MASTERS' THESIS

RELATIONSHIP BETWEEN THE LOCATION AND CAUSES OF MOTOR VEHICLE ACCIDENTS ON THE B1 ROAD, WINDHOEK TO REHOBOTH, NAMIBIA

By

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DECLARATION

I, Carolie Cisanne Cloete hereby declare that the work contained in the thesis entitled Relationship between the location and causes of motor vehicle accidents on the B1 road, Windhoek to Rehoboth is my own original work and that I have not previously in its entirety or in part submitted it at any university or other higher education institution for the award of a degree.

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DEDICATION

This thesis is dedicated to my husband, Harry, and daughters, Chloe and Caitlyn, who believe in me and support me in everything I do. Also, to the growth and development of EMS in Namibia.

ABSTRACT

PURPOSE OF THE RESEARCH: Motor Vehicle Accidents (MVAs) are fast becoming the leading cause of death globally. In 2010, one person died every 25 seconds due to an MVA. Namibia was highlighted in 2008 as the country with the highest accident-related fatality rate in the world (45 deaths per 100 000) and in 2010, ranked 9th overall for fatality rate in Africa. The B1 road in the Hardap region (Rehoboth and its surrounding areas) was identified in 2009 as one of the top ten locations for MVAs and in 2014 as an area with high MVA associated fatality. Despite the identifiable causes of MVAs, accident rates continue to rise and have been recognised as a neglected epidemic due to poor data capturing and reporting. Despite the availability of data in Namibia there has been very little research performed to investigate the causes of these statistics and no research linking the cause to the location. Filling in these research gaps is important in beginning to remedy the high number of accidents and fatalities associated with MVAs in Namibia.

OBJECTIVES: The study aimed to map the causes of MVAs in relation to the location (at 20km intervals) on the B1 road between Windhoek and Rehoboth. The objectives of the study were to identify clusters of causes per location interval and determine and describe the relationship between the causes and location of MVAs. The final objective is to formulate and propose endorsements for the erection of cause-specific features at identified locations as a prevention strategy.

PRINCIPAL RESULTS: The main cause of MVAs on the studied road was driver-related causes (56.3%). Other common causes of MVAs included collision with an animal and mechanical failure. The greatest number of accidents occurred in the 0-20km interval (29.3%), closest to Windhoek. The highest reported injuries (27.3%) and fatalities (32.9%) was in the 21-40km interval. Clusters of causes identified revealed that driver-related factors were the main cause of accidents across all location intervals, followed by a collision with an animal and vehicle mechanical failure. Weather/road conditions and pedestrian-vehicle accidents played a role closer to Windhoek and closer to Rehoboth, respectively. There was a statistical relationship between the location and cause of accidents and a cluster of causes could be identified for each location interval. The odds of fatality increased with distance from Windhoek. Other contributing factors to accidents, injuries and fatalities included the type of accident, the day of the week and the time of day.

MAJOR CONCLUSIONS: There is a relationship between the causes and location of MVAs on the studied road and a cluster of causes were identified. Driver causes are by far the leading cause of accidents. Updating existing laws combined with stricter law enforcement can address the key causes of MVAs on the B1 road and is thus the key to prevention. Other prevention strategies include improving data capturing to improve the quality of the data and for surveillance of implemented safety

strategies, improving public transport infrastructure to the number of vehicles on this road and making the roads safer for vulnerable road users.

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Glossary

GPS: **Global Positioning System**
GDP: **Gross domestic product**
MVA: **Motor vehicle accident**
MVAF: **Motor Vehicle Accident Fund of Namibia**
N$: **Namibian Dollars**
NRSC: **National Road Safety Council**
PVA: **Pedestrian-vehicle accident**
SA: **South Africa**
UN: **United Nations**
USB: **Universal Serial Bus**
WHO: **World Health Organisation**

CHAPTER 1: INTRODUCTION

1.1 Background

The global impact of motor vehicle accidents (MVAs) on health care and economics are undeniable and evidenced by numerous publications in various international journals (Adeloye et al., 2016; Lagarde, 2007; Nantulya and Reich, 2002; Odero et al., 1997; Odero et al., 2003; Osoro et al., 2015; Peden et al., 2013; Prato et al., 2012; Rezaei et al., 2014; Sivak and Schoettle, 2014; WHO, 2015). In 2010, globally more than one million people died as a result of MVAs, which aggregates to one person dying every 25 seconds due to an MVA. It is estimated that there are a further 20 injured victims per MVA for every fatality, which translates to more than 20 million injured victims per year (WHO, 2015).

Despite other pandemics such as HIV/AIDS and cardiovascular disease, MVAs are fast becoming the leading cause of death, globally. The most productive population, aged 15-29 years, are most affected by MVAs (Nantulya and Reich, 2002; Odero et al, 2003; Sivak and Schoettle, 2014; WHO, 2015). The effects span much further than just the lives lost, and the injuries sustained by accident victims. National economies are affected by the higher incidence of MVAs amongst the working class, resulting in a change of demographics, loss of production, escalating medical expenses and damage to infrastructure and private property (Osoro et al., 2015; Rezaei et al., 2014). Fifty-four percent of global vehicles are owned by people in developing countries, like African countries, yet these countries contribute to the vast majority (90%) of accidents and associated deaths worldwide (Bonnet et al., 2018; WHO, 2015).

The United Nations (UN) instituted a safety policy, the Decade of Action in 2011 in a bid to decrease the global accident rate and associated deaths. Due to the identifiable causes of MVAs and safety policies being implemented and reinforced in developed countries, fatality rates in these countries decreased significantly (WHO, 2015). Increased visibility and activity of law enforcement officials for example were shown to decrease fatalities by as much as 17% in Uganda (Bonnet et al., 2018). Conversely, in the developing world, fatality continued to rise, particularly in the African region where fatality increased by two-fold even with the implementation of the plan, 8 years ago (Bonnet et al., 2018; WHO, 2015). Nantuyla and Reich (2002) appreciate the true impact of MVAs and refers to it as the ‘neglected epidemic’ attributing its ‘neglect’ to the underreporting of accidents and poor data management systems used in some countries. Despite the (unreported) global health and economic burden of MVAs the subject does not get the recognition and attention it warrants as funds and interventions are not appropriately directed at trying to effectively reduce the incidence of MVAs in developing countries (Adeloye et al., 2016; Odero et al., 1997). In Africa, it was concluded that very little safety interventions are being implemented to address the concerning MVA related statistics (Bonnet et al.,2018).

1.2 Problem Statement

In 2014, the Michigan Transportation Research Institute conducted a retrospective analysis of global accident data for 2008 obtained from the World Health Organization (WHO). The study compared MVA deaths to three other leading causes of death (cancer, stroke and heart disease) in countries across the world. Namibia was found to be the country highest ranked for MVA associated deaths (per 100 000) in the world for the period with a fatality rate of 45 deaths per 100 000 compared to the global average of 18 per 100 000 (Sivak and Schoettle, 2014). This data was refuted by the Motor Vehicle Accident Fund (MVAF) and the National Road Safety Council (NRSC) in a joint media release. It was highlighted that Sivak and Schloette (2014) based their findings on estimated population information from the WHO instead of exact population totals as reported in the census for that period. Additionally, the key role-players, the MVAF and the NRSC, were not consulted to confirm the accuracy of the data published. Nevertheless, the two role-players agreed that the incidence of MVAs and associated fatality are on the rise but not to the proportion stated by Sivak and Schloettle (2014), as the data reported also included calculations to factor in underreporting of MVAs which may have been exaggerated.

In 2015, Namibia's population was 2.5 million with a total of 580 MVA-related deaths recorded in the same year (WHO, 2017). Compared to other countries the number of deaths may seem insignificant, yet the economic impact of MVAs may be comparable when considering the country's smaller population (Amweelo, 2016; WHO, 2017). Although, exact annual MVA deaths can be a valuable measure, death rates per 100 000 is a more pertinent indicator of the effect of MVAs allowing for comparison with other countries (WHO, 2015). An average of 580 deaths per year was reported in Namibia from 2010 to 2015 which was said to articulate to a fatality rate of about 33 per 100 000 in 2015 (Amweelo, 2016). Based on the study data, the annual MVA associated fatalities increased with an average of 9% per year from 2010 to 2015 apart from 2011 when a 9% decrease was reported. In 2010, Namibia was ranked 9th overall (25 deaths per 100 000) for MVA associated deaths in African (Peden et al., 2013; WHO, 2015)

Despite national initiatives by the NRSC and the MVAF to increase awareness in the country, accident rates continue to increase annually, with it becoming more serious and involving more fatalities per accident. The NRSC presents data from police reports of all accidents countrywide, whether an injury or fatality has occurred or not. The MVAF, in contrast, reports on MVAs where injuries and/or fatalities occurred. Unpublished data of the NRSC reports more than 21 000 MVAs in 2015 in Namibia. In the same year, only 4 221 MVAs were reported to the MVAF with almost 150 million Namibian dollars (N$) paid to service providers for medical costs alone (MVA Fund, 2015). In a local newspaper, the Namibia Economist, it was reported that for the period of January to May 2015, MVAF paid out N$266 million every month to the effects of MVAs. These expenses included medical bills to service providers, loss of income to injured persons and loss of support to families where the breadwinner had died (Namibia Economist, 2015).

Namibia is located on the southwest border of Southern Africa with an 824 292 km² landscape and a sparsely populated landscape of 0.4 people per m^2 (Advameg Inc, 2019). The B1 road is the main highway connecting several of the country's towns and acts as a transport carriageway for import and export. Additionally, the road is used daily by commuters between the capital city, Windhoek and Rehoboth by both single occupant vehicles as well as multiple occupant minibus taxis. The NRSC identified the B1 road in the Hardap region (Rehoboth and surrounding areas) as one of the top ten locations for MVAs, in 2009. The Hardap region was identified again in 2014, as an area with a high fatality rate as a result of MVAs (NRSC, 2014).

Considering the concerning statistics related to MVAs in Namibia, very little research focusing on this issue is conducted. Of the existent research in Namibia, none investigated that actual causes of MVAs, particularly in relation to their location in order to focus energy on specific preventative strategies or to remedy the shocking statistics.

1.3 Research question, hypotheses, aim and objectives

1.3.1 Research Question

What is the relationship between the location and the causes of MVAs with injuries or fatalities occurring on the B1 road, between Rehoboth and Windhoek, Namibia?

1.3.2 Hypotheses

Null hypothesis: There is no relationship between the location and causes of MVAs with injuries or fatalities occurring on the B1 road, between Rehoboth and Windhoek, Namibia.

Alternative hypothesis: There is a statistical relationship between the location and causes of MVAs with injuries or fatalities on the B1 road, between Rehoboth and Windhoek, Namibia.

1.3.3 Research Aim

The aim of the study is to establish the relationship between the location (at 20 km intervals) and the causes of MVAs with injuries and/or fatalities on the B1 road, between Rehoboth and Windhoek, Namibia for the period of 2011 to 2017.

1.3.4 Objectives

- To map MVA causes according to their location (at 20 km intervals);
- To determine clusters of causes per location interval (20 km intervals);
- To determine and describe the relationship between the causes and location and to rank causes accordingly;

- To formulate and propose endorsements for the erection of cause-specific safety features at identified locations as a prevention strategy.

CHAPTER 2: LITERATURE REVIEW

The literature review intended to survey current research on MVAs, nationally and internationally, in order to describe the global burden, identify common causes and trends as well as identify the gaps in the literature.

2.1 Global burden of MVAs

By the year 2030, MVAs will rise to become the 5th leading cause of death globally if no intervention is taken. In fact, despite the increase in the prevalence of other pandemics such as HIV/AIDs, heart disease and cancer, MVAs are believed to become the 2nd leading cause of death in low-to-middle-income countries by 2020 (Chen et al., 2016).

Rezaei et al. (2014) undertook a one-year cross-sectional study to investigate the extent, consequences and economic burden of MVAs in Iran. It was estimated that globally 518 billion (US) dollars is spent annually on MVAs with more than 12% consumed in low-to-middle-income countries. It was further shown that in some countries the cost related to MVAs (be it direct [medical expenses], indirect [production lost] or intangible [pain]) was at least 1% of their Gross Domestic Product (GDP) which sometimes exceeded the aid received from high-income countries, as was the case in Iran. The data for the study however was for a year, thus making generalisability problematic.

In 2012, MVAs became the leading cause of death amongst the age group 15 – 29 years, worldwide, with Africa remaining the continent with the highest rate of MVA associated fatalities (WHO, 2015). Globally, vehicle occupants (31%), motorcyclists (23%) and pedestrians (22%) were identified as the most vulnerable road users. In Africa, in contrast, vehicle occupants (40%) and pedestrians (39%) were found to be significantly more vulnerable (Adeloye et al., 2016; Nantulya and Reich, 2002; Peden et al., 2013; Seyni et al., 2017; WHO, 2015). Despite the high impact of MVAs and the data available from the WHO and other role-players, research pertaining to road accident rates and safety in Africa is lacking (Chen et al., 2016; Lagarde, 2007; Nantulya and Reich, 2002; Peden et al., 2013, WHO, 2015). In a review of epidemiological studies of road traffic injuries in developing countries the authors evaluated 73 studies, all descriptive. The data used in the majority of the studies were from secondary sources such as hospital databases. There were however vast similarities in the factors related to MVAs in the various studies, such as that pedestrians were the most vulnerable road users and ironically the drivers (which most often caused the accidents) were never rated as the most vulnerable with respect to fatality. Other consistencies in the studies were that most accidents occurred during the daytime, over weekends and involved males. All included studies were published from the late 1960s up to 1993 and included only one Namibian based study. Another strong association was that the increase in vehicles and population led to a direct increase in the number of MVAs and related deaths (Odero et al., 1997).

Seyni et al. (2017) conducted a retrospective, descriptive study during a six-month period in a morgue in Niamey, Niger. They assessed the demographic profile of the corpses admitted to the two mortuaries in Niamey, a total of 133 of the 3 865 deaths were due to MVAs. They found that the populations most affected were the working class (16-30 years) and included the male gender but there was no discrimination with regard to profession. However, school children and people from rural areas were affected more significantly. This correlated with the global trend that the most vulnerable population is those aged 15-29 years (WHO, 2015). A decrease in this specific demographic can greatly affect the productivity and overall population growth of a country.

In a meta-analysis of MVAs in developing countries, Nantulya and Reich (2002) suggest that low- to middle-income countries were often synonymous with developing countries as they share the same GDP. The WHO (2015) shows that low-income countries have twice the amount of accidents compared to high-income countries and further state that this is inconsistent considering that there are fewer motor vehicles in low-income countries. This higher rate however was suggested by Nantulya and Reich (2002) to be due to the fact that the main mode of transport used in low-income countries is public transport, with more occupants per vehicle thus more injuries/fatalities per accident. This increased number of victims per accidents is believed to further contribute to the burden of MVAs in developing countries. In the 2013 Global Status Report by the WHO, accidents from 2001-2013 were reviewed and showed a plateau in accidents globally in 2007. This is in contrast with the increased population and total vehicles and was indicative that the global initiatives implemented where successful in most countries. Opposite to high-income countries, there was a large number of low-to-middle-income countries that had more deaths in the three-year period between 2010-2013. Middle-income countries were shown to make-up most of the world's population (70%) followed by high income (18%) and low-income (12%). Proportionally 74% of the global traffic accidents occur in middle-income countries followed by a distortional 16% of the global traffic accidents occurring in low-income countries where only 1% of the world's vehicles are registered (WHO,2015). Nantulya and Reich (2002) supported this statement by showing that in developing countries, the impact of MVAs was far worse than it is given credit for, as it is a major cause of death and disabilities and it primarily affects the working class and children. Injuries and fatalities are further expected to increase as the population and use of vehicles continues to increase in developing countries. The poor socioeconomic status in some developing countries further exacerbates the situation as people are forced to use public transport as their only means of transport. They also identified the six main causes contributing to the high burden of MVAs in developing countries as, increased vehicle use, the high amount of people injured or killed per MVA, poor law enforcement, underdeveloped public health infrastructure and poor access to healthcare (Nantulya and Reich, 2002).

Adeloye et al. (2016) conducted a systematic review and meta-analysis to determine the burden of MVAs and injuries and death in Africa. The authors reviewed data from 39 African based studies published between 1980-2015. Although the burden of MVAs was found to be masked by the use of registry-based reports, the overall impact of MVAs in Africa was still very high. They showed that despite a decrease in fatality associated with MVAs (attributed to improved pre-hospital care) for the period of 1990-2015, injuries increased with the most common victims being vehicle occupants and pedestrians. They further pointed out that the lack of reporting and appropriate means of data collection greatly detracts from portraying the true effect of MVAs as a public health problem. The findings of the study were limited by the inclusion of unpublished articles with questionable reliability and the fact that some African countries, like Namibia were excluded perhaps due to the lack of availability of published articles in this field. Considering that Namibia stands out as a country with one of the highest MVA associated fatalities in the world, exclusion of this data from the meta-analysis could have implications on the study outcomes. Some the studies reviewed in this article were cross-sectional with data being analysed over a very short period (1 year), making the reliability of the data questionable, particularly due to annual fluctuations in MVA associated injuries and deaths. The authors also pointed out that the problem with cohort studies which were reviewed was that they will always reflect a high fatality rate purely due to the nature of the study being focused on the population being studied and that registry-based reports in contrast underestimate the burden of MVAs (Adeloye et al., 2016).

Rezaei et al. (2014) support these findings by showing that the burden of MVAs in Africa is substantially high and may even be underestimated due to the lack of reporting. The author attributes the disproportionately high accident rate (only 47% of the world's registered vehicles are in low-to-middle-income countries) to economic development, with more people using motor vehicles as their means of transport as opposed to developed countries who rely greater on an established public transport infrastructure such as commuter trains. They further state that despite the increase in road users in low- to middle-income countries the infrastructure has not been upgraded to accommodate the increased use. In a study conducted by Norman et al. (2007) investigating the burden of injuries in South Africa (SA), it was found that MVAs was a high contributing factor to the countries' economic burden second only to interpersonal violence. Factors contributing to the very high burden of injuries in SA included poverty, the incidence of chronic diseases as well as the impact of AIDS, which can be comparable to the circumstances in Namibia, despite the notably lower rate of violence. Fatalities associated with MVAs was ranked 2ndsecond to homicide in SA in the year 2000, with a rate of more than twice that of the global average. All the studies reviewed on the topic showed MVAs to be a public health problem that does not receive the attention it clearly warrants (Adeloye, et al., 2016; Nantulya and Reich, 2002; Norman et al., 2007; Rezaei et al., 2014).

Museru et al. (2002) analysed the impact of MVAs in Tanzania over a ten-year period. They showed that despite the shocking global statistics related to MVAs it does not earn the same attention as any other 'diseases' in developing countries. This oversight is attributed to the possible underreporting of accidents as well as the presence of infectious diseases in some developing countries that overshadow MVA statistics. The authors further show that more than half of the accident causes were shown to be due to 'drivers' inappropriate behaviours' (Museru et al, 2002). In 2013, in Iran, a country with almost triple the population of Namibia, reported a high fatality rate associated with MVAs, similar to Namibia (38 fatalities per 100 000 in 2004). There were many fluctuations noted in fatalities during the study period 2004 to 2011. Despite a growth in the population and vehicles there was a decrease in fatalities in 2007 which was attributed to stricter traffic regulation and enforcement as well as a change in the legislation pertaining to compensation of MVA victims (Bahadorimonfared et al., 2013).

2.2 Common causes of MVAs

Lagarde (2007) suggested that MVAs were considered *'to be inevitable and caused by random, unpredicted events*.' This definition, in the author's opinion, has led to the delay in recognising the full impact of MVAs globally because there are in fact recognisable causes and factors. The author adds that this problem was further aggravated by poor reporting of accidents, a lack of appropriate pre- and in-hospital care and poor preventative strategies. A study similar to the proposed study was conducted in Israel over a four-year period however the emphasis was on pedestrian-vehicle accidents (PVAs). The data collected was analysed and used to recognize patterns of fatal pedestrian accidents (Prato et al., 2012). The accident location was found to be one of the most important causes of fatal PVAs. Five accident clusters were identified with a specific population linked to a specific demarcation on a road, however overall most PVAs occurred in urban areas. Other factors that were shown to contribute to PVAs included the cause of the accident (driver vs pedestrian cause), sociodemographic causes (such as age, gender) and the condition of the road. The authors emphasised that there are preventable measures for identifiable causes. These are thus some of the factors that will also be investigated in this study.

Bahadorimonfared et al. (2013), Chen et al. (2016), Odero et al. (1997) and Odero et al. (2003) identified the three main factors contributing to road accidents as the road user/human factor, the vehicle and the infrastructure of the road. Odero et al. (2003) further show that human factors attribute to more than 80% of MVA causes. Odero et al. (2003) conducted a study on the magnitude of MVAs in Kenya and showed that the majority of accidents occurred on rural roads, mostly highways linking cities. Geurts et al. (2003) highlighted the importance of identifying high profile accident locations with the aim of making recommendations for safety initiatives. They made use of a method called association rules, which entails extracting pertinent information from a large pool of data. An association rule will identify how commonly a rule occurs in a set of data. The MVA data used for the purpose of their study was collected over a one-year period (1999) in a region of Belgium. In the data obtained a number of variables surrounding the MVA were recorded (location of accident, type of vehicle, number of occupants). Using this empirical data, exact locations of accidents were linked to patterns of high frequency. Commonalties that were identified was that high-frequency locations included dual carriage roadways outside of the inner city, similar to parts of the road being studied; the age group most common affected was 30-45 years and private vehicles were more often involved in these accidents. The authors deduced that the location was not the common denominator as hypothesised but in fact the number of persons involved in the accident. Additionally, one can appreciate the very different settings of the two countries (Namibia and Belgium) with regard to infrastructure and population (Geurts et al, 2003). In a separate study by Osoro et al (2015) MVA victims, traffic officers, motor vehicle drivers and non-drivers were surveyed to establish their perspective of MVAs in Kenya. Almost 60% of the respondents attributed driver error as the most common cause of MVAs in the country. Further causes of driver behaviour were said to be speeding, poor driver judgement and overtaking. All of the recommended methods of preventing MVAs by the respondents were aimed at stricter road law enforcement.

A number of safety measures emerged from the various articles including benchmarking of safety measures to developed countries such as the European countries (Chen et al., 2016; Prato et al., 2012; WHO, 2015). The development of policies to protect the most vulnerable road users (Nantulya and Reich, 2002; Peden et al., 2013; WHO, 2015) was shown to be one of these strategies. Another safety measure identified by Bahadorimonfared et al. (2013) was to identify accident prone areas to make improvements to these areas as well as efforts to improve vehicle safety (stricter vehicle clearance). The authors further highlighted a need to increase the emphasis on providing effective emergency services. From the literature reviewed, it is evident that injuries and deaths associated with MVAs are a global burden still little to nothing is being done to shift the focus in developing countries to prevention (Nantulya and Reich, 2002; Odero et al., 2003; WHO, 2015). Bahadorimonfared et al. (2013) suggests that there is a clear separation in the patterns of MVAs in developing and developed countries with different causes and factors contributing to fatality, thus different approaches should be undertaken in addressing the burden of MVAs. The WHO (2015) suggests that the key element to address in terms of improving road safety is to strengthen road safety laws as it directly impacts the behaviour of road users. This however should be supplemented with consistent law enforcement. An important point that emerged from the report was that the only way to truly impact the deaths associated with MVAs is to address the most vulnerable road users (pedestrians, cyclist, motorcyclists). Addressing the coordination surrounding vehicle safety standards was also identified as a factor in the bid to road safety. (Odero et al., 2003; Prato et al., 2012; WHO, 2015)

2.3 MVAs in Namibia

From 2002, the NRSC reported an annual increase of 5.5% in accident rates in Namibia (NRSC, 2014). The Khomas region had the highest accident rate, with the Hardap region highlighted as one of the areas with a high fatality rate (defined as >2 fatalities per 10 000) (NRSC, 2014). Regions highlighted with higher fatality rates included areas with a higher population and vehicle density. The Windhoek-Rehoboth road was identified as one of the top ten accident locations according to the NRSC (2014).

Namibian-based research in the area is unavailable, particularly on the financial burden of MVAs in the country this despite the availability of the data. One of the very few Namibia published articles based on MVAs is one by Amweelo (2016). The author provided an overview of accidents in Namibia based on data from the MVAF, NRSC and Roads Authority and focuses his discussion on a proposed new road traffic act. The lack of law enforcement officials in the country and the effects of this on the reporting of accident information and enforcement of existing laws were highlighted in the study. Safety strategies with some consideration of implementation strategies were made however there was no reference made to the causes of MVAs in Namibia. In another Namibian based article by Iipinge and Owusu-Afriyie (2014) high school students' perspective on the efficacy of road safety initiatives were evaluated. The participants of the study reported that despite the number of available safety strategies/campaigns, the methods used to create awareness were ineffective as media was not efficiently utilised. Additionally, the periods during which the initiative took place was too close to peak accident times, thus did not have a marked impact. They further contribute to the ineffectiveness of initiatives to public ignorance (Amweelo, 2016; Iipinge and Owusu-Afriyie, 2014).

The financial impact of MVAs in Namibia is evident from the 2014 – 2015 MVAF Crash Report. A total of 4 038 and 4 212 MVAs with injuries and/or fatalities were reported in 2014 and 2015, respectively. Of the 4 212 MVAs which occurred in 2015, 702 fatalities were reported. A significant increase from the 492 MVA associated fatalities reported in 2011. Passengers and pedestrians were shown to be the most vulnerable groups with reference to fatality, with the age group 16-35 years most affected (MVA Fund, 2015). The MVAF covers the cost of up to N$1 million per person, which includes costs from transport from the accident scene to rehabilitation costs. Service providers submitted 24 549 claims to the MVAF in 2015 with a total of N$145 096 746.95 spent on medical expenses in the same year. Additionally, 3 651 benefit claims were registered in 2015 which included injury grants, funeral grants, loss of income and loss of support benefits (The MVAF, 2015).

Poor reporting of data by the public and emergency medical services may also be masking the true impact of MVAs on the country. The lack of infrastructure and vastness of the country with long distances between towns likely further contributes to the fatalities associated with MVAs.

CHAPTER 3: METHODOLOGY

3.1 Study Design

The study is a descriptive retrospective review of MVAs on the B1 road between the capital city of Namibia, Windhoek and the southern town Rehoboth, for the seven-year period, January 2011 and December 2017.

3.2 Study setting

Namibia is divided into 14 regions, with the B1 road crossing the country, north to south (see figure 3.1 below). The Khomas region consists of Windhoek and its surrounding areas and the Hardap region includes Rehoboth, Malthöhe and Mariental. The area of interest includes the B1 road from the Windhoek/Rehoboth roadblock (point A) just outside Windhoek up to the final landmark upon exiting Rehoboth, the Total service station (point B). In the absence of any other clear demarcation of the city/town borders, these two points were selected for the purpose of the study as the start (point A) and end (point B) of the road. The B1 road between Windhoek and Rehoboth is a tarmac surface road which is fairly straight with only 5 gradual bends within the entire stretch of road. The initial section of the road (0-20km interval) runs through a fairly sloped area and has a number of bends. The remaining intervals consist of a fairly straight road with evenly sloped planes. There is no official maintenance schedule available of the road, but the road is kept in a fairly good condition as there is very little degradation and physical damage such as large potholes from a physical investigation done of the road.

Figure 3.1: B1 road across Namibia

(Source: www.namibiabookings.com/namibia_hotels/border_stopover_hotels.html.)

3.3 Data collection and data management

Written permission was requested from the MVAF Chief Executive Officer to use the data (see Appendix 1: MVAF permission letter). The data for MVAs in the Hardap and Khomas regions were extracted from the MVAF database, Siebel by the MVAF statistics department as secondary data for the purpose of the study. The data was exported to Microsoft Excel 2016 (Office 365) on an external universal serial bus (USB) device and was only accessed by the researcher, supervisors and statistician. The data received contained information of MVAs from the inception of their systems in 2008 up to April 2018. Due to the sporadic and incomplete entries of data preceding 2011 only data from January 2011 to December 2017 was used for the purpose of the study. The inclusion criteria for the study were accidents which occurred on the B1 road between Windhoek and Rehoboth in the aforementioned period whereas accidents which occurred in and around the town of Rehoboth or the city of Windhoek, or on roads other than the B1 were excluded. A case was further excluded if there was no location (in kilometres or a specific landmark) available and if there were more than 2 missing fields of information. The data received from the Statistics department included all the relevant information required for the study except for the location of accidents. Subsequently, the research student was granted access to the system to individually capture the location of MVAs which met the inclusion criteria. The data was screened and cleaned using Microsoft Excel 2016 and preliminary analysis performed. Subsequently, the data was imported to IBM SPSS Version 25 for descriptive and inferential analysis.

The MVAs which met the inclusion criteria were ranked according to its location from point A to B. The total distance between the two points (A and B) were established by marking reference points along the road using a handheld global positioning system (GPS) receiver. The data from the receiver was extracted, and the distance was measured between the points using Google Maps in order to determine the (corrected) total distance of the road. The total distance from point A to B was 80 km. Some of the locations (in kilometres) were missing from entries and only had landmarks in the original data thus the location for the landmarks were obtained manually using the GPS to obtain the distance to complete the data.

On the MVAF database, Siebel, only a limited number of fields had predefined categories therefore where information was missing or unclear the causes and types of accidents had to be categorized manually. For the causes of MVA’s, the eight most commonly occurring categories were chosen and are summarised in Table 3.1.

Table 3.1: Categories of causes for MVAs

Identified cause of MVA	**Description**
Collision with animal	Wild or domestic animals
Collision with object	Tree, pole, secondary stationery car, infrastructure along the road
Driver causes	Speeding, suspected alcohol intoxication, overtaking
Mechanical failure	Tyre burst, failure of brakes
Passenger fell from moving vehicle	Only considered MVA if passenger fell from a moving vehicle
Pedestrians	PVAs, including hit and runs
Weather/road conditions	Poor visibility, wet or slippery road, potholes
Unknown	If no cause could be established from the information present

In most instances, the types of MVAs were present and categorized according to the most commonly occurring types of MVAs presented in the data. The identified types of accidents are summarised in Table 3.2.

Table 3.2: Types of MVAs

Type of MVA	**Description**
Chain collisions	MVA involving more than 2 vehicles
Collision with an animal	Where there was actual contact with the animal domestic or wild
Collision with an object	Objects may include a tree, pole, secondary stationery vehicle, infrastructure alongside the road
Head on collision	Where vehicles collided head to head
Motorcyclist	On its own or with a secondary vehicle
Passenger fell from moving vehicle	Passenger fell from moving vehicle
Rear-ended collision	Where one vehicle collided into the rear of a secondary vehicle
Rollover	If the vehicle rolled
Sideswipe	Contact with lateral aspects of the vehicles
T-bone collision	If two vehicles collided at a right angle with each other
Vehicle left the road	If the vehicle left the road but did not overturn
Pedestrian Vehicle Accident	Collision involving a pedestrian and a vehicle

In some cases, it was difficult to appropriately assign the causes particularly where animals were involved, as the causes were that the driver was trying to avoid colliding with an animal but ended up losing control causing the vehicle to overturn. In such cases, the cause would have been assigned to driver behaviour as there was no actual collision with the animal and the type of accident recorded as either a rollover or vehicle left the road.

3.4 Data Analysis

The data was manually filtered on Microsoft Excel 2016 and the final dataset imported to SPSS Version 25 for statistical analysis. For objective one, to map MVAs according to its location, the data was sorted and arranged from point A to B in 20 km intervals. Count and percentages were calculated by cross-tabulation of accidents, fatalities and injuries per 20 km location interval and presented in bar graphs. The mean, mode and median were also calculated for the number of injuries, fatalities and location of accidents. For the second objective which was to identify clusters of MVA causes counts and percentages were calculated by cross-tabulating accidents, injuries and fatalities with the eight predefined common MVA causes (see table 3.1) for overall data and for the 20 km location intervals. The data was presented in bar graphs. For objective three which had two parts, one was to determine and describe the relationship between the causes and location of MVAs and the second was to rank the causes per location interval. To test the associations between data the Chi-square test was used, and the Pearson correlation test was used to determine the correlation between causes and location. Variables considered included the number of accidents, injuries and fatalities against the location, cause and type of accident as well as the time of day and day of the week. A one-way ANOVA was done to assess the statistical difference between the 4 location intervals and a further test of variance was conducted using the Tukey post hoc test. Poisson regression was used to predict the number of fatalities compared to several variables. To rank the causes per location interval the two variables were plotted on a bar graph and cross-tabulation was done using SPSS. Once the cluster of causes for MVAs was identified literature was reviewed to formulate and propose endorsements for the erection of cause-specific safety features at the identified location as a preventative strategy in order to answer objective four.

3.5 Study limitations

The lack of complete data greatly deterred and delayed the data capturing process despite receiving the original data at an early stage of the research process. The initial data received did not include a column with the location (in kilometres) for the MVAs. Permission had to be granted to gain access to Siebel in order to assign a location for each case from the case information. This could only be done at the MVAF head office as remote access to the database was not possible and was subject to the availability of a computer with access to the system. The data received included all MVAs for the Khomas region and Hardap region and was not exclusively for MVAs that occurred on the B1 road. Each case had to be manually scrutinised in order to include or exclude.

The initial objective was to investigate the exact locations of MVAs however some cases only had landmarks. GPS locations would allow the researcher to view environmental factors that may impact MVAs. The sporadic capturing of data prior to 2011 and the incompleteness of data decreased the sample size with only 300 cases meeting the inclusion criteria. An additional 55 cases were excluded due to missing information.

The generalisability of the study is also problematic as only a section of a road was studied unlike the literature reviewed where roads in urban areas of main cities were studied. The importance of this road however is highlighted in previous sections and the study can be replicated along other sections of this highway.

3.6 Ethical Considerations

The research title and proposal were approved by the NUST internal Higher Degree committee in May 2017. Subsequently ethical approval (REC-0003/2017) was received from the Institutional Research and Planning Committee (see Appendix 2) in September 2017. No major ethical issues related to the study exist as there was no interaction with human subjects and no capturing of personal information was done. However, the data was managed with confidentiality.

CHAPTER 4: RESEARCH RESULTS

JOURNAL TITLE: Accident Analysis and Prevention

TITLE: Relationship between the location and causes of motor vehicle accidents on the B1 road, Windhoek to Rehoboth, Namibia

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ABSTRACT

INTRODUCTION: Motor Vehicle Accidents (MVAs) are fast becoming the leading cause of death globally. In 2010, one person died globally every 25 seconds due to an MVA. In 2008, Namibia was highlighted as the country with the highest fatality rate in the world (45 deaths per 100 000) and ranked 9th overall in Africa with MVA related deaths in 2010. The B1 road in the Hardap region (Rehoboth and its surrounding areas) was identified in 2009 as one of the top ten locations for MVAs and in 2014 as an area with high MVA associated fatality. Despite identifiable causes of MVAs, accident rates continue to rise. The objective of the study was to determine and describe the relationship between the causes and location of MVAs on the B1 road, between Windhoek and Rehoboth.

METHODS: Data was collected for MVAs on the B1 road, between Windhoek and Rehoboth. The accidents were ranked according to their location and causes. Clusters of causes were identified for location intervals and the relationship between the causes and location identified using inferential statistics.

RESULTS: Driver-related causes (56.3%) was the most common cause of accidents. Other common causes included collision with an animal and mechanical failure. Most accidents occurred in the 0-20km interval (29.3%), closest to Windhoek. The highest reported injuries (27.3%) and fatalities (32.9%) was in the 21-40km interval. There was a statistical relationship between the location and cause of accidents and clusters of causes could be identified for each location interval.

CONCLUSIONS: There are identifiable causes of MVAs with recognised preventative strategies. Updating existing laws and stricter law enforcement can address the key causes of MVAs on the B1 road. Data capturing needs to be improved and can also act as a safety strategy when used in conjunction with technology.

KEYWORDS: Namibia, motor vehicle accidents, causes, location.

1. INTRODUCTION

The global impact of motor vehicle accidents (MVAs) on healthcare and economics are undeniable and evidenced by numerous publications in various international journals (Adeloye, et al., 2016; Lagarde, 2007; Nantulya and Reich; 2002, Odero et al., 1997; Peden, et al., 2013; Rezaei, et al., 2014; Sivak and Schoettle, 2014; WHO, 2015). In 2010, globally more than 1 million people died as a result of MVAs, which articulated to one person dying every 25 seconds. A further 20 injured victims were estimated for every fatality per MVA which accrues to 20 million people per annum (WHO, 2015).

Despite other pandemics such as HIV/AIDS and cardiovascular disease, the incidence of MVAs is on a steep incline and is fast becoming the leading cause of death globally (WHO, 2015). Since the working-class populations are most affected, the economic consequences of MVAs are predominantly due to loss of productivity. Still, effects span much further than just the lives lost, escalating medical expenses and rehabilitation of injured victims as well as damage to local infrastructure and private property contribute to the financial burden (Nantulya and Reich, 2002; Odero et al. 2003; Osoro et al, 2015; Sivak and Schoettle, 2014; WHO, 2015). It is estimated that the economic burden in some developing countries ranges between 1 and 9% of their gross domestic product (GDP) whereas in Namibia, it is estimated to be 3% annually (Bonnet et al., 2018; Legal Assistance Centre, 2016).

The highest fatality rates reported in the literature are recorded in African countries (26 deaths per 100 000) and these numbers are alleged to be higher (up to 65 per 100 000) (Adeloye, et al., 2016, WHO, 2015). Increased vehicle use, the number of occupants per vehicle, poor law enforcement, underdeveloped public health sectors and poor access to healthcare are all factors continuing to contribute to the high burden of MVAs in developing countries (Nantulya and Reich., 2002; WHO, 2015). The global statistics may be more terrifying as poor data management systems and underreporting is said to mask the true effects of MVAs (Nantulya and Reich, 2002; Museru, et al., (2002).

Human factors including alcohol and drug use, reckless driving and speeding are the most common cause of MVAs globally and contributes to as much as 80% of all MVAs. Other factors at play are environmental factors (road surface, animals and visibility) and vehicle defects (Bahadorimonfared, et al. 2013; Chen, et al., 2016; Odero, et al. 1997; Odero, et al., 2003; Osoro et al, 2015). The accident location has also been shown to be an important factor in the number of accidents, particularly in PVAs (Bonnet et al.,2018, Prato et al., 2012).

In 2008, Namibia was highlighted as the country with the highest fatality associated with MVAs (45 deaths per 100 000), more than double the global average (18 deaths per 100 000) (Sivak and Schoettle, 2014). The published data was refuted by the leading role-players of MVAs in Namibia, the Motor Vehicle Accident Fund of Namibia (MVAF) and the National Road Safety Council (NRSC) since they were not consulted about the validity of the data. Despite gross inaccuracies noted with the data, the MVAF and NRSC agreed with Sivak and Schloette (2014) that MVA related deaths are on the increase (MVA Fund and NRSC, 2014). In fact, there has been a steady increase of 9% in fatalities in Namibia from 2010 to 2015 and in 2015 the fatality rate was estimated to be 33 deaths per 100 000 (Amweelo, 2016). In the same year, in unpublished data of the NRSC, 21 000 MVAs occurred in total (with and/or without injuries) with only 4 221 recorded by the MVAF for compensation. Shockingly, 250 million Namibian dollars (N$) was paid out in compensation during the five-month period from January to May 2015 and N$150 million was paid to service providers for medical costs alone in that year (MVA Fund, 2105, Namibian Economist, 2015).

The B1 road is the main highway connecting several Namibian towns, acts as a transport carriageway for import and export and is frequently used by commuters. The B1 road in the Hardap region (Rehoboth and its surrounding areas) was identified in 2009 as one of the top ten locations for MVAs and in 2014 as an area with high MVA associated fatality (NRSC 2014). In spite of the availability of the data of MVAs in Namibia there is no published research reporting on the causes of MVAs in Namibia, the reason for the country's high fatality rates and whether it is affected by the location/environment it has occurred in.

The aim of the study is to establish the relationship between the location (at 20km intervals) and the causes of MVAs with injuries and fatalities on the B1 road, between Windhoek and Rehoboth for the six-year period, from January 2011 to December 2017 with the objectives to 1) map the MVAs according to their location (20 km intervals), 2) determine clusters of causes per location interval (20km intervals), 3) determine and describe the relationship between the causes and location and ranking the causes and 4) formulate and propose endorsements for the erection of cause-specific safety features at the identified locations as a preventative strategies.

2. MATERIALS AND METHODS

The study is a descriptive, retrospective review of MVAs that occurred on the B1 road between Windhoek and Rehoboth for the period 2011 to 2017. The B1 road is one of the country's main highways that spans from the North to the South of Namibia, see figure 4.1 below. The stretch of road (point A to B) between Windhoek (located in the Khomas region) and Rehoboth (Hardap region) is the area of interest.

Figure 4.1: B1 road across Namibia

(Source:www.namibiabookings.com/namibia_hotels/border_stopover_hotels.html.)

Data of all MVAs that occurred in the Hardap and Khomas regions between 2008 and April 2018 was obtained from the MVAF database, Siebel, in a Microsoft Excel (2016) format. Due to the sporadic entry of data prior to 2011 only accidents from January 2011 to December 2017 were included in the study. Accidents were included if it occurred on the B1 road between Windhoek and Rehoboth during the study period, had an identifiable location (in kilometres) and the data recorded was complete (less than 2 missing fields/details). Despite having occurred on the B1 road, between Windhoek and Rehoboth, several cases had to be excluded due to missing information (55 cases).

The location (in kilometres from Rehoboth or Windhoek) was not captured on the Microsoft Excel (2016) sheet thus each case had to be individually checked to add the location. For some accidents, no location, only a landmark was recorded. A Global Positioning System (GPS) device was used to track the distance of the landmarks which was then added manually to the data. Another disparity was that there was no clear delineation of the towns' borders thus reference point A was chosen as the roadblock just outside Windhoek and all the locations were orientated in relation to this point. Reference point B was identified as the final landmark upon exiting Rehoboth, the Total Service Station. The total distance of the road was 80 km. All cases did not have a specified cause captured on the original data thus had to be extrapolated from the description of the accident. The eight most commonly occurring categories were chosen for the causes of the MVAs and are summarised in Table 4.1

Table 4.1: Categories for causes of MVAs

Identified cause of MVA	Description
Collision with animal	Wild or domestic animals
Collision with object	Tree, pole, secondary stationery car, infrastructure along the road
Driver causes	Speeding, suspected alcohol intoxication, overtaking
Mechanical failure	Tyre burst, failure of brakes
Passenger fell from moving vehicle	Passenger fell from a moving vehicle
Pedestrians	PVAs, including hit and runs
Weather/road conditions	Poor visibility, wet or slippery road, potholes
Unknown	If no cause could be established from the information present

The types of MVAs were categorized according to the eleven most commonly occurring types of MVAs presented in the data (see Table 4.2)

Table 4.2: Types of MVAs

Type of MVA	Description
Chain collisions	MVA involving more than 2 vehicles.
Collision with an animal	Where there was actual contact with the animal domestic or wild.
Collision with an object	Objects such as a tree, pole, secondary stationery vehicle, infrastructure alongside the road.
Head on collision	Where vehicles collided head to head.
Motorcyclist	On its own or with a secondary vehicle.
Passenger fell from moving vehicle	Passenger fell from moving vehicle.
Rear-ended collision	Where one vehicle collided with the rear of a secondary vehicle.
Rollover	If the vehicle rolled
Sideswipe	Contact with lateral aspects of the vehicles
T-bone collision	If two vehicles collided at a right angle with each other
Vehicle left the road	If the vehicle left the road but did not overturn

In some cases, there was difficulty to appropriately assign the causes of the MVA. An example of this would be if the driver was trying to avoid a collision with an animal but lost control of the vehicle and it overturned. In these cases, the cause was assigned as driver related causes as there was no actual collision with the animal and the type of accident as either a rollover or vehicle left the road depending on the final outcome.

The final compiled data was imported to SPSS version 25 for statistical analysis. Mapping of accidents according to its location was done by sorting and rearranging the data from point A to B at 20km intervals. Clusters of causes of MVAs were identified by arranging the causes of accidents per 20 km location interval in Microsoft Excel (2016), subsequently allowing for ranking the leading causes of accidents per location. Count and percentages were calculated by cross-tabulation of accidents, fatalities and injuries per 20 km location interval and presented in bar graphs. The mean, mode and median were also calculated for the number of injuries, fatalities and location of accidents. Accidents and causes were plotted on a geographical map of the section of the road using the geospatial information system, QGIS 3.4 Madeira.

The relationship between the causes and location was established using inferential analysis on SPSS which included Chi-square test of association, Spearman's and Pearson tests for correlation and Poisson regression. A one-way ANOVA and Tukey post hoc test was done to assess the statistical difference between the 4 location intervals. Subsequently, the existing body of literature was reviewed to propose safety features as preventative strategies for the most common identified causes of MVAs on the B1 road.

3. RESULTS

A total of 1 080 MVAs were recorded in the Hardap region and a total of 9 047 were recorded in the Khomas region for the study period. Three hundred accidents met the inclusion criteria, with a total of 686 injuries and 99 fatalities recorded. On average 3-4 people were involved per accident (SD3.429) and 2-3 persons (SD2.555) were injured per accident. The chance of a fatality was approximately 1 in 3 per accident (SD1.078).

The highest number of accidents were recorded in the 0-20 km interval (starting from point A), a total of 88 accidents (29.3%), 167 injuries (24.3%) and 27 fatalities (27.3%) however the highest number of injuries (32.9%) and fatalities (31.3%) was recorded in the 21-40km interval. The total number of accidents, injuries and fatalities per location interval is shown in figure 4.2 below. The average location of MVAs was 39.46 km (SD 22.4779) from Windhoek however the location with the highest frequency of MVAs was 20km from Windhoek. Most of the accidents occurred in a shorter and closer distance to Windhoek which is evidenced by 50% of the MVAs in the data occurring within 37 km from Windhoek and the remaining 50% occurred in the subsequent 44 km up to Rehoboth.

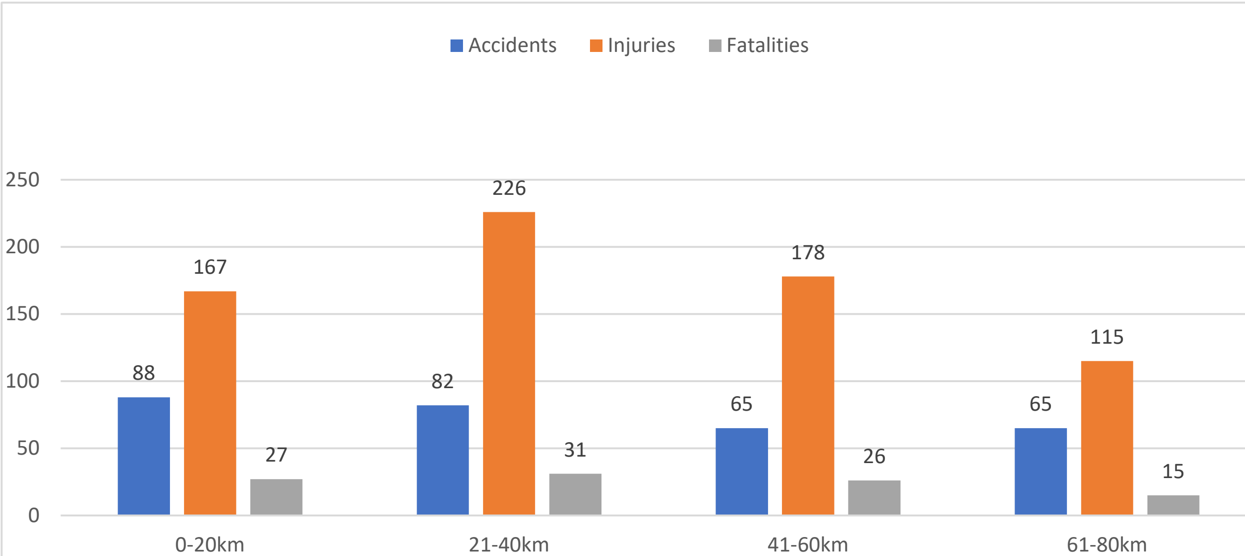

Figure 4.2: Number of accidents, injuries and fatalities vs location of accident from Windhoek

The leading cause of MVA was driver related which accounted for 169 incidents (56.3%), 421 injuries (61.4%) and 57 fatalities (57.6%). Ranked 2nd overall was collision with an animal which accounted for 48 accidents (16%) with 93 injuries (13.6%) and 14 fatalities (14.1%). The 3rd and 4th ranked overall caused of accidents was mechanical failure which resulted in 25 accidents (8.3%), 79 injuries (11.5%) and 14 fatalities (14.1%) and PVAs accounting for 22 accidents (7.3%), 22 injuries (3.2%) and 3 fatalities (3%). Collision with an object (4.3%), weather or road condition (3.7%), passenger falling from a moving vehicle (2%) and unknown causes (2%) accounted for ranking 5 through to 8 of overall causes of accidents (see figure 4.3).

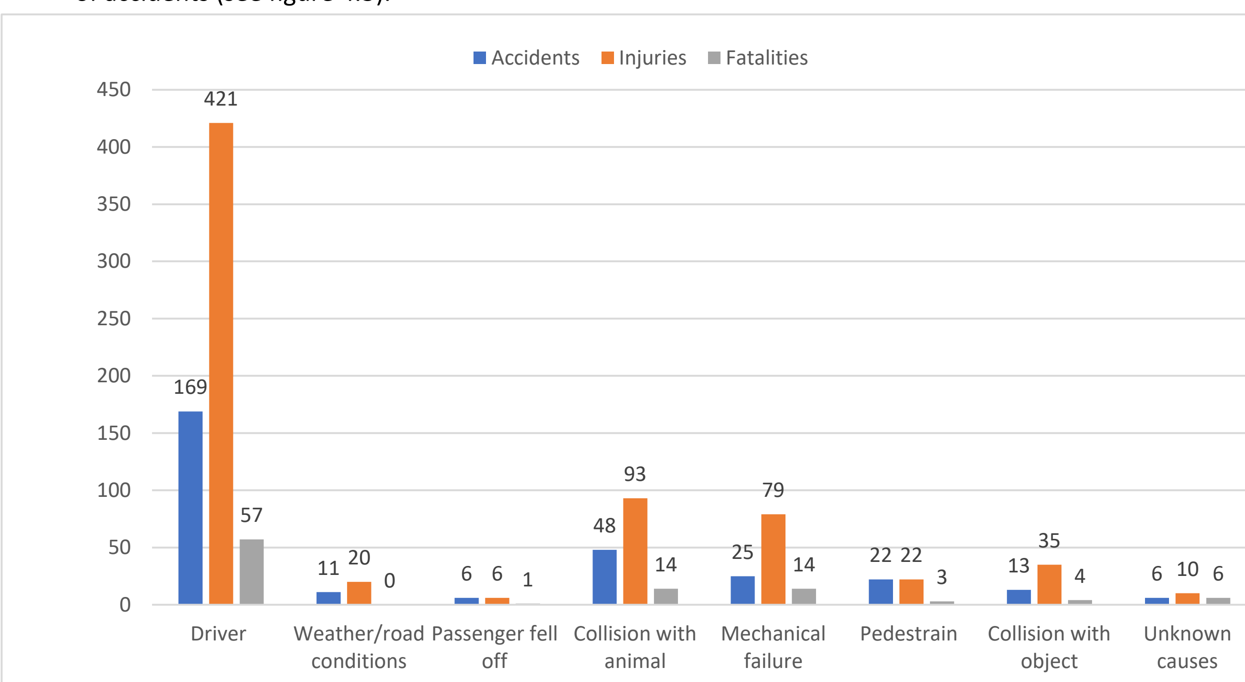

Figure 4.3: Number of accidents, injuries and fatalities vs Causes of accidents

Ranking of the four leading causes of accidents per 20 km location interval is summarised in Table 4.3.

Table 4.3: Ranking of causes per location interval

Location Interval	Ranking of causes	Number of accidents (%)
0 – 20 km	1) Driver related causes	58 (65.9%)
	2) Weather/road conditions	7 (8.0%)
	3) Collision with animal	6 (6.8%)
	4) Pedestrian vehicle accident	5 (5.7%)
21 – 40 km	1) Driver related causes	44 (53.7%)
	2) Collison with animal	14 (17.1%)
	3) Mechanical failure	9 (11%)
	4) Pedestrian vehicle accident	5 (6.1%)
41 – 60 km	1) Driver related causes	40 (61.5%)
	2) Collison with animal	13 (20%)
	3) Mechanical failure	7 (10.8%)
	4) Collision with object	3 (4.6%)
61 – 80 km	1) Driver related causes	27 (41.5%
	2) Collision with animal	15 (23.1%)
	3) Pedestrian vehicle accident	12 (18.5%)
	4) Collision with object/Mechanical failure	5 (7.7%)

Figure 4.4. shows the mapping of the accidents on a geographical map per location interval. The accidents were mapped according to the causes at the location they occurred. Each cause is indicated as per the key below the map and the number of accidents at the specific sections along the road is indicated next pie chart showing the causes at that location. Driver related causes stand out as the main cause in each interval (green). Common causes can be identified in the various location intervals which correlate with the above statistical analysis done. High-frequency accident locations are identifiable on the maps, however despite driver related causes being the overwhelming reason for accidents at each high accident location, there are other causes that contribute as well. Further investigation is required to establish the impact of environmental factors particularly in these high accident location areas. The incidence of PVAs is increased in the final stretch of the 61-80km interval and collisions with an animal also predominate in this location interval. Weather/road conditions only appear in the 2nd and 3rd location intervals.

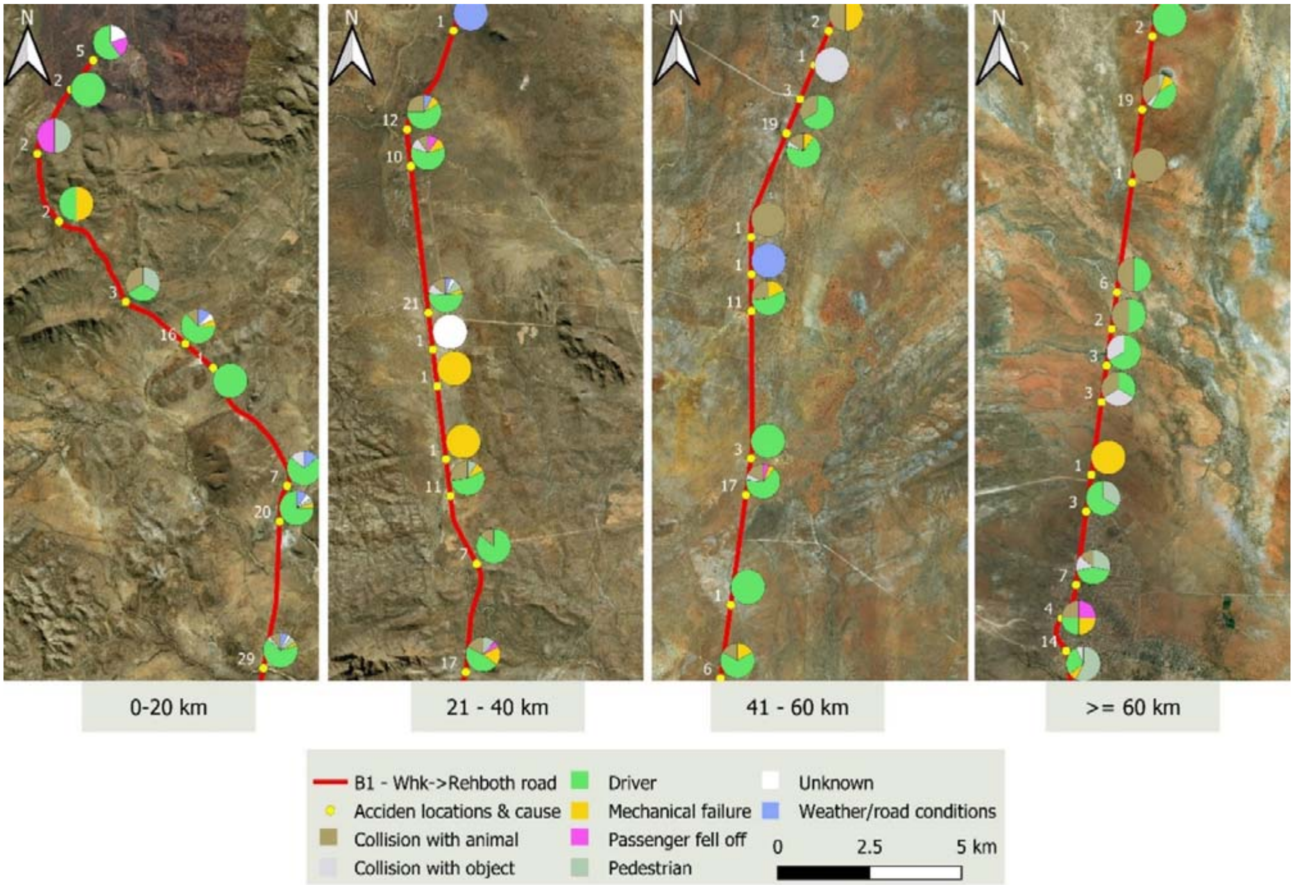

Figure 4.4: Mapping of accidents on geographical map of the B1 road per Causes of accident

Crosstabulation between the causes and location of accidents showed that a relationship exists between these two variables as there were a number of similar causes that was consistently high in various location intervals. The two variables are significantly dependent (Pearson Chi-square test X^2 = 46.73, *df* =21, p-value 0.01) but showed a weak but linear relationship (Pearson correlation test r_p = -0.155. p-value = 0.007). A one-way ANOVA was done to assess the statistical difference between the 4 location intervals. The results revealed that there was a general difference between the location intervals, but it did not express the specific groups that had differences. A further test of variance was conducted using the Tukey post hoc test. The 2 groups that were significantly different was the 0-20km interval and the 41-60km interval (p = 0.008) with more accidents occurring in the 0-20km interval. A further significance was shown between the 0-20km interval and the 61-80km interval (p = 0.014) showing that these two locations were central to accidents by driver related causes and higher safety areas respectively.

Further analysis showed that the most common type of accidents was rollover accidents which contributed to 122 accidents (40.7%) followed by collision with an animal (14.3%) and PVAs (7.7%). Rollover accidents also contributed to the greatest number of injuries (39.9%) and fatalities (31.3%)

(see appendix 1, figure i). Most MVA occurred over the weekend, 184 (61.3%) accidents occurred between Fridays and Sundays with 401 (58.5%) injuries and 57 (57.6%) fatalities. Sundays had the greatest number of accidents (21.3%) and Saturdays the greatest number of injuries (21.9%) and fatalities (27.3%) (see appendix 3, figure ii). However, a high number of injuries were also recorded on Tuesdays (15.6%). Tuesdays however are considered an outlier as there were two accidents with multiple injuries that occurred on a Tuesday which skewed the data in this category. There is an association between the day of the week and the number of injuries (Chi-square test X^2= 107.6, df = 84, p-value 0.042). These two variables are shown to be significantly dependent however there is no association between the day of the week and the number of fatalities (Chi-square test X^2= 35.6, df = 42, p-value 0.744). A positive but weak correlation was however found between the number of injuries and the day of the week (Regression results R_2 = 0.063, p-value 0.274>0.05) as well as the number of fatalities and the day of the week (Regression results R_2 = 0.061, p-value 0.289>0.05) indicative that although there is not a statistically significant relationship between the number of injuries and fatalities and the day of the week they do influence each other.

The time of day also played an important role in the prevalence of MVAs were highest between 18:01-21:00 (19%). Half of the accidents occurred during the 15-hour period between 00:01 and 15h00 and the other half occurred during 15:01 to 00:00. There is a relationship between the type of accident and the type of day as shown in appendix 3, figure iii where rollover accidents where consistently high throughout the day and night however were most prevalent during 12:01-15:00, 15:01-18:00 and 03:01-06:00 with the latter two-time intervals coinciding with peak commuting times. Collisions with animals were high during times were visibility could have been compromised before sunrise and after sunset (03:01-06:00, 18:01-21:00 and 21:01-00:00). PVAs also increased at night which can likewise be attributed to compromised visibility at night (15:01-00:00).

Poisson regression was run to predict the number of fatalities that occurred based on the location of the accident, the type of accident and the day of the week. The results below show that the independent variables such as the day of the week, type of accident and location from Windhoek, have a statistically significant effect on the dependent variable (number of accidents). There is 1.978 times more fatalities in the 21-40km distance interval (p-value=0.035) and 2.072 times more fatalities in the 41-60km distance interval (p-value= 0.032) as compared to the 61-80km interval. This means that there is a twice likely chance of a fatality occurring in the 21-40 and 41-60km interval compared to the 61-80km distanced interval. Other variables that were significant were Saturdays, Sundays and Tuesdays and rollover accidents. The cause of the accident was however removed as a variable as it was considered non-significant in this particular test.

4. DISCUSSION

The aim of the study was to establish the relationship between the location and causes of MVAs with injuries and/or fatalities on the B1 road between Windhoek and Rehoboth. The first objective of the study was achieved by mapping the causes of accidents per location interval (20km intervals). Descriptive analysis was carried out to determine the most common cause and location of accidents on the B1 road. The accidents were also plotted on a geographical map to further display the causes per location interval. Four main causes were identified and ranked for each location interval and which yielded a cluster of causes of accidents on the B1 road. The relationship between the location and causes was established using descriptive analysis.

The highest number of accidents occurred in the first location interval, closest to Windhoek. The chances of an accident in fact decreased with increased distance from Windhoek. Despite the greater incidence of MVAs closer to Windhoek, it did not correlate with the highest number of injuries and accidents. The 21-40km interval had a greater incidence of injuries and fatalities which could have been due to several factors such as increased speed, the condition of the road which had more curves and bends and was located in a relatively mountainous areas and the presence of dual carriageways, the latter which is said to contribute to increased incidence of accidents in rural areas and between cities (Geurts et al, 2003).

Driver related causes was the most frequent cause of MVAs on this road and was associated with the highest number of injuries and fatalities (fig.4.3) which coincides with global findings that this cause contributes to as much as 80% of all accidents (Bahadorimonfared et al., 2013; Chen et al., 2016; Odero et al., 1997, Odero et al., 2003, Osoro et al., 2015; WHO, 2015). Driver related causes were in fact ranked the highest across all location intervals. Collision with an animal, vehicle mechanical failure, road/weather conditions and PVAs were also identified as common causes of MVAs on this road which is consistent with the three most common causes of MVAs globally namely human factor/road user, vehicle factors and road infrastructure (Bahadorimonfared et al., 2013; Chen et al., 2016; Odero et al., 1997, Odero et al., 2003).

Rollover was the most common type of accident, particularly in the first location interval (0-20km) which corresponded with the highest number of injuries and fatalities in other location intervals. High numbers of injuries and fatalities were also noted in collision with an animal and head-on collisions. High velocity and high impact collisions may explain the higher number of injuries and fatalities associated with these types of accidents. These 3 types of accidents, along with PVAs, have previously been identified as the leading types of accidents in Namibia (MVA Fund and NRSC, 2014). Accidents peaked during the night (18h00-06h00) and PVA's, rollover accidents and collision with an animal were particularly prevalent during this time which is most likely due to altered visibility. This finding is supported by Odero (1997) who identified that there are peak times related to certain types of accidents.

Most of the accidents occurred on a Sunday followed by Saturdays and during the weekend (Friday to Sunday) which was consistent with findings in a similar study (Odero, 1997). The highest number of injuries and fatalities were recorded on Saturdays, Tuesday, however, also stands out with a high number of injuries but is statistically considered an outlier as the high number of injuries is contributed to two specific accidents where which involved buses that occurred on a Tuesday. One of these in 2016 that involved 26 people of which 19 were injured and 7 people died another in 2015 which involved 13 people, 12 were injured but there were no fatalities.

The accident location has been shown to be particularly important in PVAs, with more accidents occurring closer to and within Rehoboth (Prato., 2012). A cluster of causes could clearly be identified and ranked in all location intervals (table 4.3 and appendix 3, figure iv) and was almost identical across all location intervals with the exception of weather and road conditions being ranked second in the 0-20km interval and PVAs being more frequent in the 61-80km interval. The higher number of PVAs in the 61-80km interval, close to and within Rehoboth, could be attributed to the increased number of people crossing the highway within the town and hitchhikers next to the road. Statistical analysis showed that there was an association between the cause and location of MVAs and that these two variables are dependent meaning that the cause is determined by the location of the accident.

In plotting the accident locations on the geographical maps on the location intervals high accident location intervals were identifiable. Despite driver related causes predominating the cause of MVAs at each of these high accident locations there were other causes identified at these areas as well. This calls for recording of the GPS location of accidents in order to identify and further investigate the various factors that contribute to these high accident location areas.

Most accidents are said to occur on rural roads, mostly highways linking cities such as the case in the road studied. It is thus vital to identify accident-prone roads in order to make improvements to reduce accidents (Bahadorimonfared et al., 2013; Geurts et al., 2012; Odero et al., 2003). Preventative strategies discussed was thus based on the five most common causes identified namely; driver related causes, collision with an animal, mechanical failure, PVAs and road/weather conditions.

Recommendations for cause-specific prevention strategies are based on stricter laws and law enforcement as well as improved data capturing to outline and address the main identified causes of accidents. Stricter law enforcement is the single most effective method to decrease accidents caused by driver behaviour (Bahadorimonfared et al., 2013; WHO, 2015). A number of internationally proposed regulations are captured in the Road Traffic and Transport Act 22 of 1999 of Namibia however the need for stricter law enforcement is captured in Namibia's 5th National Development Plan (Republic of Namibia, 2018). There is a need to update current road safety policies to be on par with international standards considering the Namibian MVA statistics far exceed international averages (fatalities per 100 000) (WHO, 2015). Namibia's legal alcohol limit, for example, is 0.079mg/dL which is well above the global limit of 0.05mg/dL. Blood alcohol levels as low as 0.02-0.05mg/dL triples the chances of being involved in an accident (WHO, 2015). The Legal Assistance Centre (2016) recommended a point merit system whereby a driver is given demerits for offences. The above recommendation however is already catered for in the existing act where drivers' licences can be suspended if they are convicted of an offence. Average speed cameras can be installed on various points on a road. These cameras measure the time taken to travel between two points and calculates the speed the driver undertook to cover this distance. The advantage of these cameras is that they also capture the vehicle registration number and does not require an operator (Roads and Maritime Services New South Wales, 2017). Laws on the driver, passenger and child restraints too are captured in the Act yet are shown to be leniently enforced for children in Namibia as the rating for its enforcement was 1 out of 10 in 2017 (WHO, 2017). The challenge is that to effectively enforce road safety laws additional traffic officials, need to be trained and extra vehicles and monitoring equipment need to be acquired. This would require redirection of capital funds which would however in the long run decrease the economic financial burden of MVAs on the country.

Collisions with animals and PVAs were also frequent causes on MVAs particularly close to and within Rehoboth. These two causes of accidents are also addressed in the Act, which again eludes to stricter enforcement of existent laws. Standard operating procedures can be implemented to guide law enforcement officials on how to deal with animals alongside the road can better guide them in this aspect. Another inexpensive option would be to erect specific road signs at high accident areas to alert the driver of the potential hazards, pedestrians or high accident zones ahead. Improved separation of animals from the road can be achieved by frequently checking and fixing fencing along the B1 road. Stricter fines to owners of straying animals or confiscation of animals could also attribute to improved monitoring of animals by owners. Speed humps and pedestrian crossing on the stretch of road that is located within the town may reduce PVA's that are higher close to and within Rehoboth. Upgrading the public transport sector may decrease the number of vehicles on this road. Increasing laws related to minibus taxi safety may encourage increased use of this type of transport and the erection of commuter train between Windhoek and Rehoboth could further decrease the use of vehicles on this road. Little can be done to mitigate the effects of weather (wet/slippery road, poor visibility) on MVAs however maintaining road surfaces can prevent damage (potholes). Stricter and more frequent vehicle clearance and roadworthiness testing could contribute to safer vehicles and thus fewer mechanical failure related accidents (Legal Assistance Centre, 2016; WHO, 2015).

The lack of accurate data capturing system underrates the burden MVAs (WHO, 2015). Including data of all accidents (including and excluding injuries) in Namibia would be more valuable to establish the financial impact of MVAs on the country. Current data capturing systems may also be excluding MVA related deaths that are not immediate which further contributes to underreporting. Additionally, more complete data would allow for epidemiological studies to evaluate all the variables that influence the incidence of MVAs in Namibia. Updating current data capturing systems are required to ensure that accurate and complete data is captured. Data capturing can further be used as a safety intervention as it allows for monitoring and surveillance of accidents (and interventions) when used with technology (Bonnet et al., 2018). Integration between various role-players (MVAF, NRSC, Police and Insurance companies) could allow for continuous data capturing and monitoring to provide a more complete picture of the effects of MVAs Namibia.

Road safety in developing countries is different from the developed world as there are different causes of accidents and factors leading to fatalities (Bahadorimonfared et al.,2003). Tackling the identified causes directly should decrease the number of accidents, injuries and fatalities (Prato, 2012). The findings however are not unanimous for the entire B1 road or for other roads within Namibia, the process however can be replicated on other parts of the B1 road to identify specific causes in order to implement specific safety strategies. If no intervention is taken to address the rising statistics injuries, fatalities and the financial burden of MVAs will continue to rise as motorisation and populations increase within the country. Further studies need to be conducted to evaluate the effectiveness of implemented preventative strategies.

5. CONCLUSIONS

The cause of an accident is directly related to its location on the B1 road between Windhoek and Rehoboth. There is a cluster of causes on the B1 road between Windhoek and Rehoboth, that are consistent with global causes of MVAs. The causes of MVAs are well known with the single most common cause being driver-related behaviour. The most effective intervention for this causes of accidents is stricter law enforcement (Bahadorimonfared et al., 2013; WHO, 2015). Despite existent laws in Namibia to address the identified causes there is a need to benchmark laws pertaining to road safety to international standards to address the shocking statistics related to MVAs. Stricter law enforcement would require increased resources but would still be a more feasible option compared to the money spent on the effects of MVAs. Stricter control of animals along the road and stricter roadworthiness and clearance is required to assist in reducing the other common causes of accidents on the B1 road between Windhoek and Rehoboth. There is also a need to address the incidence of PVAs close to and within Rehoboth along this road. Improved public transport infrastructure could also contribute to decreasing the number accidents, injuries and fatalities on this road.

Factors such as the day of the week, time of day and type of accident need to be addressed in the choice of safety strategies as these too are identified contributing factors to MVAs on this road. Recommended preventative strategies need to be erected in the location intervals depending on the most common causes in order to effectively reduce the accidents, injuries and fatalities. Most of the strategies are existent and all are relatively cost-effective but needs stricter enforcement. Data capturing plays an integral role in painting a true picture of the effects of MVAs globally. There is a need to improve data capturing systems and to establish a national database to capture all relevant data. Research needs to be done on other highways in Namibia to determine the causes in relation to the locations to find further relationships.

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CHAPTER 5: GENERAL DISCUSSION AND CONCLUSIONS

Most accidents were attributed to driver related causes (which includes drinking and driving, speeding, overtaking and reckless driving) and were associated with the highest number of injuries and fatalities (fig.4.3). This finding coincides with other literature showing that driver causes contribute to as much as 80% of all accidents globally (Bahadorimonfared et al., 2013; Chen et al., 2016; Odero et al., 1997, Odero et al., 2003, Osoro et al., 2015; WHO, 2015). Driver causes were in fact ranked the highest across all location intervals in the study. The highest number of accidents occurred in the first location interval (0-20km) however there were sections within each interval where a high number of accidents occurred with varying causes. This calls for further investigation to determine the effect of road and/or environmental factors that may be contributing to the occurrence of accidents at these specific locations.

There is an urgent need to update current road safety legislation considering that the Namibian MVA statistics of MVA related fatalities far exceed international averages (WHO, 2015). Driver behaviour has been identified as 'a critical factor in road safety – to reduce road traffic crashes, injuries and deaths' (WHO, 2015). Recommended preventative measures to address this common cause of accidents include reducing drinking and driving, a point demerit system for repeated offenders, the use of average speed cameras to curb speeding and stricter enforcement of seatbelts and child restraints (WHO, 2015).

Blood alcohol levels as low as 0.02-0.05mg/dL triples the chances of being involved in an accident (WHO, 2015). Decreasing Namibia's legal alcohol limit and even creating a separate (lower) category for novice drivers could reduce drinking and driving related accidents. A point demerit system for offences could appropriately penalise repeat offenders whilst creating awareness to decrease this type of behaviour (Legal Assistance Centre, 2016). The use of average speed cameras is another option to address speeding as it measures and captures the speed and time it should have taken for a driver to cover a distance between points (Roads and Maritime Services New South Wales, 2017). The advantage of this intervention is that it does not require an operator which is a more cost-effective measure. Laws pertaining to driver, passenger and child restraints are captured in current legislation however are leniently enforced particularly in children as the rating for its enforcement in Namibia was 1 out of 10 in 2017 (Republic of Namibia, 2018; WHO, 2017). The challenge is to effectively enforce road safety laws additional traffic officials, need to be trained and extra vehicles and monitoring equipment need to be acquired. This would require redirection of capital funds which would however in the long run decrease the economic financial burden of MVAs on the country.

Other causes of accidents that were frequent were collision with an animal, vehicle mechanical failure, road/weather conditions and PVAs which is consistent with the three most common causes of MVAs are human factor/road user, vehicle factors and road infrastructure (Bahadorimonfared et al., 2013; Chen et al., 2016; Odero et al., 1997, Odero et al., 2003). Collision with an animal was ranked 2nd in all location intervals except in the 0-20km interval. This implies that there is poor control of and separation of animals in these areas. Farms owners adjacent to national roads need to take ownership to ensure that fencing is maintained. Fines and even confiscation of stray animals could assist to address this problem. Vehicle mechanical failure was ranked the 3rd leading causes of MVAs in the 21-40km and 41-60km intervals. Stricter and more frequent vehicle clearance and roadworthiness testing could contribute to safer vehicles and thus fewer mechanical failure related accidents (Legal Assistance Centre, 2016; WHO, 2015). Improving the road infrastructure, particularly after the rainy season could reduce potholes and other damage to road surfaces however little can be done to address slippery/wet road and reduced visibility caused by weather conditions. Awareness campaigns, particularly prior to and during rainy seasons can however be beneficial to warn drivers of the risks.

The most common type of accidents were rollover accidents which are consistent with data reported by the MVAF and NRSC in 2013 (MVA Fund and NRSC, 2014). Loss of control and avoidance of collisions with an animal or another vehicle were frequent causes of this type of accident. Despite the lower number of vehicles being involved in rollover accidents overall there is still a high number of injuries and fatalities per accident. This could be exacerbated by the types of vehicles involved and the purpose of the vehicle (minibus vs sedan and private vehicle vs public transport vehicle). This area too needs to be investigated to identify the most common type of vehicle (and its use/purpose) involved in accidents as a contributing factor to accidents on this road. This road is used at least twice a day by commuters who travel to and from Windhoek, with a number of multiple passenger vehicles (minibus taxi's) and private vehicles with an increased number of passengers (commuters) using the road, increasing the number of potential victims per accident. One of the reasons for the high burden of MVAs in developing countries is the mode of transport (multi-passenger vehicles and buses) that results in a higher number of victims per MVA (Nantulya and Reich., 2002). Improved public transport infrastructure could decrease the number of vehicles. Improving the public transport infrastructure could assist in encouraging commuters to make use of this type of transport instead of private vehicles thus reducing the number of vehicles on this road, particularly during commuter peak times.

The location of the accident was shown in this study to play an important role in the cause of the accident. Statistical analysis showed an association between the cause and location of MVAs on the road studied and showed that these two variables are dependent. This means that the cause of the MVA is determined by the location (interval) which proves the stated alternate hypothesis of the study. This finding was not previously studied or identified as a contributing factor in MVAs in Namibia. The day of the week also played an important role in the occurrence of accidents on this road with most accidents occurring during the weekends and during the night. There was however an increase in the frequency of rollover accidents and collisions with an animal during dusk and dawn and commuting times .

Improving the quality of the data pertaining to MVAs in Namibia is integral in identifying the true impact that MVAs has on this population. Current data capturing systems are not integrated amongst important role-players thus do not capture all the accidents (with and without injuries/fatalities) and the circumstances related to it. Current data capturing systems used needs to be evaluated to ensure that complete and appropriate data is captured. An array of epidemiological studies can be conducted to identify the effects and factors that contribute to MVAs in Namibia. A further value of improved data capturing (systems) is that retrospective data can be used to evaluate the effectiveness of implemented safety strategies.

The findings of this study are not unanimous for all the roads in Namibia however can be replicated in order to establish the causes and locations of MVAs on various roads. Other dangerous roads in Namibia can be analysed to find the causes according to the location. It is strongly suggested that redirection at specific preventative strategies may significantly reduce these costs and finally the impact on the economy (Nantulya & Reich, 2002).

CHAPTER 6: RECOMMENDATIONS

It needs to be appreciated that the trends in MVAs differ in developed and developing countries (Bahadorimonfared et al., 2013). Not only does the mode of transport (sedan vs minibus) differ other factors such as the number of occupants, the age of the driver and occupants as well as the surface area of the road plays a role. The approaches to road safety and prevention thus need to be adapted and developed to the country's specific needs (Bahadorimonfared et al, 2013; Prato, 2012). The findings of this study provided a snapshot of the causes of accidents on a stretch of road, there is however a need to identify the most causes of accidents in Namibia in order to develop national safety strategies.

The most important avenue in addressing the burden of MVAs in Namibia is to improve existent data capturing systems to allow for the capturing of accurate, relevant and complete data. Improved data capturing systems with clear and concise predefined fields (with drop-down lists) for the cause of the MVA, the type of collision and the type of vehicle can assist in capturing information in these fields for every case. The use of a data capturing application to capture MVAs in Namibia can make room for collaboration between various role-players. A data capturing application like this has been implemented in Nigeria (Road Traffic Accident Monitoring System [RTAMS]) and is shown to be a valuable safety strategy as surveillance of implanted safety strategies can be done (Bonnet et al, 2018). Once the initial data was captured it was sent to a server where additional information and updates could be added. The increased use of smartphones, tablets and Wi-Fi makes this another feasible avenue to improve data capturing. Primary data can be captured by first responders and photos of the scene can even be uploaded to assist in the investigation of the accident at a later stage. The GPS location can be recorded by means of a photo of the scene. This information is vital as the exact geographical location can be recorded to identify possible road and environmental factors that may contribute to the causes in high accident locations. GPS location can further contribute to reducing response times by emergency services by providing the exact accident locations to the devices. Data capturing is also regarded as a safety intervention as it allows for monitoring and surveillance of the effectiveness of implemented safety strategies via the use of technology.

There is a dire need for stricter law enforcement that is accompanied by campaigns to improve awareness within the community (Bonnet et al., 2018). Inclusivity of the community is crucial in order for them to appreciate and understand the justification behind the stricter laws (WHO, 2015). Increased visibility and activity of law enforcement officials were shown to decrease fatalities by as much as 17% (Bonnet et al., 2018). This intervention is one of the most cost-effective measures as it already forms part of the duties of law enforcement official, however there would be a need to increase resources to ensure effective and consistent implementation of this intervention. National policies (National Development Plan 5) are existent with ambitious targets of decreasing the number of accidents in Namibia by half by the year 2020 (Republic of Namibia, 2017). These plans however need to be implemented with ownership, funding and accountability and should involve all the major role-players to ensure its successful attainment.

The current legislation pertaining to road safety (Road Traffic Act) was recently revised but still does not effectively address human behaviour in the context of road safety (Amweelo, 2016). The level of maturity and appreciation of road safety may not be adequate at the current age of licencing (18 years) in Namibia. A prerequisite probationary period (proof of 100-200 hours supervised driving) and a first aid course for a driver's licence could contribute to a better appreciation for the road and other road users in novice drivers. The feasibility of this intervention needs to be evaluated. Other key areas to address in road safety laws to address driver behaviour should include speeding, drinking and driving, a demerit point system and the use of seatbelts and child restraints.

Speed reduction to 50km/hour is recommended in urban residential and industrial areas to reduce PVAs in particular (WHO, 2015). This has been implemented in certain areas in Windhoek. Enforcement of speed limits is key to reducing high-speed accidents, thus could be better monitored with increased visibility of traffic officers on highways and additional speed cameras. Average speed cameras could further assist in monitoring speed less invasively. These cameras use the speed that a vehicle is driving to determine the time it should take to reach the next camera. The cameras do not require an operator and record the vehicle's registration number as well (Roads and Maritime Services New South Wales, 2017). There is a need to compare average speed cameras to speed traps in its effectiveness.

The baseline legal alcohol limit needs to standardise to international standards (≤0.05g/dL). Younger and inexperienced drivers in fact have a lower legal limit in some countries (≤0.02g/dL) (WHO, 2015). In 2017 Namibia's legal limit was 0.079g/dL, well above the international limit, with no provision for novice drivers (WHO, 2017). A driver point demerit system has been recommended by the Legal Assistance Centre (2016), where drivers licences can be suspended for a certain period based on the severity of or repeated offences. A driver's licence can be suspended after three offences for a certain period. This penalty would remove dangerous drivers from the roads and create awareness to refrain from this type of behaviour. Stricter penalties for offences could further assist in this.

New car technologies greatly assist with the increased seatbelt as built-in prompts are only deactivated on the seatbelt it applied. This feature, however, is not present for rear occupants. The use of a seatbelt can reduce injury and death by up to 50% (WHO, 2015). Again, strict enforcement of these was highlighted as a key success factor (WHO, 2015). Stricter regulations of required safety features in vehicles are also recommended to ensure that all vehicles used within the country are safe.

Increased use of appropriate child restraints was identified as another factor to decrease MVA associated fatality particularly in this population. Rear-facing seats, forward-facing seats and booster seats should be used in appropriate age groups. In fact, in some country's children are prohibited from sitting in front seats (WHO, 2015). The WHO (2015) also recommends attention to ensuring safer roads and vehicles. Stricter and more frequent vehicle clearance and roadworthiness checks should be made compulsory to prevent the high incidence of mechanical failure related accidents.

The infrastructure of the road and the environment has been identified by numerous authors as an important contributing factor to accidents (Bahadorimonfared et al., 2013; Odero et al., 1997; Odero et al., 2003; Prato et al., 2012). An improved road infrastructure does however not necessarily guarantee safer roads (WHO, 2015). Thus improving roads in Namibia on its own is not sufficient to decrease the occurrence of MVAs. Construction of safety features to reduce speed (speed bumps), for cyclists (cyclist only lane), pedestrian crossings (or completely separating pedestrians from vehicles by means of an overhead bridge) are lower cost safety strategies that can aid in separating vulnerable road users from vehicles. Careful planning is recommended in the upgrading and construction of safer roads to ensure that all road users are catered to. An improved national road infrastructure to accommodate increased motorisation can also contribute positively by job creation within the country.

Improved emergency care and rescue services following the MVA are believed to save an additional half a million lives per annum (WHO, 2015). Community first aid, a universal emergency number, advanced trauma life support for emergency healthcare practitioners and level I trauma centres are all additional recommended strategies to improve the outcome of victim's post-accident (Bonnet et al, 2018; WHO, 2015). Namibia's public emergency services need upgrading in order to improve the delivery of emergency services. The MVAF have invested in this avenue already by sponsoring paramedic students at NUST as well as specialist training of medical doctors in Namibia to try to increase the capacity of healthcare providers. The implementation of level I trauma centres, that are fully equipped to deal with polytraumatised patients, could also decrease the time to definitive care for acutely injured patients. This could contribute positively to lessening both immediate and delayed MVA associated fatalities by bypassing medical facilities that are unable to accommodate these patients.

It needs to be appreciated that the implementation of safety strategies to effectively reduce MVA associated fatality is complex and requires strict and consistent enforcement once implemented

(WHO, 2015). Constant surveillance of implemented safety strategies can further be a guide to its effectiveness and could raise the need to readjustment. Aligning safety strategies to international standards is important as these include strategies that have been proven to effectively reduce MVAs but Bahadorimonfared et al (2013) and Nantulya and Reich (2002) warn that safety strategies are not a one size fit all as the settings in the developed and developing world are uniquely different and thus require different approaches.

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Appendix 1: MVAF Permission Letter

MVAFund

THE MOTOR VEHICLE ACCIDENT FUND OF NAMIBIA

MVA Fund Service Centre | 8596 Church Street | P.O. Box 25158, Windhoek | Tel: +264 61 289 7000 | Fax: +264 61 249 688

Tuesday, November 14, 2017

Mrs Carolie Cloete
P O Box 4559
REHOBOTH

Dear Mrs. Cloete,

REQUEST FOR PROVISION OF DATA ON PROPOSED STUDY (B1 ROAD, WHK-RHB)

The aforesaid and your letter dated 10 November 2017 refers.
Please note that the MVA Fund hereby grants you permission to access and use the required data for purposes of conducting your research on the B1 Windhoek and Rehoboth Road. Please be informed however that the Fund reserves its right not to divulge information which might be of a confidential and / or a sensitive nature. Save for such information, the Fund will endeavor to assist you to the best of its ability with the necessary information and assistance to complete the research.

Kindly further note that the MVA Fund expects to be provided with a draft copy of your final report and / or presentation on your findings of the research focused on the relationship between geographical location and causes of motor vehicles on the B1 road, Windhoek-Rehoboth. The MVA Fund wishes you success in conducting your studies and looks forward to valuable recommendations to be received from your research which could help improve the road safety interventions in Namibia.
For further information or assistance kindly contact our Manager: Business Improvement, Mr. Rio Jossop at email rio@mvafund.com.na or at 061-2897089/ 0812488202.

Kindly be assured of the Fund's consideration at all times.

Yours sincerely,

JULIUS HAIKALI
SENIOR MANAGER: BUSINESS STRATEGY

Deloitte

Appendix 2: Ethical Clearance

NAMIBIA UNIVERSITY OF SCIENCE AND TECHNOLOGY

13 Storch Street
Private Bag 13388
Windhoek
NAMIBIA

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FACULTY OF HEALTH AND APPLIED SCIENCES

DECISION/FEEDBACK ON RESEARCH PROPOSAL ETHICAL CLEARANCE

Dear Prof/Dr/Mr/Mrs/~~Other(s)~~: Carolie Cloete

Student No (if applicable): 217132766

Research Topic:	Relationship between the geographical location and causes of motor vehicle accidents on the B1 road, Windhoek to Rehoboth
Supervisor (if applicable):	Ms Andrit Lourens
Co-supervisor(s): if applicable	Dr Adam Flowers
Qualification registered for (if applicable):	Master of Health Sciences

Re: Ethical screening application No: REC -0003/2017

The Research Ethics Screening Committee has reviewed your application for the above-mentioned research project. Based on the recommendation of the expert reviewer, the research as set out in the application is hereby:

(Indicate with an X)

Approved: i.e. may proceed with the project		
Approved provisionally: i.e. may proceed but subject to compliance with recommendation(s) listed below	X	
Not approved: Not to proceed with the project until compliance with recommendation(s) listed below and resubmit ethics application for consideration		
IS MINISTRY OF HEALTH & SOCIAL SERVICES (MoHSS) APPROVAL REQUIRED?	YES	NO: √

It is important to note that as a researcher, you are expected to maintain ethical integrity of your research, strictly adhere to the ethical policy of NUST, and remain within the scope of your research proposal and supporting evidence as submitted to the REC. Should any aspect of your research change from the information as presented, which could have an impact or effect on any research participants/subjects/environment, you are to report this immediately to your supervisor or REC as applicable in writing. Failure to do so may result in withdrawal of approval. Kindly consult your supervisor or HoD if you need further clarification.

We wish you success in your research endeavour and are of the belief that it will have positive impact on your career as well as the development of NUST and the society in general.

Ethical issues that require compliance/ must be addressed		
No.	**Ethical issues**	**Comment/recommendation**
1.	None	A retrospective study using data from MVA. Identity of accident victims will not be revealed. However, MVA official approval will be required.
2.		To submit copy of approval letter to FHAS-REC secretariat*.

NB: May attach additional page as required; * Failure to do so will invalidate research outcome

Full Name (reviewer): ...PROF SYLVESTER R. MOYO...Signature: .... Date: 04/09/2017

Full Name: PROF OMOTAYO AWOFOLU.................... Signature: .... Date: 4/9/2017
Chair: Ethics Screening Committee

Appendix 3: Additional Figures

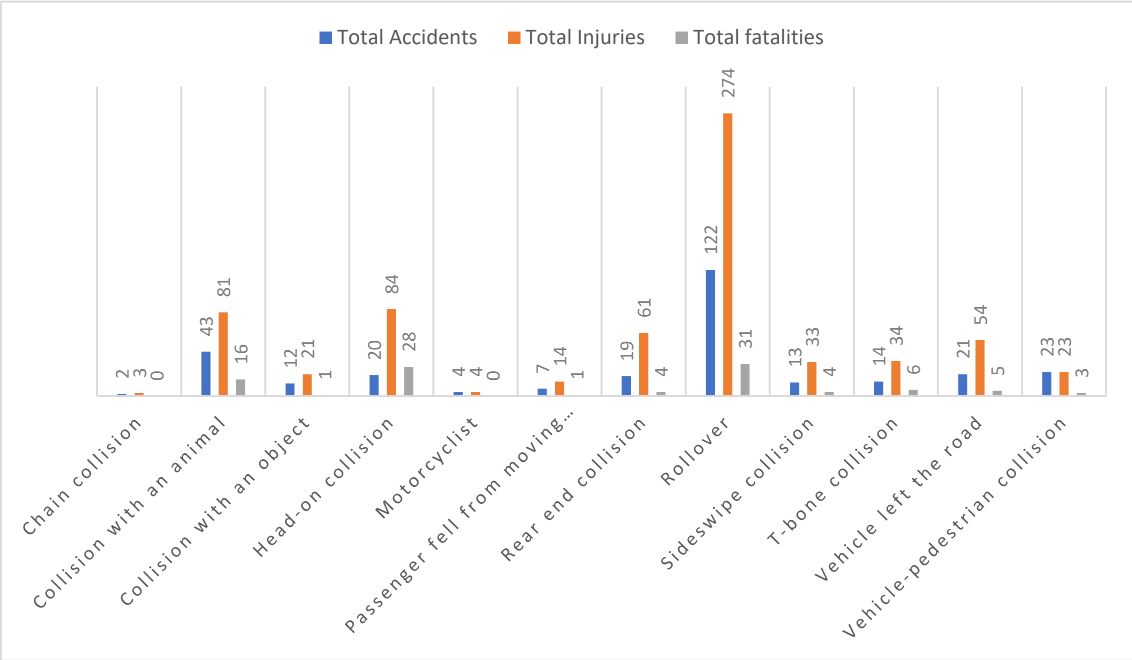

Figure i: Number of accidents, injuries and fatalities and the Type of accident

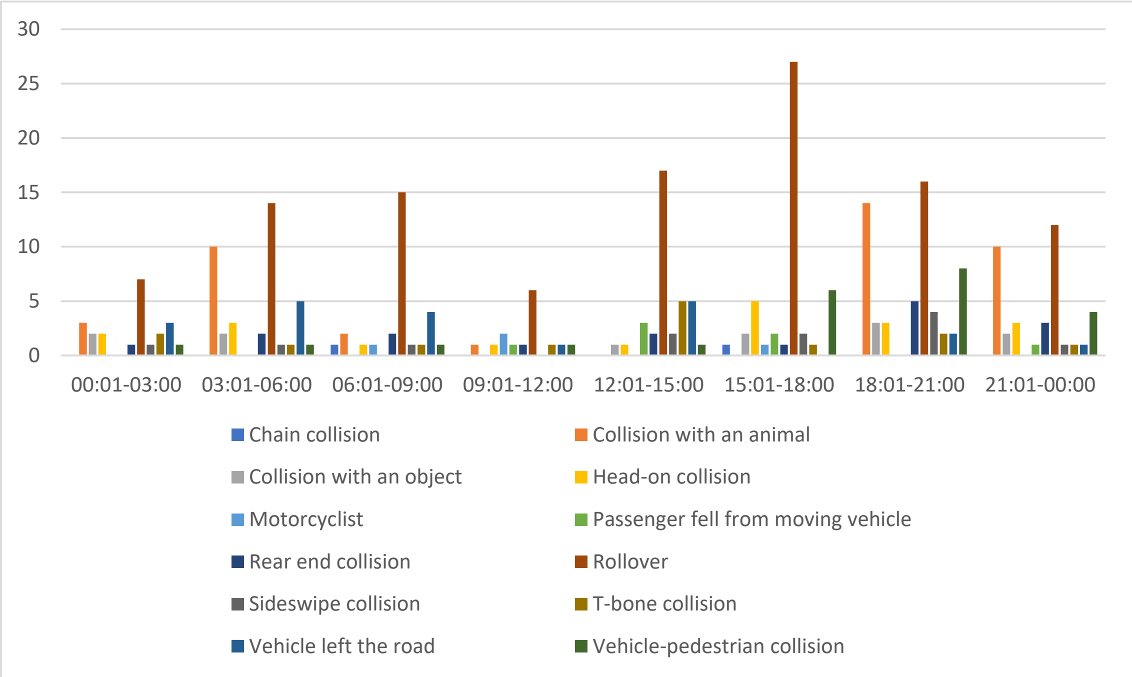

Figure ii: Time of accident vs Type of accident

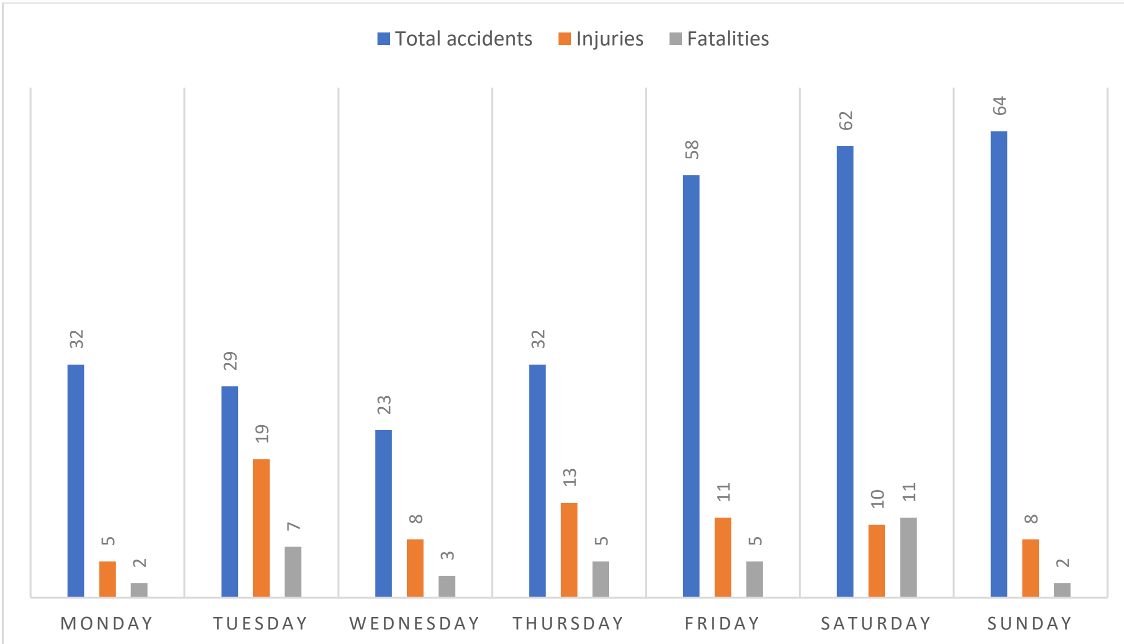

Figure iii: Number of accidents, injuries and fatalities and the day of the week

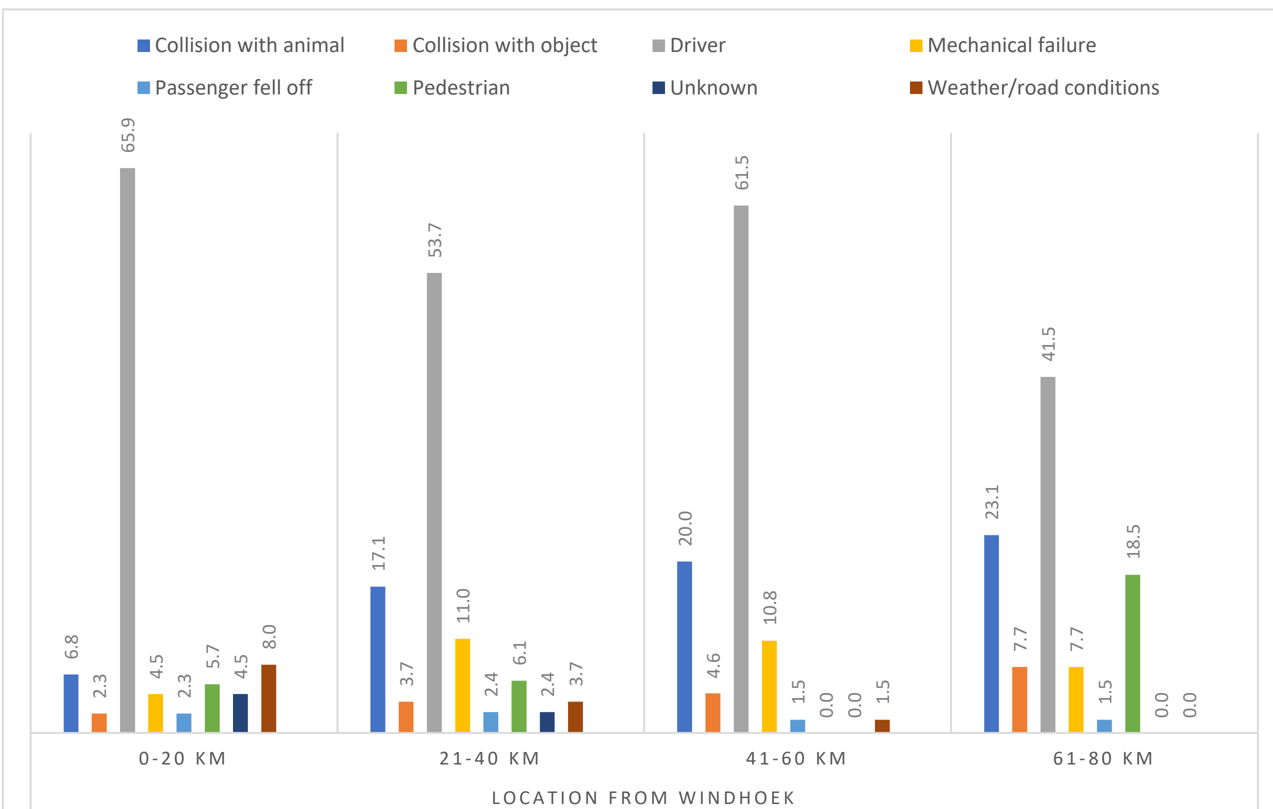

Figure iv: Location from Windhoek vs Cause of Accident (%)