)	84(6.4%)	71(6.2%)
Accident caused by cycle	25 (1.7%)	23(0.15%)	52(3.3%)	81(6.2%)	42(3.7%)
Accident caused by Passenger	11(0.8%)	7(0.4%)	10(64%)	2((0.15%))	6(0.5%)
Accident caused by animals	26(1.8)	16(1%)	14(0.9%)	8(0.6%)	8(0.7%)
Accident caused by vehicle defect	29(2%)	15(0.95%)	13(0.8)	21(1.6%)	14(1%)
Accident caused by road defect	8(0.6%)	11(0.7%)	10(0.64%)	6(0.5%)	1(0.09%)
Accident caused by others [includes unknown and very rare conditions].	4(0.3%)	4(0.3%)	2(0.13%)	3(0.2%)	10(0.9%)
Accident caused by obstruction [vehicle parked on a road or a road construction or animals on the highway were considered an obstruction]	-----	2(0.12%)	1(0.06%)	-----	1(0.09%)
Accident caused by weather	-----	-----	-----	3(0.2%)	-----
Total	1,446	1,575	1,558	1,316	1139

Source – Manzini, Swaziland Traffic Police Periodical Statistical report

Appendix C

Table C: Description and adjusted ratios of the sociodemographic characteristics of the drivers involved in the accidents, the actions of those drivers and the environmental circumstances in which the accidents occurred. (Running multivariate logistic regression model for variables with p-value of = or < 0.05)

Variable	Variable Category	Adjusted Odds Ratio	95% CI	P value
Gender of driver	Male	6.18	(1.80-21.29)	0.004
	Female	Constant		
Produced Driver's License at accident scene	Yes	0.65	(0.36-1.18)	0.154
	No	Constant		
Driver Suspected of driving while under the influence of Alcohol	Yes	1.51	(0.76-3.03)	0.243
	No	Constant		
Driver used a Seatbelt	No, driver seatbelt used	3.65	(1.61-8.30)	0.002
	Yes, driver seatbelt used	Constant		
Pedestrian error resulted in RTA	Pedestrian error	2.82	(1.52-5.23)	0.001
	No pedestrian error	Constant		
Road Factor at site of RTA: *Road Surface Type at the time of the RTA*				
	Gravel/Earth	1.64	(0.75-3.60)	0.218
	Concrete/Asphalt	Constant		

Table C: Continuation

Variable	Variable Category	Adjusted Odds Ratio	95% CI	P value
Season during which the RTA occurred	Winter	2.18	(0.98-486)	0.056
	Spring	1.16	(0.49 -2.79)	0.733
	Summer	1.51	(0.65 - 3.51)	0.34
	Fall	Constant		
Day of week	Friday/Saturday	3.45	(1.94-6.12)	0.000
	Rest of days in week	Constant		
Time of day	18:00 - 23:59	12.26	(4.61-32.57)	0.000
	24:00 - 5:59	2.79	(0.75-10.35)	0.125
	6:00 - 11:59	1.17	(0.62-2.21)	0.64
	12:00 - 17:59	Constant		

Appendix D

Table D: Description and backward stepwise regression modelling of the sociodemographic characteristics of the drivers involved in the accidents, the actions of those drivers and the environmental circumstances in which the accidents occurred.

Variable	Variable Category	Adjusted Odds Ratio	95% CI	P value
Gender of driver	Male	5.96	(1.75-20.25)	0.004
	Female	Constant		
Driver used a Seatbelt	No, driver seatbelt used	5.03	(2.34-10.82)	0.004
	Yes, driver seatbelt used	Constant		
Pedestrian error resulted in RTA	Pedestrian error	2.62	(1.43-4.80)	0.002
	No pedestrian error	Constant		
	Concrete/Asphalt			
Season during which the RTA occurred	Winter	2.09	(0.95-4.59)	0.066
	Spring	1.17	(0.50 -2.74)	0.724
	Summer	1.66	(0.73 - 3.81)	0.229
	Fall	Constant		
Day of week	Friday/Saturday	3.44	(1.96-6.06)	0.000
	Rest of days in week	Constant		
Time of day	18:00 - 23:59	11.79	(4.48-30.99)	0.000

	24:00 - 5:59	3.15 1.03	(0.88-11.30)	0.078
	6:00 - 11:59	Constant	(0.55-1.92)	0.920
	12:00 - 17:59			

Appendix E.

Copy of Ethical approval letter from the University of the Western Cape Research and Ethics committee

UNIVERSITY of the WESTERN CAPE

OFFICE OF THE DEAN
DEPARTMENT OF RESEARCH DEVELOPMENT

09 November 2015

To Whom It May Concern

I hereby certify that the Senate Research Committee of the University of the Western Cape approved the methodology and ethics of the following research project by:
Dr M Demissie (School of Public Health)

Research Project:	Risk factors associated with serious and fatal road traffic accidents in Manzini district, Swaziland.
Registration no:	15/7/10

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

The Committee must be informed of any serious adverse event and/or termination of the study.

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

A place of quality,
a place to grow, from hope
to action through knowledge

Appendix F. Copy of letter from Swaziland Police commissioner granting permission to conduct the study

Telegrams: NATCOM
Telephone: (+268) 2404 2501/5
2404 5541/5
Telex : 2017 WD
Telefax : (+268) 2404 4545
NOTE : All correspondence should be addressed to **The National Commissioner of Police** and not to individuals.

THE ROYAL SWAZILAND POLICE HEADQUARTERS
P. O. BOX 49
MBABANE H100
SWAZILAND

Our ref: NATCOM/49/5/11/157

10th March, 2015

Dear Sir/Madam,

TO WHOM IT MAY CONCERN

Permission is granted to Dr Motuma Demisse student number 3311959 to conduct a data analysis on the road traffic accidents in the Manzini region for a final research Thesis, with the University of the Western Cape, South Africa.

Information contributed to the questionnaire will be treated with confidentiality as no personal details (names) are required. Your assistance in this project will be highly appreciated

Thanking you in advance.

Yours faithfully

M. Mabuza

F: C.J. DLAMINI
FOR: NATIONAL COMMISSIONER OF POLICE

Appendix G.

Copy of Ethical approval letter from the Swaziland National Ethics Committee

PER767676767T
Telegrams:
Telex:
Telephone: (+268 404 2431)
Fax: (+268 404 2092

MINISTRY OF HEALTH
P.O. BOX 5
MBABANE
SWAZILAND

THE KINGDOM OF SWAZILAND

15th February, 2016

Dr. Motuma Demisse
Principal Investigator
MANZINI

REF: MH/599C/FWA 000 15267/ IRB 000 9688

Dear Dr. Motuma,

RE: RISK FACTORS ASSOCIATED WITH SERIOUS AND FATAL ROAD TRAFFIC ACCIDENTS IN MANZINI REGION, SWAZILAND.

The committee thanks you for your submission to the Swaziland Scientific and Ethics Committee, an expedited review was conducted.

In view of the importance of the study and the fact that the study is in accordance with ethical and scientific standards, the committee grants you authority to conduct the study. You are requested to adhere to the specific topic and inform the committee through the chairperson of any changes that might occur in the duration of the study which are not in this present arrangement.

The committee requests that you ensure that you submit the findings of this study (**Electronic and hard copy) and the data set** to the Secretariat of the SEC committee.
The committee further requests that you add the SEC Secretariat as a point of contact if there are any questions about the study on 24047712/24045469.

Yours Sincerely,

MINISTRY OF HEALTH
11 FEB 2016
SWAZILAND

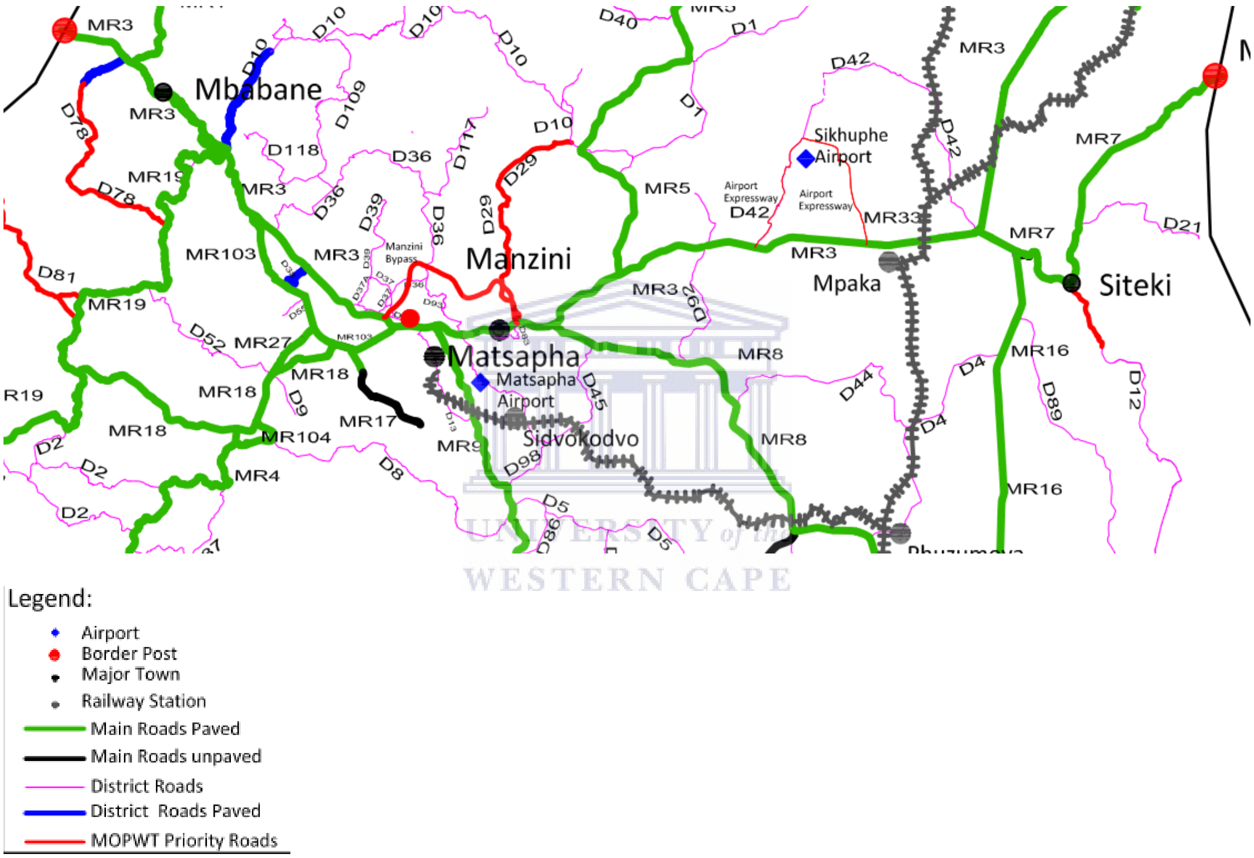
RUDOLPH T.D. MAZIYA
THE CHAIRMAN, SEC
cc: SEC members

Appendix H

Figure A: Traffic Highway Map of Manzini District, Swaziland

South Africa

Mozambique



Source: Swaziland Transport Master Plan Report 2013