An Analysis of Patterns and Trends of Road Traffic Injuries and Fatalities in Vhembe District, Limpopo Province, South Africa

By

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An Analysis of Patterns and Trends of Road Traffic Injuries and Fatalities in Vhembe District, Limpopo Province, South Africa.

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A Master's dissertation submitted to the Department of Geography and Geo-Information Sciences in the School of Environmental Sciences, University of Venda in partial fulfillment of the requirements for Masters of Environmental Sciences.

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Declaration

I Osidele Olujimi A. student number 11639645, hereby declare that the research dissertation titled **"An Analysis of Patterns and Trends of Road Traffic Injuries and Fatalities in Vhembe District, Limpopo Province, South Africa"** submitted for the degree, Masters of Environmental Sciences (MENVSC) at the University of Venda, is my own original work and has not been submitted previously by me for any degree at this or any other University. I further declare that all the sources that I have quoted and cited, are acknowledged and indicated by means of a comprehensive list of references.

Signature: …… Date: ……

Abstract

Road transport safety is challenging globally, especially in developing countries, where it affects both road users and governments. The aim of road traffic safety is to ensure a reduction or total eradication of road fatalities and other injuries that are related to road accidents resulting from public road usage. In South Africa, one of the major problems faced by the Department of Roads and Transport is the issue of road traffic accidents. Between 2004 and 2010 the annual road traffic accidents increased to over 500,000 and 28,000 or more are fatal, which has led to serious injuries, as reported by the Department.

This study analysed patterns and trends of road traffic injuries and fatalities in Vhembe District Municipality from January 2011 to August 2015. It also mapped road accident hotpots using Getis hotspot analysis and linear referencing in ArcGIS 10.2 spatial statistics extension. The research further established correlation between accidents spots and road design geometry. Factors that are responsible for road traffic accidents leading to fatalities, injuries, and loss of property were also examined. Pedestrian behavioural attitude towards adhering to road safety measures was studied using systematic random sampling, field observation and questionnaires. Finally, the study investigated if there has been any significant reduction in the road traffic injuries and fatalities occurrence rate within the last five years in Vhembe District since the commencement of World Health Organisation; Decade of Action for Road Safety 2011-2020. It was found out that most of the accidents occurred as a result of changes in human social behaviour, negligence and indulgence. The passenger road users category is the worst affected followed by drivers and pedestrians. It was found out that road crashes have decreased by 35% since the commencement of decade of action for road safety. The composition of road traffic injuries and fatalities since 2011 shows a reduction in the numbers of victims recorded. An average of 86 fatalities, 326 serious injuries and 701 minor injuries occurred per annum within the study period. There was high significant value ($p < 0.05$) among all the categories of road users understudied. The differences observed were real and did not occurred by chance for the 5year period (2011 – 2015).

Keywords: GIS; Road accident hotspots; Road design; Road fatalities; Road traffic injuries; Safety policy; Patterns and trends.

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Dedication

This dissertation is dedicated to my father, Pa Hector Abayomi Osidele, for his fatherly support in ensuring a good education for me. To my grandmother Mrs. Ayoola Luciana Osidele- Adesanya. To my mummy Mrs. Aderonke Adebimpe Bamgboye, Mrs. F.O. Bella, Mrs. A.A. Adeyemi and Mrs. M. Ashiru. To my daddy Mr. G.A. Ashiru and Alhaji Adeleke Adesanya. To all my siblings, cousins, nieces, nephews and friends.

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List of Abbreviations

DoT	Department of Roads and Transport
eNaTIS	Electronic National Traffic Information System
GIS	Geographical Information System
GPS	Global Position System
LDRT	Limpopo Department of Roads and Transport
RAF	Road Accident Fund
RTMC	Road Transport Management Corporation
SAPS	South Africa Police Service
UN	United Nations
VDM	Vhembe District Municipality
VDMTD	Vhembe District Municipality Traffic Department
WHO	World Health Organisation

CHAPTER ONE: INTRODUCTION

As part of the complexities of an evolving lifestyle, human beings are increasingly becoming mobile in their quest to fulfill numerous activities. Displacement or movement from origin to destination can be achieved through various modes of transportation, depending on the distance to be covered and costs associated with the resultant movement. Road transportation effects are positive on the economy, and negative on safety and the environment (Luoma & Sivak, 2011:30). The essence of road transport safety is to ensure that all vehicle accidents as related to deaths, loss of property, injuries and productive time distortion, are eliminated for vehicle crashes on all road networks. Road accidents and vehicle crashes contribute to problems encountered within the public health sector throughout the world. According to the World Health Organisation and United Nation reports on road safety, injuries due to road crashes are presently the ninth leading cause of death in the world (WHO, 2013). Recent projections indicate that road accidents will be the third leading cause of death by 2020 (see Table 1), unless there is a new commitment to prevention (Wei & Lovegrove, 2012:34; WHO 2010; UN 2007). This poses greater challenges because the population age bracket that is involved in most of these car accidents has been found to be productive youth in the prime of their lives. The World Health Organisation (2013) states that, over 1.24 million people are killed annually as a result of road accidents globally. The average road traffic related death rate among African region members is 24.1 deaths per 100,000 people, compared to 10.3 deaths per 100,000 people for European Region members (WHO, 2013).

South Africa is an emerging economy. Therefore, rapid growth in terms of industrialisation, economy and businesses is increasing. This translates into the gradual development of transport infrastructure at a much faster rate than the developed world, as well as increase in motor vehicle acquisition by the citizens. Road traffic collisions constitute both a social and economic burden on societies worldwide (WHO, 2013). It is often understood that most of the road collisions leading to high road safety figures can be associated with failures in at least one of the three road system components- driver, vehicle and road (Wei & Lovegrove, 2012:23). Road transport safety involves dealing with all issues of road externalities and adequate consideration of all vulnerable road users to get to their various destinations safely. Makomene (2008:4) citing Van Heerden *et.al.,* (1983), defines road safety as the “ideal state in which various elements (road signs, road education, side-walks, traffic regulation) of traffic control are integrated to ensure that all road users need not fear injury to themselves, damage to their property, unnecessary waste of their

time or unreasonable prosecution". The issue of road transport safety also forms part of the sustainability of transport in ensuring that community access roads are safe and all stakeholders as well as road users are actively concerned.

Table 1: Top ten global leading causes of death, disease or injury

2004	2020	2030
1. Ischaemic heart disease	1. Ischaemic heart disease	1. Ischaemic heart disease
2. Cerebrovascular disease	2. Unipolar Major Depression	2. Cerebrovascular disease
3. Lower respiratory infections	3. **Road traffic accidents/ injuries**	3. COPD
4. COPD	4. Cerebrovascular disease	4. Lower respiratory infections
5. Diarrhoeal diseases	5. COPD	5. **Road traffic accidents/ injuries**
6. HIV/ AIDS	6. Lower respiratory infections	6. Diabetes Mellitus
7. Tuberculosis	7. Tuberculosis	7.Trachea, bronchus, lung cancers
8.Trachea, bronchus, lung cancers	8. War	8. Perinatal conditions
9. **Road traffic accidents/ injuries**	9. Diarrhoeal diseases	9. Stomach cancer
10. Prematurity and low birth weight	10. HIV/ AIDS	10. HIV/ AIDS

Source: WHO, Global Burden of Disease 2004.

1.1 Background to the problem

The road safety problem magnitude has been a global focus for decades and more than 90% of road transport casualties have resulted from road traffic accidents. Road transportation is often regarded as the most dangerous means of movement, judging by the chances of an individual

dying on the road, which is about 2 in 20,000 every year. This figure is apparently 10 times greater than the risk of travelling by air and rail (Shavhani, 2007:35). Road design, traffic regulations, amongst others, are challenges that the transport sector faces in its quest to achieve sustainable road transport safety in most developing countries. Some countries, both developed and developing have regarded vehicles as murder weapons, making it possible to charge and prosecute drivers after car accidents and reckless driving (Choueiri, *et.al.,* 2010).

In its 2005 report, the World Health Organisation stated that nearly 3,400 people die on the world's roads every day and as many as 50 million people are injured or disabled by road traffic crashes every year. Half of all crash victims are vulnerable road users such as pedestrians, cyclists, and motorcyclists. Developing countries experience a high burden of road traffic injury. This accounts for 85% of annual deaths and 90% of the disability-adjusted life years (DALYs) lost due to road traffic injury (Choueiri, *et.al.,* 2010). The population of low-middle income countries constitute about 84% of the world's population and they are responsible for 94% of road traffic-related deaths with just over half of the world's registered vehicles (WHO, 2013). The increased death rates among low-middle income countries are associated at least in part, with rapid motorisation with a lack of concomitant road safety strategy implementation and safe road infrastructure development (Sebego, *et.al.,* 2014:35; Borowy, 2013:112; WHO, 2013). Road traffic injuries often affect males, constituting about 73% of deaths and those between 1 and 44 years old, creating enormous economic hardship resulting from loss of most family caretakers and breadwinners (Choueiri, *et. al.,* 2010).

Africa's roads have been earmarked as the deadliest in the world, even though the continent is the least of the motorised region in the world. Among the 6 regions of the world, Africa has 2% of the world's registered vehicles, yet the risk of dying as a result of a road traffic collision is highest at 24.1/100,000 population, surpassing the global rate of 18/100,000 population. According to a World Bank report, road traffic injuries cost about 1 to 2 percent of the gross national product of developing countries. This can also be evaluated to twice the total amount of development aid received worldwide by developing countries to fund development projects that will benefit and foster development in their countries (WHO, 2013; Choueiri, *et.al.,* 2010).

South Africa road safety records showed over 400,000 traffic accidents with 28,000 being fatal, or leading to serious injuries, making it 12.3 fatal accidents per 10,000 vehicles and total revenue loss of approximately 13 billion Rands annually. According to a Road Accident Fund 2014 press release, in the 2013/2014 financial year, 22.2 billion Rands was paid as claim expenditure to road

accident survivors and families of deceased road accident victims. The road accident fund raises concerns about reducing the frequency, severity and impact of accidents being the fund's highest priority, as the estimated cost of road crashes to South Africa's economy remains staggeringly high at 306 billion Rands per annum (RAF, 2014). The number of fatalities increased from 9,068 in 2000 to 14,993 in 2011 and fatal crashes per 100 Million Vehicle Kilometer (MVK) travelled increased from a low 6.20 in 2000 to 8.79 in 2011 (Shavhani, 2007:36, RTMC, 2011). Among other regional Southern African countries, South Africa road fatality rates are considered to be higher compared to countries such as Botswana and Zimbabwe with lower traffic death rates, owing to the role played by South Africa as the economic hub of the region (Luoma and Sivak, 2012). In 2007, the Department of Road and Transport reported that South Africa's traffic deaths were at 33.2 per 100,000 people and 56.78% were drivers/passengers of 4-wheeled vehicles, while 39.1% were pedestrians, 1.8% were drivers/passengers of motorised 2-wheelers and 2.3% cyclists. Road traffic injuries and fatalities involve approximately 41% of vulnerable road users and pedestrians (Department of Transport, SA, 2007). Therefore, road traffic injuries and fatalities in developing countries need to be taken seriously and to be regularly studied to ensure that efforts are made to reduce or eliminate the road deaths annually.

1.2 Problem statement

A 2013 World Health Organisation report on road safety 2013 entitled: Supporting a Decade of Action, in Geneva, Switzerland, shows that about 1.24 Million road traffic deaths occurred throughout the world in 2010, indicating a plateau since the 2003 report publication (WHO, 2013). Based on the outcome of the report, the United Nation General Assembly, through resolution 64/255 in 2010 declared the Decade of Action for Road Safety (2011-2020). The goal of the decade is to reduce the increasing trend in road traffic deaths, and save an estimated 5 Million lives over the period.

Road traffic safety in Africa is devastating when compared to other motorised countries in the world. Africa's road traffic injuries and deaths are mostly induced by speeding, jaywalking, reckless and negligent driving, unsafe overtaking, as well as drinking and driving (WHO, 2013). The number of registered vehicles in South Africa has increased relative to approximately 9.8 Million in 2010 from 7.4 Million in 2007, with over 8.7 Million being light vehicles (eNaTIS, SA, 2010). This relative increase in the numbers of registered vehicles within the country has increased the concerns for traffic safety. The Department of Roads and Transport, South Africa,

annually raised the concerns of increase in traffic accidents on a yearly basis. Approximately 468,000 traffic accidents have occurred annually, of which 31, 000 are fatal or have led to serious injuries. The annual traffic deaths on South African roads is approximately 10,000, with close to 46, 500 persons being seriously injured, resulting in many being permanently disabled (Department of Transport, SA, 2007). Furthermore, the Road Traffic Management Corporation (RTMC) from November 2011-March 2012 recorded a total of 5,511 fatalities which involved drivers, passengers and pedestrian on the country's roads (RTMC, 2012).

In Limpopo Province, there were approximately 352,906 registered vehicles in 2007, and over 321,845 were light vehicles. These increased to 486,619 in 2010 (eNaTIS, SA, 2010). The Limpopo Department of Road and Transport (2013) states that in the 2011/2012 fiscal year the province recorded a staggering 383 road traffic accidents which resulted in 75 fatalities. However, in 2012/2013 it recorded a decrease to 297 road traffic accidents, resulting in 71 fatalities (LDRT, 2013). In the Vhembe District Municipality, during the festive season of 2012/2013 a total of 196 road traffic accidents occurred, amongst those 20 involved pedestrians, 51 drivers and 115 passengers. As regards causalities, 5 lives were lost, 12 persons were slightly injured and 37 sustained critical injuries (Vhembe District Municipality, 2013). Even though the government organizes road safety campaigns such as Arrive Alive, issues traffic levies and fines, and arrests drivers for reckless driving, road traffic injuries and fatalities continue unabated.

Therefore, there is a need for an analysis of road traffic injuries and fatalities in Vhembe District, since the commencement of decade of action for road safety. This is to provide better understanding of the patterns and trends of road injuries and fatalities in the district. It is also important to find out the contributing factors associated with road injuries and fatalities. The use of geographical information system techniques in mapping road injury hotspot is equally of great importance to establish road accident spots and road geometry of such area. This will assist in identifying such accident hotspots and caution road users accordingly. The behavioural attitude of pedestrian and road users should also be evaluated in order to determine their level of compliance with road safety measures. Finally, understanding contributing factors to road traffic injuries and fatalities will assist and contribute to raising awareness amongst government agencies, road users, pedestrians and drivers on measures to take in the effort to promote and improve safety on Vhembe District roads.

1.3 Research Aim and Specific Objectives

1.3.1 Research Aim

The overall aim of the study was to analyse patterns and trends of road traffic injuries and fatalities in Vhembe District, Limpopo, South Africa.

1.3.2 Specific Objectives

The specific objectives of the study were geared towards achieving the following:

- Examine the composition of road traffic injuries and fatalities resulting from motor vehicles in Vhembe District Municipality from 2011 to 2015;
- Examine the contributing factors associated with the road traffic injuries patterns and trends;
- Identify and map road traffic injuries and fatalities hotspots within Vhembe District Municipality using GIS techniques; and
- Evaluate the behavioural attitudes of road users in complying with pedestrian road safety prevention measures.

1.4 Research Questions

In order to address the above objectives, the following research questions were suggested:

- What is the composition of road traffic injuries and fatalities in Vhembe District from 2011 to 2015?
- What are the factors that road traffic injuries and fatalities are responding to in terms of changes in the patterns and trends?
- How can GIS techniques be used to identify and map road traffic injuries and fatalities hotspots?
- What are the behavioural attitudes of road users in complying with existing road safety prevention measures?

1.5 Justification of the study

Transportation often evolves in response to changes emanating from economic growth and social connectivity between settlements and communities over time (Van Wyk, 2010:17). Transport systems generate routes and networks which then become integrated into communities' access path to harness and exploit diverse opportunities provided in respect to the network systems and transportation routes. Transportation links, system and network need to be provided and managed carefully to ensure their existence in continually generating the social development and economic growth of communities. Moreover, transport is regarded as a derived demand, which normally is not an end in itself, but a means to more interconnected ends (Chakwizira, 2010:117).

The evolving road transportation network and systems has contributed in forming community access roads. These roads provide integrated support and accessibility to people in order to satisfactorily gain access to various activities. The key issue will then be; how safe are the roads people are using in accessing vital services? Are the roads environmentally sustainable for the future safety of road users? Is there any correlation between road design and accident hotspots? All road networks and transport systems exist and co-habit with humans in the society within the community environment. Therefore, ensuring that roads are safe, free of carnages, injuries and fatalities are a concern to all stakeholders and road users.

The essence of road transport safety is to ensure that all vehicle accidents as related to deaths, injuries and fatalities, loss of property and productive time distortion, are limited from vehicle crashes on all road networks. Road accidents and vehicle crashes contribute immensely to problems encountered within the public health sector in the world. A 2014 WHO report states that the mandatory use of child restraints can reduce child deaths from road traffic accidents globally by 40%, and helmet usage, reduces fatal and serious head injuries by over 70%. Also, enforcing a drinking and driving law around the world could reduce alcohol-related crashes by 20% and for every 5% cut in average speed, there is possibility of as much as 30% reduction in the number of road crashes globally.

According to a Limpopo Department of Roads and Transport (LDRT) 2013 press release, human factor was identified as the main cause of fatalities on the provincial roads. Reckless, insensitive and negligent behaviour were responsible for LDRT not meeting its target of reducing road crashes by 25% in the 2012/2013 fiscal year, even though the Department tried their best to ensure there was a carnage-free festive season. Every year the Vhembe District Municipality partners with all four local Municipalities within the district in establishing joint operational centres

around Vhembe District for Arrive Alive campaigns during the festive season. These are to ensure that people are well-behaved and sober to achieve an annual reduction in road crashes. Even though it has been anticipated that road traffic crash fatalities will increase to 80% between 2000 and 2020, if necessary, safety measures and well-enforced traffic laws are put into place, then the crash rate trends can be reversed.

The population size of the Vhembe District Municipality also played a role to the motivation for this study to be carried out. The majority of vulnerable road users affected by traffic crashes are from less privileged/ poor, creating an economic burden on both their families and government at large. Public transport is not regarded as safe because it does not enforce the use of safety belts and sometimes passengers are overloaded. This study sheds light on the contributing factors that result in road traffic accidents and related injuries in the public transport sector. The study further looked into the compliance levels of the public transport drivers to the operational safety measures to get passengers to their destinations safely. This is necessary because public transportation is the most common used means of movement in the Vhembe District Municipality.

1.6 Delimitation of the study and description of the study area

1.6.1 Delimitation of the Study

This study analysed road traffic injuries and fatalities within the Vhembe District from January 2011 to August 2015. The studied period was influenced by the available data from Limpopo Department of Roads and Transport. The composition of road accident report data for the District was used as presented in the report. Factors that influenced and contributed to road accidents were studied as well. In addition, road traffic injury hotspots within the study area were covered and identified together with behavioural attitude of pedestrian on road safety compliance. The literature review focused on a critical assessment of key concepts and theories that surround the issue of road traffic injury. Nodal towns along the major roads within the district formed transect points of the research sample frame. Other challenges relating to soil, water, climate and vegetation within the district were not covered in this research.

1.6.2 Description of the Study Area

- **Historical background of the study area**

The study area was Vhembe District Municipality which is a Category C Municipality as determined in terms of section 4 of the Local Government Municipal Structures Act (Act 117 of 1998). The district was established in 2000 with a Mayoral executive system contemplated in section 3 (b) of the Northern Province determination of types of Municipality Act, 2000. It is one of the five districts of Limpopo Province of South Africa. It is the northernmost district of the country and shares its northern border with Beitbridge district in Matabeleland, South of Zimbabwe and Capricorn District to the southern part of Limpopo Province. The Kruger National Park forms the boundary in the northeast while sharing border with Mopani District in the southeast and Botswana in the southwest (Vhembe District Municipality, 2013). The district has four local municipalities namely: Makhado, Thulamela, Musina and Mutale. Figure 1 shows the study area locational site in context to the Province and Country.

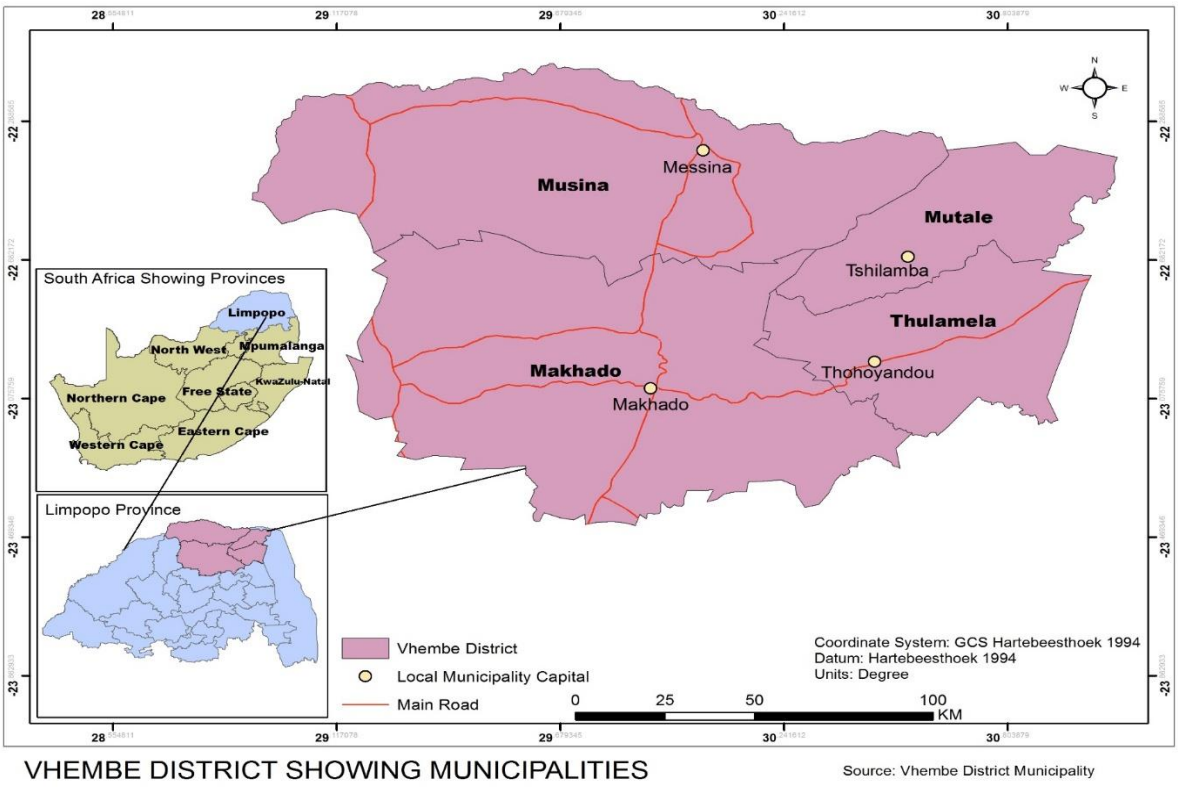


Figure 1: Location and description of Vhembe District Municipality

The District Municipal code for Vhembe District Municipality is DC 34. Major towns within Vhembe District Municipality includes: Thohoyandou, Messina, Makhado, and Malamulele. The District covers a vast track area of land, mainly tribal and agricultural. The capital town is Thohoyandou, serving as its political, administrative and commercial centre. The District lies between 22.9333° S and 30.4667° E with an altitude of 1206 meters above sea level (VDM, 2013)

- **Physical characteristics of the study area**

Vhembe District Municipality is characterized by a variety of highlands to the South West and North West area which forms part of the Southpansberg mountain extension range. The Southern area of the District consist of gently undulating plain suitable for farming activities due to its soil nutrient enrichment. Limpopo River is the prominent river within the district and there are other several perennial streams within the Luvuvhu River catchments, such as Mvudi, Dzindi and Luthada Rivers. The District soil geology is characterized by weakly structured gneiss and basalt rock formation structured with low to medium base status comprising of mesotrophic red soil and yellow colours. The dominant vegetation is of indigenous coniferous forest which include Combretum Apiculatim, and Dichrostatchys Cinerea. There are presence of shrubs and sub-tropical trees including various kinds of grasses in the plain area of the district.

- **Climate of the study area**

Vhembe District Municipality lies within the subtropical climatic region of Northern part of South Africa. It is characterized by hot summer months with high temperature and humidity during summer and cool mild dry windy weather in winter period. The temperature is relatively warm throughout the year ranging from 16 °C to 44 °C. Annual average precipitation is about 372mm and rainfall cycles during summer period starts from September extending to March.

The weather often becomes windy during summer period resulting in the spread of wildfires in some part of the District (VDM, 2013).

- **Demography of the study area**

The total population of Vhembe District Municipality is 1,294,722 with a total number of 335,276 households and total land area of 25,597.42km^2 (SA Census, 2011). The population age structure under 15 years old is 34.90%, 58.90% falls under 15 to 64 years and population over 65 year is 6.305 (SA Census, 2011). The ethnicity consists of different cultural group such as Vendas, Pedis,

Tsongas and Indians, with a relatively low community of foreigners. The population distribution of the four municipalities in the district is presented in Table 2.

Table 2: Demographic Composition of Vhembe District Municipality

VDM Municipalities	**Population (Census, 2011)**	**Households (Census, 2011)**	**Area in (km^2)**
Thulamela	618 462	156 594	5 834
Makhado	516 031	134 889	8 300
Mutale	91 870	23 751	3 886
Musina	68 359	20 042	7 577
Total	**1 294 722**	**335 276**	**25 597**

Source: Statistics SA Census, 2011

- **Socio- Economy of the study area**

The main economic sectors of Vhembe District Municipality are mining, agriculture, tourism, community services and finance. The labour market's unemployment official rate is 38.70%, and youth unemployment rate (15-34 years) is 50.60%, making the larger population to rely solely on government grants. The fertile soil, sacred and cultural areas supported by warm climate throughout the year within the district play vital role in the agricultural activities suitable for livestock farming, cash crop and fruit crop cultivation in the area. This makes the key driver of the district growth to be agriculture and tourism forming it core economy. There are many tourist destination within the district, which contribute to heavy flow of traffic during festive and holiday season. The tourist destinations include; Thate Vondo, Tshatshingo Potholes, Phiphidi and Mukumbani Waterfalls, Mphaphuli Cycad Reserve, Lwamonde Hill, Thohoyandou Arts Centre Nandoni Dam, and Tshipise Springs (VDM, 2013)

- **Land uses of the study area**

The district land use is characterized by residential areas, commercial areas, educational areas, recreational areas, forest reverse areas, governmental institutions area and hospitality areas. The different land uses contribute to the development of the district and provision of services such as water, electricity and proper sanitation attracts rural dwellers to move in search of employment to

nodal towns within the district. In particular they relocate to capital towns of the four local municipalities (VDM, 2013).

- **Transportation and Road networks of the study area**

The length of the national road (N1) within the district is 150 kilometres of surfaced road, while that of the total District roads is 3,963 kilometers. A total length of about 1,477.25 kilometers is surfaced/tarred road while 2,486 kilometers are gravel roads. Transport corridors found in the district are R521 from Musina to Makhado, R523 within Makhado linking the N1 to Musina, R524 from Makhado to Phunda Maria to Mozambique, R529 from Basani to Moeketsi, Thohoyandou to Masisi then to Phafuri Gate, from N1 T-junction to Elim then to Vuwani to Malamulele to Altein to Shangoni Gate and R572 linking R521 to the west and N1 to east with Musina (VDM, 2013). Table 3 and Figure 2 shows the primary road network distribution in Vhembe District Municipality

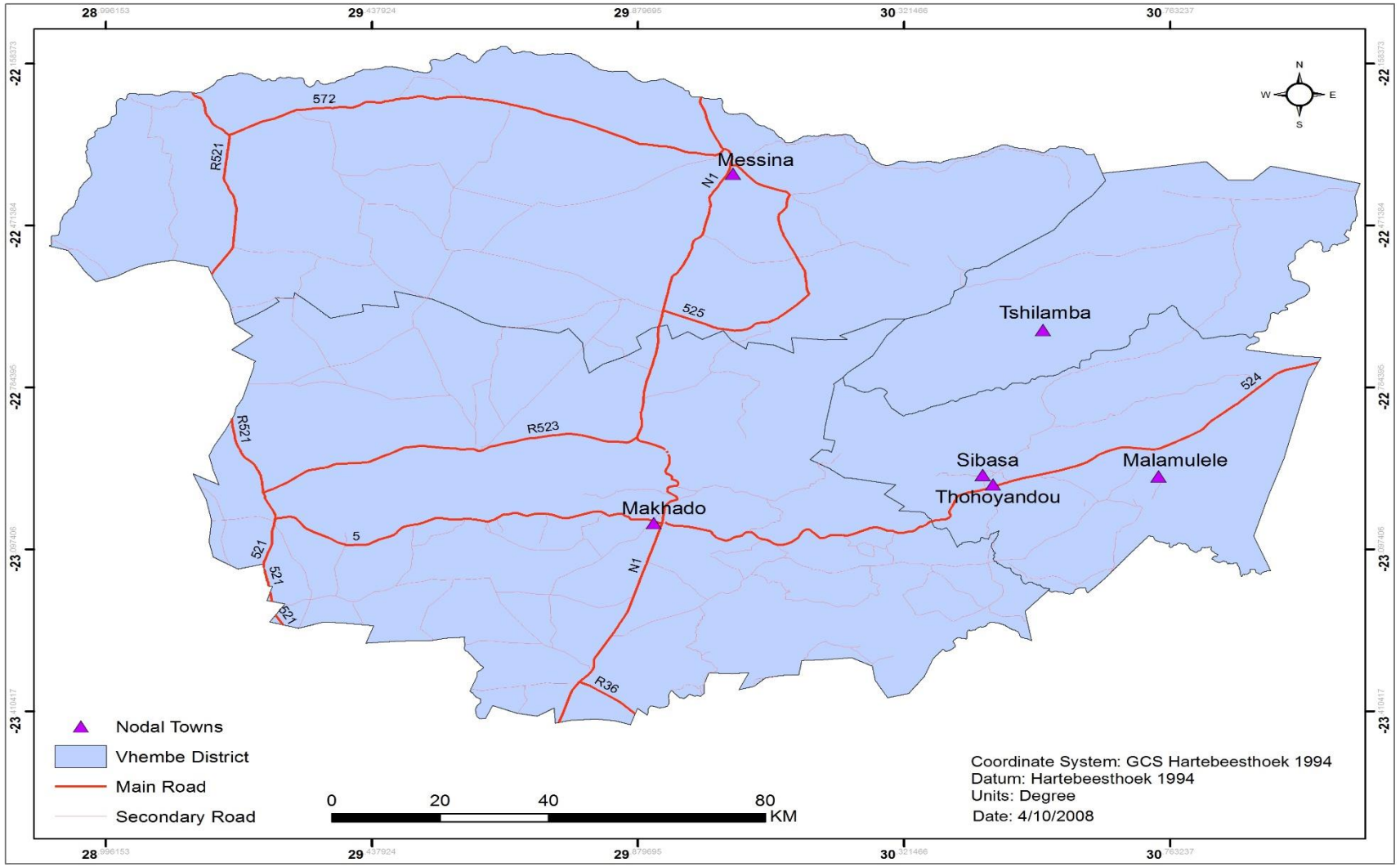
Public transportation comprising of taxis and buses is the dominant means of transport within the district. There about 3000 taxis and 300 buses used in the daily operation of commuting people from different part of the district (Vhembe Bus Association, 2011). The majority of the population rely solely on public transport for their daily use, while few minority use their private vehicle as their daily means of transport.

Road network within the district are of four categories namely; arterial roads, link roads, collector roads and gravel roads. Arterial roads are of moderate to high capacity road which is of highway level of services, e.g. N1, R523 and R524. Links roads are linkages between main roads and street routes, e.g. Mphephu road. Collector roads are mostly street corridor routes between buildings serving as passage from block to block. Gravel roads are within hinterlands.

Table 3: Vhembe District Municipality Primary Road Network

Road Number	Route Number	From	To	Length (km)	Public Transport Passengers (a.m. peak)
N1	N1	S. Border	N. Border	153	
R523	R523	W. Border	N1	67	
P98/1	R524	N1	D3653	130.3	1500 - 69800
P98/2	R522	N1	D3715	31.7	700 - 13500
D3715		P98/2	D959	25.6	900 - 5500
D2554		N1	D959	3.4	2000
P99/1	R578	N1	S. Border	60.4	3700 - 33000
P278/1	R523	N1	P277/1	62.9	6000 - 25300
D3681		P278/1	P277/1	9.3	9600
D9		D3636	P98/1	26.9	6300 - 19200
D3708		P277/1	P98/1	22	2800 - 5300
P277/1		P98/1	D3695	28.3	11200- 55500
D959		D3715	D3918	11	3450 – 9500
D3695		P277/1	D3689	5.2	8600
D3688		P277/1	END	14.5	16500

Source: Limpopo Department of Road and Transport Vhembe District Municipality, 2015.



VHEMBE DISRTICT ROAD NETWORK

Source: Vhembe District Municipality

Figure 2: Major transportation networks within Vhembe District Municipality

1.7 Limitations to the study

Some of the limitations encountered during the research were availability and reliability of the road accident reports from Limpopo Department of Road and Transport. Challenges were also faced in getting reports on road traffic injuries and fatalities from the Road Traffic Management Corporation, as much of the report were either not properly captured or recorded in the archive of Limpopo Department of Road and Transport. The researcher wanted to explore more outcomes from the study by comparing a five year period of road traffic injuries and fatalities within the study area before and after the UN road safety decade of action declaration in 2010. Due to the available data, the research only focused on the patterns and trends analysis of road traffic injuries and fatalities in Vhembe District Municipality after the UN commencement of action decade for road safety (2011-2020).

It is also paramount to mention that inadequate coordinate's location and description of road accidents sites was a limitation to this study, as the researcher had to travel throughout the District roads to achieve accurate GPS coordinate of the various road accidents locations. It was also gathered during road survey of the study area that not all road accidents were reported, as some road users decided to settle without reporting to the Traffic Department and Police Service. This usually occurs in most minor injuries cases of road traffic injuries. There were limitations in terms of the characteristics composition of age and gender to determine which of the age group is more involved in road traffic injuries and fatalities. This affected in-depth composition analysis of this research. There was limitations experiences in recapturing data from road accident report obtained from the database of the Limpopo Department of Road and Transport. This limitation was as a result of improper data capturing by personnel of the LDRT leading to non-credibility of data obtained for whoever access such reports for research purposes.

1.8 Operational Definitions

Road Fatalities:

Road fatalities are deaths caused/ resulted from road accidents/ car crashes. It can also be described as death occurring from injuries sustained from an automobile / vehicle collision on the road. Not all injuries lead to death, and as such only deaths from road traffic injuries can be categorized as fatal (Adebayo, 2015).

Road Traffic Injuries:

Injuries are not accidents, even though they are used interchangeably. Often time injuries can be self-induced with intention to experience pain by engaging in dangerous and rebellious activities. However, some injuries do occur without intention of self-inflected pain activities. Road traffic injuries occur for identifiable reasons, some are a result of factors relating to the built environment. Road injuries are a major cause of death, disability, and suffering, and therefore a leading public health priority (Sleet, *et.al.,* 2010:35*).* Most injuries are preventable through prevention strategies that modify the environment to reduce risk and increase safety amongst all road users.

Road Accidents Hotspots:

An accident is an unexpected event that occurs by chance, implying that the event could not have been influenced or controlled. Road accidents occur as a result of a combination of both predictable and unpredictable traffic external factors. Predictable factors include alcohol impaired driving and unpredictable, such as natural environmental landscape. Hotspots are high incident occurrence locations (Schuurman, *et.al.,* 2009:7). Road accident hotspots are locations where car crashes and pedestrian injuries frequently occur within a geographical area.

Road Design:

Road design signifies the transportation network and connectivity of a geographical area. This is often influenced by environmental risk factors that are identified by planners, engineers, architects, and policy makers. The built environmental design changes can prevent road injuries and well- planned, implemented road designs during initial construction are usually less costly than interventions retrofitted to correct problems later (Schuurman, *et.al.,* 2009:5).

Safety Policies:

Road safety policies are guidelines, strategies, laws and rules that govern all road users in ensuring that they get to their various final destinations safe without any injury. Prevention of road traffic crashes is often most effectively achieved through implementation of evidence-based policies. Most of the safety policies are gazetted by acts and laws, and offenders are liable to prosecution by law (Skyttner, 2005; Komba, 2006).

Patterns and Trends:

As defined by Oxford English dictionary (2010), a pattern is a particular way in which something is done, organised or happens be it on a regular repeatedly arrangement. On the other hand, a trend is a general development or change in a situation of occurrence. Road traffic injuries patterns and trends tend to look into the nature of occurrence of road crashes and possibly future projection (Oppong, 2012).

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The act of reviewing relevant literature in a research is necessary as much as conducting the entire research. This is because the reviewed literature comprises of related researches done in the same knowledge areas closely related field of study and they are reviewed in an analytical manner. In light of this, relevant literature focusing on road transport planning, road traffic injuries, road traffic accident, epidemiology of road traffic death/ mortality, traffic safety, road design and accident spots, were reviewed in this section. The review focused on various books, peer-reviewed journals, periodicals, reports and editorials from government departments, agencies and non-governmental organizational bodies. In addition, efforts were made to look into different views of the authors as they contribute to different themes of traffic safety studies from an international, regional and local perspectives. The findings and recommendations of the previous studies were summarized under related themes.

2.2 Road Traffic Injury Theory and Concept

This study looked into the bodies of theories related to road traffic injuries and fatalities. Emphasis was on system theory, road-user approach and GIS application on road traffic management. The concept of geographical spatial analysis regarding spatial variation, time factor and spatial distribution and demographic composition of road traffic accidents were considered. The reason for using these concepts and approaches is because they were relevant in the stating of research problem statements. They were also good guidance in choosing the research methodology.

2.2.1 System Theory and Safety Concept

The system theory approach can be traced and dated back to the 1930's and 1940's. It started as a response to tackling limitations in availability of classical analysis techniques in traditional scientific approaches to explain social, socio-technical and biological phenomenon (Skyttner, 2005; Komba, 2006). An important aspect of the systems theory concept is the emergence and interaction of various independent parts. When they stop being independent and start to influence each other in correlation to their existing relationships and social engagement (Skyttner, 2005; Larrson, 2007). It was further argued that relationships between the components of a system is a

function of the nature of the components themselves that determines the properties and behaviour characteristics. This was in conformity with Hollnagel (2004), who argues that road accidents occur when components of a system interact with each other and these interactions cannot be foreseen, because of their complexity (Hollnagel, 2004; Larrson, 2007).

System theory is an integral part of safety as it relates to different complex socio-technical systems in the society. As concluded by Larrson (2007), the road transport system is such a system and for that reason system theory is applicable to it from a safety point of view. In the same vein, Salmon, et. al. (2006) stated that a system perspective-based model in the road transport domain could lead to a greater understanding of the latent conditions and road error within the road transport system. This in turn could inform the development of strategies designed to promote error tolerance within the road transport domain. The environment as a system comprises of natural components, the built environments and transportation networks, which should be studied as an integrated system. This is the same manner in which the behavioural components of humans comprises of demographic characteristics of road users; age, sex, education, socio-economic status, stage in the life cycle, people's perceptions of risk and people's general behaviour on the street are studied (Komba, 2006).

Road traffic accidents result from various causes characterised by elements of a system. In a study carried out by Oppong (2012) on Ghana accident road networks, he found out that most causes of road traffic accidents resulted from influences on society factors by the middle age class. Such factors include negligence when driving, including not making use of car safety belt designed to reduce the level of impact in an event of car accident. His findings were similar to those of the Ghana National Road Safety Commission which identified over twenty factors causing road traffic accidents in Ghana. Some of these factors include boredom, lack of proper judgement of drivers, distractions, over speeding, inadequate experience, carelessness, wrong overtaking, recklessness, intoxication, machine failure, slippery road surface, road surface defect, level crossing and obstruction, and dazzling or defective car head light. When considering all these factors, they can be related to system with different components in different aspect that contribute to a whole integral part. This was further alluded to in a study by Adebayo (2015) who pointed out that poor visibility and poor vision by drivers play a major role in road traffic accidents. He recommended proper sight examination to be well-carried-out by issuing government authority responsible for individual driver's licenses.

A report published by road safety authority of Cambodia in 2007, established all key factors which work as a system responsible for road traffic accidents as human induced factors via-vis road users, environmental external factors and vehicular factors all take part in road accidents. There was a finding of fifty percent increase in Cambodia road fatalities rate over a period of five years and in order to reduce the occurrence a road accident safety committee was set up, together with well-established accident data system, accident evaluation policy and good driver training measures were put in place (Oppong, 2012; Ung Chun, 2007).

In some African societies, beliefs such as witchcraft are sometimes associated with road traffic injuries and fatalities. Okyere (2006) pointed out in his study on causal effect of road accidents in Ghana that some respondents believe that evil forces are behind road accidents. He further explained that some fraction of the country population believed that witches, wizards and other spiritual forces brings about road accidents when they are in need of human blood for spiritual activities in the underground world. However, he narrated that same people also alluded to poor government policies as one of the major contributors of road accident in the country (Oppong, 2012).

Government officials in the authorities responsible for road and transport are often accused of having contributed to factors causing road traffic accidents through corruption. Typically, in sub-Sahara Africa, bribery and corruption as perpetuated by officials by not following proper training guidelines before issuing drivers licenses contribute to factors responsible for road traffic injuries and fatalities. In a report by Arrive Alive South Africa close to 500 million rands were used annually to combat fraud, bribery and corruption in different agencies related to roads and transport administration in the country (Arrive Alive SA, no date).

2.2.2 GIS Application on Road Traffic Accident

Geographic information system is a powerful tool that has been used in the analysis of road traffic injuries data interpretation. There have been different studies which focus on the issue of road traffic safety analysis using GIS techniques. This is made possible because road accidents statistical data; such as accident crash location coordinates, number of crashes and road geographic data can be meaningfully used for road traffic accident spatial analysis. GIS techniques can also assist in the mapping of accident hotspots and further establish any correlation between road geometry and accident's location. It can further assist in identifying

factors that are associated with road traffic injuries and fatalities when data attributes are being looked into and cross-normalized in GIS software.

Some of the potential uses of GIS were presented in Lai and Chan's (2004) study in analysing road accidents in Hong Kong. They used various points-pattern techniques and were able to observe and reveal distinctive distributional patterns of hidden behaviour of accident data. Another study by Ziari and Khabiri (2005) presented the development and findings of Iran car crashes data from the police accident reports using GIS. They were able to develop a tool that generates a contour map in identifying areas of high crash occurrence determined by crash density and clusters of crashes involving pedestrians and cyclists. A spatial kernel density estimation method in GIS was used by Jang *et.al.,* (2013) to measure the concentrated density of pedestrian crashes. Prasannakumar *et.al.,* (2011) carried out a study in a South Indian city using hot-spot analysis in GIS to evaluate and map road accident hotspots within the city. Another study, conducted in Delhi, India by Rankavat and Tiwari (2013) used GIS techniques to identify pedestrian accident-prone areas, pedestrian accident-prone roads which had clusters of accidents and vehicular factors were involved in the road accidents.

Molla *et.al* (2014) investigated geostatistical approach of traffic crash data using ordinary kriging and clustering analysis to detect traffic accident hotspots clusters in North Dakota. They found that GIS techniques were very useful in discovering significant facts and features yielding critical threshold zones for higher accident prone areas in North Dakota state. They established that much can be done using GIS techniques to analyse different aspects of traffic accident reports, depending of the statistical data available as inputs in the attribute field. They generated different maps showing different attributes on the road network in North Dakota.

Spatial display of road traffic injuries can be directly added if the exact geographic coordinates in respect to XY points (latitude and longitude) are known, by using GPS during road accident report data collection. It contributes to how accurate the locational analysis of such road accident will be when applying GIS techniques to understand possible contributing factors to the crash. Various researchers have used network extension tools in ArcGIS such as clustering analysis to display crash locations on digital map which can easily be interpreted at a glance. Identifying road traffic accident hotspot is vital to establishing effective road safety management (Moon *et.al*, 2009). This statement conforms with a study carried out by Anderson (2009) who reiterated that traffic hot spot identification should be the start off point for proper road safety management identification and implementation (Anderson, 2009; Molla *et.al*, 2014).

Spatial integration of road traffic accident data from different sources can also be linked together with the use of GIS to further understand the correlation of crash data and traffic data, such as road survey, speed limit, vehicle survey, traffic volume. Researchers have also alluded to the usefulness of GIS in analysing road traffic injuries even when GIS is not the centre focus of such a study in many parts of the world (Li, 2006). Specific spatial queries can be done using GIS to limit selected contributing factor analysis in understanding road traffic accident patterns, such as the time of day which has the highest accident rate and the date of the month that has the lowest accident rate.

2.3 Road Transport Planning and Strategy

Transport planning long-term objectives include the creation of fundamental changes that will contribute to the safety, mobility of vehicles and vulnerable road users. To achieve this, measures will require a framework that will take the various needs of vulnerable road users into consideration. Transport infrastructure, administration and planning continue to expand rapidly among developing and low-income countries to meet people's expectations and commercial and industrial needs. Proper planning framework concepts should outline road fatalities avoidance and the probability of a drastic reduction of motor crashes by means of infrastructure design. In cases where crashes do occur, the process which determines the severity of these crashes should be influenced in such a manner that the possibility of severe injury is virtually eliminated (Quigley *et.al.,* 2012; Safety Net Consortium, 2009). The Department and Transport authorities are bestowed with the responsibilities of ensuring the implementation of planning framework as agreed by governmental process relating to the development of road scheme both in urban and rural area.

Quigley *et.al.,* (2012) in their review of transport planning guidance in Europe, identify the main consequences of the necessary frameworks and new concepts for road planning and design as follows:

- Motorised traffic with a flow or distribution function must be segregated from non-motorised traffic;
- A network of the main traffic routes must be created for pedestrians and cyclists;
- A fair balance between motorised and non-motorised traffic for priority at crossings should be achieved;

- The maximum speed of motorised traffic should be limited on roads where it mixes with non-motorised traffic and road intersection.

There have been studies seeking to identify the best practice for transport planning and providing recommendations that take into consideration all road users' prioritised safety. The transport planning best practice principles that have been adopted in Europe following numerous studies, as stated by Quigley *et.al.,* (2012), are as follows:

- Ensure the relevant stakeholders are involved in the planning process and an effective level of participation is determined;
- Ensure that the principles which consider vulnerable road users' safety as a priority are taken into account during the planning process;
- Ensure that a well-defined step by step planning process is used to develop the plan and that each step is considered.

Road planning strategy and process involve rules based on the technicality of the environment as deemed fit by road engineers. At some stage in the planning of a road or road system, it will be necessary to carry out traffic studies to estimate the volume(s) of traffic that will have to be considered in design years, as well as to satisfy statutory obligations relating to noise (O'Flaherty, 2006:29). Technical know-how of road design engineers, acquired through experience, can influence the professional design layout of roads. The network design, and distribution of roads has adverse effects on road safety. Literally road planning that seems adequate on paper might not necessarily conform to the safety correlation of the environment. Road planning, implementation should be finalised after careful consideration of the surrounding environment scenery and future prediction of growth in terms of population and economy, as this will influence the increase of vehicle mobility.

2.4 Road Design Impact on Road Traffic Accident

The acceptance of a particular road design requires the consideration of traffic data for economic and environmental assessment in relation to the justification, scale and location of road scheme alternatives (O'Flaherty, 2006:29). A road design component involves using traffic volumes which are both derived from measurements of current traffic and estimates of future traffic. This is to ensure that the present road design will cater for a specific future period, which can be 10-15 years or more. There is a possibility that 10-15 years can elapse before a new road scheme is open to full utilisation by traffic, therefore a current road design should take up to 30 years into

the future. The increasing of time will affect the credibility of road design due to the prediction that was involved in the future generation of usage.

O'Flaherty (2006), identifies the basic constituents of the design volume for an individual road to be the following; current traffic, reassigned traffic, redistributed traffic, normal traffic and generated traffic. He explained that all these constituents should be adequately and thoroughly evaluated when designing a new/improved road, even though these data can be complex in urban areas. Despite all the careful considerations regarding constituents of road design, some studies reveal the corresponding effect of road design and site characteristics of road traffic crashes and injuries. Shawky *et.al.,* (2014:32) investigated the impact of road and site characteristics on the crash-injury severity of pedestrian crashes in Abu-Dhabi, UAE and found that road width has a significant effect on road injuries and fatalities. They pointed out that, the risk of severe road traffic injuries and fatalities increase with increasing number of road lanes at the expense of the slight and medium road traffic injuries. In the same light, Zegger *et.al.,* (2002) in their study revealed that road traffic crashes on two-lane road did not significantly differ from collision occurring at marked and unmarked crosswalks, but did on multi-lane roads. They recorded that there was evidence of more fatal crashes at marked crosswalks compared to unmarked crosswalks.

Vasconcellos (2005), in his research findings submitted that often transport planners and traffic engineers are not responsible for road traffic crashes because planners and engineers have no formal obligation to be responsible for the traffic safety consequences of their acts as transportation planners. Thus, Harwood *et.al.,* (2008) in their findings established that some pedestrian crashes occur from geometric road design attributes. It was further highlighted that after controlling pedestrian and traffic volumes, the number of lanes and the presence of raised medians had significant effects on collision frequency.

Road design condition mostly corresponds with road traffic crashes in developing countries. Different studies in the late 1990 identified road environmental circumstances as one of the important causal factors for road traffic accidents. Peltzer & Mashego, (2003:31) highlighted that causes of road traffic crashes involving the interaction of pre-crash factors that include road environment geometry and poor road design. Clifton *et.al.,* (2009:428) studied the severity of road traffic injuries resulting from pedestrian-vehicle crashes and reported that the built environment which connotes road design among others has a significant influence on pedestrian crashes, with emphases on micro-scale design features such as the design of intersection, presence of crosswalk and transit access.

Improvements of existing road design have contributed to the reduction of road traffic crashes and injuries, more especially in developed countries. In a study conducted in Alameda County, California by Schneider *et.al.,* (2010:43), they found that raising road medians on both intersecting streets was significantly associated with a reduction of road traffic crashes and lower numbers of pedestrian crashes. Also Davies, (2000) in his report on the United Kingdom Implementation, of Pedestrian Safety Facilities found that an increase in extensions of pedestrian safety crossing width in Nottingham by 2.5m into the street and including substantial lengths of guardrail for further safety measures, had a significant influence on pedestrian safety records. The effect of this extension was noticed in the reduction on average of pedestrian crashes from 4.7 to 1 per year after the treatment and the new road scheme was opened for usage.

2.5 Road Safety Policy Perspective

Many studies have established in their literature regarding road traffic crashes, accidents and injuries, multi-factorial causes, and it involves the interaction of a number of pre-crash factors that include people, vehicles and the road environment (Peltzer & Mashego, 2003:30). However, safety policy rules and regulations are meant to reduce road traffic crashes and accidents when they are enforced and strictly adhered to by all road transport stakeholders and users. Safety policies are established by regulating government departments, agencies and transport regulatory bodies by act and government gazette, ensuring that offenders and violators are prosecuted and punishable under the law.

According to the United Nations, traditionally, road safety policies aim to reduce the likelihood of a crash by improving road infrastructure, by educating road users, and to reduce the severity of crashes by improving vehicle technology and enforcing seatbelt and helmet laws. Different countries have road safety laws which are binding to drivers and road users within their country(s). The “South African Road Traffic Act” provides guidelines for road users, drivers and pedestrian. The effective monitoring of road safety will require increases in traffic law enforcement and related research capacity (Hyder and Vecino-Ortiz, 2014:425). Some road safety regulations embedded in the South African Road Traffic Act includes:

- Speed limit: all drivers must strictly adhere to speed limit and speed zones regulation at all times;
- Traffic signals: should meet all the requirements of volume 3 of the South African Road Traffic Signs Manual (SARTSM) and must be obeyed by all road users at all times;

- Keep left, pass right: this should be the appropriate direction and position of overtaking on highways;
- Respect other road users and allow the right of way to pedestrians crossing at zebra crossing points;
- All drivers must adhere to vehicular capacity and should not overload above the regulated and standard weight capacity of the vehicle at all times.

2.6 Conceptual framework

A conceptual framework can be described as a tool that aids thinking and executing any given task or research. It outlines the underlying methodologies, principles and rationale for a particular concept or project. It is known that a good conceptual framework tends to be simple and shows what is important. It should inspire the researcher to take actions that will address complex and challenging issues. With respect to the above explanation, the conceptual framework for this study will be to consider a model for road traffic accidents.

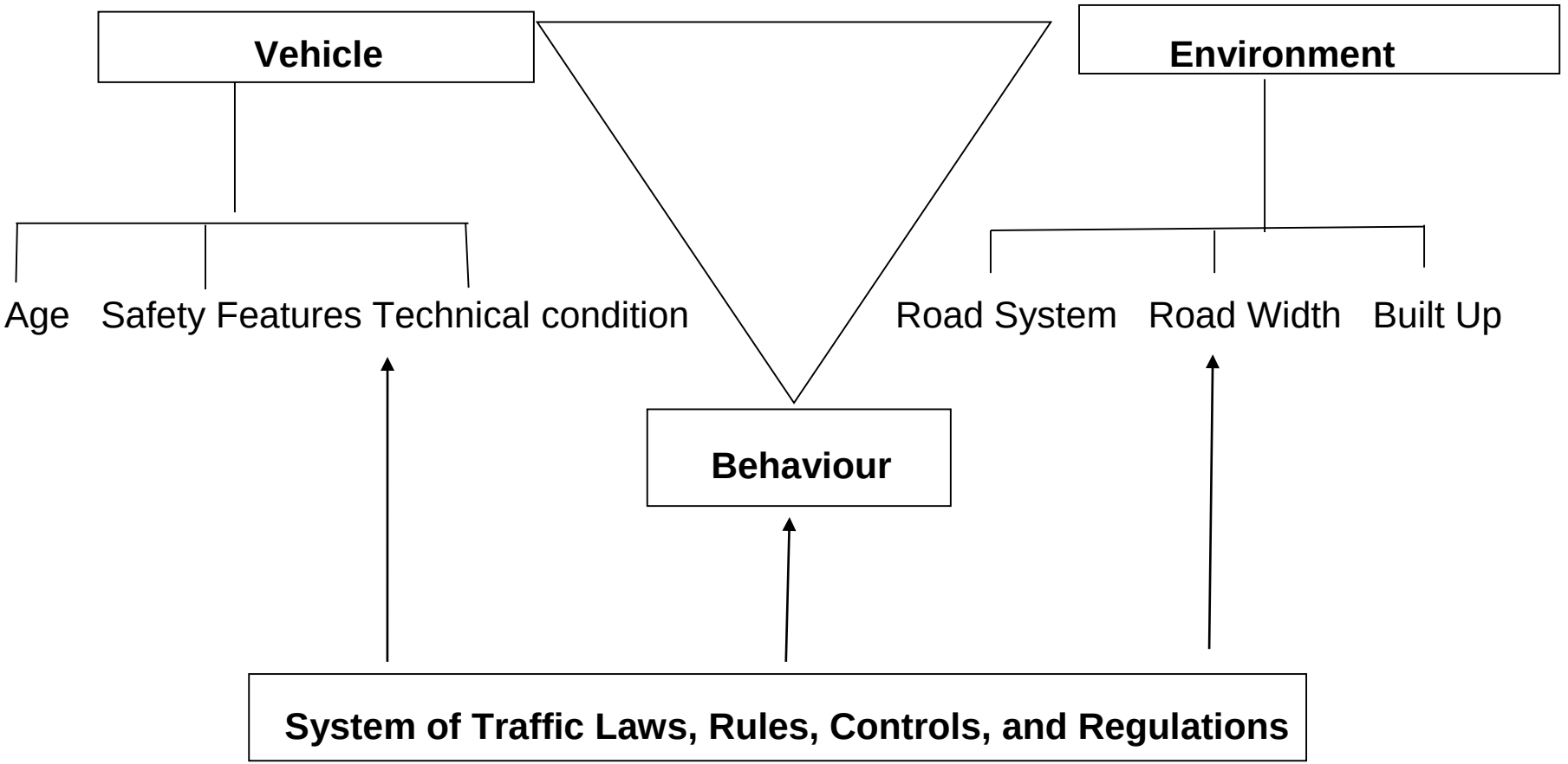
2.6.1 Model for Road Traffic Accidents

A human ecological theory, which focuses on the human as a social being in interaction with their environment, can be modified to suit the study of road traffic accidents. This was inspired by Jorgensen and Abane (1999) when they made a heuristic adjustment to human-ecological model which is used in the study of diseases, to suit road traffic accident analysis. The model comprises of the three main components considered in road traffic accidents:

- The vehicle: this takes into consideration the vehicle composition, age, safety features such as air bag, seat belt, and vehicular technical condition;
- The environment: this relates to all external surroundings of the road system, the road width and built up environment. All aspects of the physical environment were further classified as; daylight and climate referring to weather climatic conditions and road conditions. Also spatial conditions in terms of arrangements and macro-structures, settlement distribution pattern (urban or rural/ sparse or populated area), situation of areas of residence and working areas, road intersection, principle of traffic separation, topography and road constructions qualities, are also included.
- The behaviour of the population: this includes the demographic composition of the population, attitudes and general traffic behaviour. It also extends into general driving

nature of the population relating to driving behaviour, years of driving experience, driving style and driving under the influence of hard substance.

The model has a system of traffic laws, regulations and mode of enforcement designed to superimpose on the population to comply with traffic laws, rules and to convict offenders for various traffic violations. This assists in controlling and maintaining a certain regulated level of law and order in road safety (Jorgensen and Abane, 1999; Komba, 2006). Figure 3 depicts the model framework for understanding the multiple interaction, causes and prevention of road traffic accidents occurrence in most low and middle-income countries.



Source: Jorgensen and Abane, 1999; Komba, 2006

Figure 3: Model for Road Traffic Accidents

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

Methodology is a sequence of activities that starts with decision-making, problem recognition and ends with a recommendation (s). The quality of decision-making depends on the sequence in which the activities are undertaken. The procedures and techniques adopted in this research are outlined in the methodology matrix in Table 4.

3.2 Research Design

A research design can be described as a blueprint that states out procedures and methods to be adopted in collecting and analysing relevant information derived from the research. The research adopted a descriptive and explanatory design for this study, which was triangulated using both qualitative and quantitative techniques. Mathematical digits were used for coding data from field survey and questionnaire response from participants. GIS techniques was used to plot injuries and fatalities hotspot location that was derived from road accidents records as presented by the Vhembe District Municipality traffic division, Department of Roads and Transport traffic accident unit and other related agencies and non-governmental organisation.

3.2.1 Type of Research Design

The overall research design method employed in this research was triangulated within the framework of a case study approach. Questionnaires, structured interviews, focus group discussions, field observations and secondary data were used accordingly to obtain relevant information that was required to achieve the research aim and objectives. Road traffic records were collected from Department of Roads and Transport Traffic Accident Unit, Road Traffic Management Corporation (RTMC) and the South African Police Service (SAPS).

Qualitative methodology involves a wide range of alternative techniques, which include structured interviews, field participant observation and focus group discussion. This approach helps in understanding the true life experiences and provides better understandings on issues relating to people's everyday living and behaviour.

The qualitative methodology approach was used for primary data collection through structured interviews, key informant interviews, main informant interviews and questionnaires from police service officials, health officials, road injury victims and accident traffic unit officials. Field participant observation and focus group discussion with traffic officials was used to obtain behavioural attitude of drivers, pedestrians and other road users within the Vhembe District.

The quantitative methodology provides empirical analysis of numerical data collected through questionnaires and surveys. It focuses on gathering such data and generalising it across groups of people.

The quantitative methodology approach was used for secondary data obtained from government agencies and publications, as well as newspaper articles, speeches and websites on road traffic accidents, injuries and fatalities within the Vhembe District.

RESEARCH METHODOLOGY MATRIX

Table 4: Research methodology matrix

Research Objectives	Research Questions	Methodology and materials used in achieving objectives; data collection and analysis method
1) Examine the composition of road traffic injuries and fatalities resulting from motor vehicles in Vhembe District Municipality from 2011 to 2015.	What is the composition of road traffic injuries and fatalities in Vhembe District Municipality from 2011 to 2015?	- Accident data from Vhembe Traffic Department and Police Services - Road traffic survey report from RTMC - Data capturing using Microsoft Excel 2013 - Data presentation using graphs and charts
2) Examine the contributing factors associated with the road traffic injuries patterns and trends.	What are the factors that road traffic injuries and fatalities are responding to in terms of changes in the patterns and trends?	- Accident reports survey - Road inventory survey - Questionnaires - Key informant interview (KII) - Patterns and Trends analysis - Field survey
3) Identify and map road traffic injuries and fatalities hotspot within Vhembe District Municipality using GIS techniques.	How can GIS techniques be used to identify and map road traffic injuries and fatalities hotspots?	- GPS coordinates - ArcGIS 10.2 Spatial Statistics extension - Linear referencing - Getis Hot Spot Analysis
4) Evaluate the behavioural attitudes of road users in complying with pedestrian road safety prevention measures.	What are the behavioural attitudes of vulnerable road users in complying with existing road safety prevention measures?	- Questionnaires - Field observation - SWOT I - Key informant interview (KII)

3.2.2 Sampling Method, Size and Unit of Analysis

Sampling can be described as the act, process, or technique of selecting a suitable sample, or a representative part of a population for the purpose of determining parameters or characteristics of the whole population. The sampling method adopted in this research was systematic sampling. The sampling frame were the nodal transect roads along the Vhembe District Local Municipality towns. Transect cut across R524 from Makhado to Thohoyandou to Malamulele, N1 from Makhado to Musina, R523 from Thohoyandou via Willysport to N1 intersect, then R527 from Musina to Shiramba.

Systematic random sampling was used to administer questionnaires to road users (I.e. motorists and pedestrians) and key informants in the Department of Roads and Transport, health officials, road injury victim, as well as agencies involved in road traffic accidents. There were forty questionnaires administered in each of the four local municipality relevant offices and participants.

Sample size is defined as a finite part of a statistical population or a subset of all population groups of interest to be studied and gain information about the whole (Oppong, 2012). It is also referred to as a set of respondents of people selected from a larger population for study survey purpose. The sampling size for this research was all major roads in the study area. Figure 4 below shows the sample road network that this research was based upon.

The sampling frame target for this research was Vhembe District Municipality road traffic injuries and fatalities. There was an emphasis on the sample transect roads and all the other roads as seen from the accident report obtained from the Limpopo Department of Road and Transport. This was because a high traffic volume tend to flow along the nodal town routes.

The unit of analysis for this research were all road accident reports in Vhembe District Municipality from January 2011 to August 2015, as well as factors that contributed to road traffic injuries and fatalities.

Questionnaires were formulated to obtain information and different views of road users. These questionnaires were distributed randomly in locations where road traffic injuries occurrence was high if the location was within human habitation. Stratified purposeful sampling was used to administer five questionnaires to traffic officials in each of the four local municipalities within the Vhembe District Municipality. Five questionnaires were administered to health officials and ten to road injuries victims in four different hospitals, one in each of the four local municipalities. Forty questionnaires were administered to motorists and pedestrians in each of the four local

municipalities. Table 5 shows the breakdown of questionnaires administered during primary data collection.

Table 5: Questionnaires distributed to obtain research data in Vhembe District Municipality

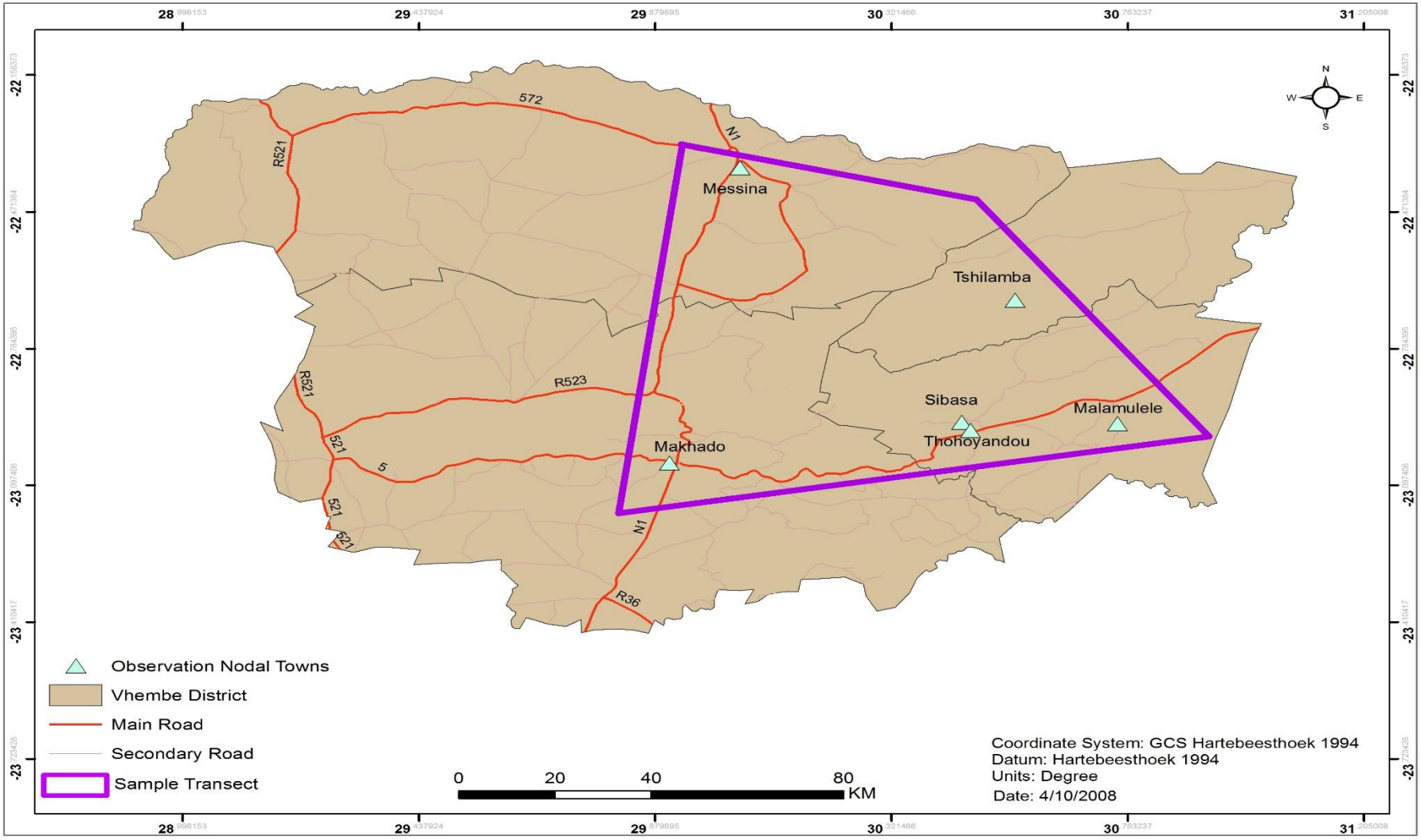
VDM	Motorists	Traffic Officials	Health Officials	Pedestrians	DQ (%)	RQ (%)
Thulamela	40	5	2	40	100	100
Makhado	40	5	2	40	100	100
Musina	40	5	2	40	100	100
Mutale	40	5	2	40	100	100
Total	160	20	8	160	400	400

Source: Researcher's field data collection 2015

Key: VDM- Vhembe District Municipality
DQ- Distributed questionnaires
RQ- Returned questionnaires

3.2.3 Ethical Considerations

In this study ethical clearance was obtained to access accident report data from the database of South Africa Police Service, government agencies, and Department of Roads and Transport traffic division. Ethical clearance was obtained to interview health officials, road traffic injured victims and traffic officials (see Appendices). The data composition and location of traffic accidents were included to use such information and complete this research.



SAMPLE TRANSECT ROADS

Source: Vhembe District Municipality

Figure 4: Sample road networks within Vhembe District Municipality

3.3 Methods of Data Collection

The data collection method adopted for this study were technical reports and sector department documents review, key informant interviews, field survey, questionnaires, participant and non-participant observation, and focus group discussion.

3.3.1 Technical Reports and Sector Department Documents

The study examined the composition of road traffic injuries and fatalities resulting from motor vehicles in Vhembe District Municipality from 2011 to 2015. Secondary data and records were obtained from all relevant road agencies that take charge during road accident occurrences. Agencies such as the South African Police, Limpopo Department of Road and Transport, Municipality Traffic Department, Road Accident Funds agency, Road Traffic Management Corporation, Emergency Medical Service operatives and World Health Organisation reports on traffic injuries and fatalities were employed to achieve this objective. Primary data collected from field inventory survey of traffic flow along the major road identified in this study also formed part of the documents used.

3.3.2 Interviews, Field Survey, Questionnaire and Focus Group Discussion

To elucidate contributing factors associated with road traffic injuries patterns and trends within Vhembe District Municipality, interviews were conducted with traffic accident unit officials of the Limpopo Department of Road and Transport to assist in classifying the contributing factors that lead to road injuries and fatalities in Vhembe District. The researcher employed a road inventory survey, traffic classification and traffic flow volume to better understand and determine which causal factor was dominant. This was undertaken to understand the present situation of road network in terms of factors such as road characteristic that are likely to contribute to road traffic accidents; that is, road geometry design, road surface tension (i.e. road attrition/ smooth or rugged) and quality of infrastructure, as well as road signage.

Field survey assisted in the collection of GPS coordinates of accident hotspots within the study area. Primary data from structured interviews responses from road traffic injury victims and focus group discussions with traffic officials were also evaluated. Questionnaires were administered to available road users and key informants in the Department of Road and Transport. Face to face

interviews were also used to obtain personal view and possible solutions for road safety implementation.

3.3.3 Participant and Non-Participant Observation

This was used to study the traffic characteristics and built environment factors affecting road traffic accident in the study area. Field non-participant observation helped in taking road inventory surveys, traffic volumes, traffic density, and traffic classification. Likewise, average speed of vehicle and road behavioral attitude of vulnerable road users were determined. The researcher participated in activities such as jay walking and indecent road crossing to experience vehicle drivers' reaction towards jay walkers.

3.4 Method of Data Analysis

The data analysis method used in this research was systematic grounded theory, which involves the coding of qualitative data from interviews and observations. The quantitative data was analysed using the Microsoft Excel 2013 software package, where cross-tabulation was carried out. In addition Microsoft Excel 2013 was used to sort and arrange questionnaires responses in a thematic tabular form.

The behavioural attitude of pedestrians was evaluated using SWOT (strengths, weaknesses, opportunities and threats) in reducing the level of road traffic offense applicable to road traffic offenders.

3.4.1 Trend Analysis, Comparative Analysis and Factorial Analysis

The researcher captured the data on road traffic injuries and fatalities on Microsoft Excel, where cross-tabulation frequency was performed. Measure of frequency distribution was used to evaluate data obtained from technical reports and sector department documents on road traffic injuries and fatalities within Vhembe District Municipality. The data findings were presented on graphs and charts. This was followed by a comparative analysis of road traffic injuries and fatalities amongst local municipalities that comprise the Vhembe District Municipality. Factors that were identified as contributing to road traffic injuries and fatalities were categorised under themes using factorial analysis approach. Questionnaire responses were captured on Microsoft Excel before final cross-tabulation output.

3.4.2 Geographical Information System Techniques

In order to Identify and map road traffic injuries and fatalities hotspots within Vhembe District Municipality, GPS coordinates of accident spots were plotted, representing the occurrences of each road traffic accident. In cases where the road traffic accident involved two people, that spot would count for two road traffic incidents. A minimum of 4 incidents were taken as a hotspot and then ranked to the number of incidents recorded over the five-year period. Serious injuries and fatalities were ranked equally with incidents that are regarded as minor injuries. The rationale behind this is that the same incident could have been worse, leading to fatalities and minor injuries are potentially fatal to humans in the long run.

GIS techniques in ArcGIS 10.2 software package were used to map road traffic injuries hotspots. The techniques considered were linear referencing in spatial analyst tool. Geographical coordinates for location of road traffic injuries were captured on Microsoft Excel 2013 then further application tools were employed to convert them into a suitable format in ArcGIS software. Spatial Statistics analyst extension in ArcGIS 10.2 software was used to determine locational areas of road traffic injuries and fatalities hotspots within the Vhembe District Municipality using Getis Hot Spot Analysis tool to differentiate the level of confidence of the hotspots identified in the study area. The Getis hotspot analysis tool made use of road accident categories values of injuries to derive level of confidence and hotspot point.

3.4.3 Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis

To evaluate the behavioural attitudes of vulnerable road users in complying with pedestrian road safety prevention measures. SWOT was used to determine strengths, weaknesses, opportunities and threats to the present road safety measures. Questionnaires were administered to road users with focus on pedestrian and also road safety officers to get their views on the effectiveness of the road safety measures; either they were being adhered to during road usage or not. Also the behavioural attitude of drivers in compliance with road signage was evaluated using field participatory observation.

CHAPTER FOUR: DATA PRESENTATION AND ANALYSIS

4.1 Introduction

The aim of the study was to analyse the patterns and trends of road traffic injuries and fatalities in Vhembe District Municipality. This was to determine the effort done by the district Traffic Department on the reduction of road accidents occurrences. The analysis entails graphs and maps production to show the dynamics of the research findings, amongst which are to describe the composition of road traffic injuries and fatalities in Vhembe District Municipality; and to identify road traffic injuries and fatalities hotspots within the study area, as well as to analyse the different attributes that contribute to injuries and fatalities as determined from the research data collected. The major caption in the specific objectives was used to formulate the heading wherein the data collected from the research findings were graphical presented and explanatory analysed.

4.2 Road Traffic Injuries and Fatalities Composition in Vhembe District

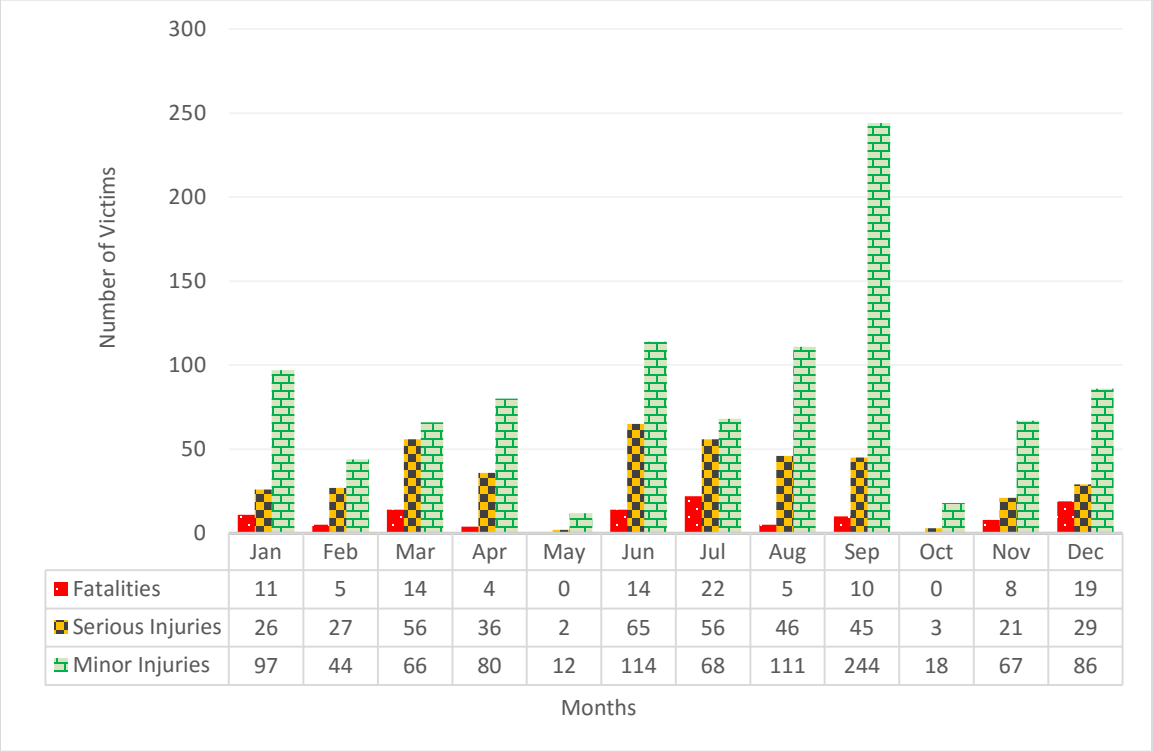
The data comprising composition of road traffic injuries and fatalities in Vhembe District Municipality was obtained and collected from road accident reports as compiled by the Department of Roads and Transport all accidents reported in all police station within the district. This was also double checked with the traffic department office responsible to dispatch traffic officers to scenes of road accidents within the district. The daily road accident reports from January 2011 to August 2015 was used in the data presentation and analysis for this research and reported in this dissertation. The researcher was able to streamline all the information provided from the road accident reports databased even though some of the reports were skewed due to some errors in correctly entering information in the traffic department database.

4.2.1 Road Traffic Injuries and Fatalities Composition for 2011

Figure 5 shows distribution of road traffic injuries and fatalities for Vhembe District Municipality in 2011, which serves as the commencement year for a decade of action for road safety and road traffic accidents globally. Road traffic accidents for May and October recorded no fatalities within the district, while July and December recorded the highest fatalities rate. The month of July recorded 22 fatalities and December recorded 19. The recorded figures for the other months ranged from 4 to 14 fatalities.

Figure 5 also shows the categories of road accidents related to road traffic injuries and fatalities within the district on a monthly basis. It shows that June recorded the highest rate of serious injuries, with 65 people, followed by July with 56. This can be linked to the severity of the road accidents occurring during those months. In cases where there are accidents where victims sustain serious injuries, chances are some may end up being permanently disabled and losing full functionality of some of their body parts. In the same vein, September recorded the highest number of minor injuries with 244, followed by June with 114 people.

The passenger category has the highest figures in all related traffic accidents. This can be attributed to the high numbers of passengers using the road daily to commute from one place to another. The month of July recorded 15 passenger fatalities followed by December, March, June, September and November. Similarly, the month of September recorded over 200 injured passengers, followed by August, June, December and April with an average of over 100. The next category of road users with high numbers of road fatalities and injuries are drivers followed by pedestrians.



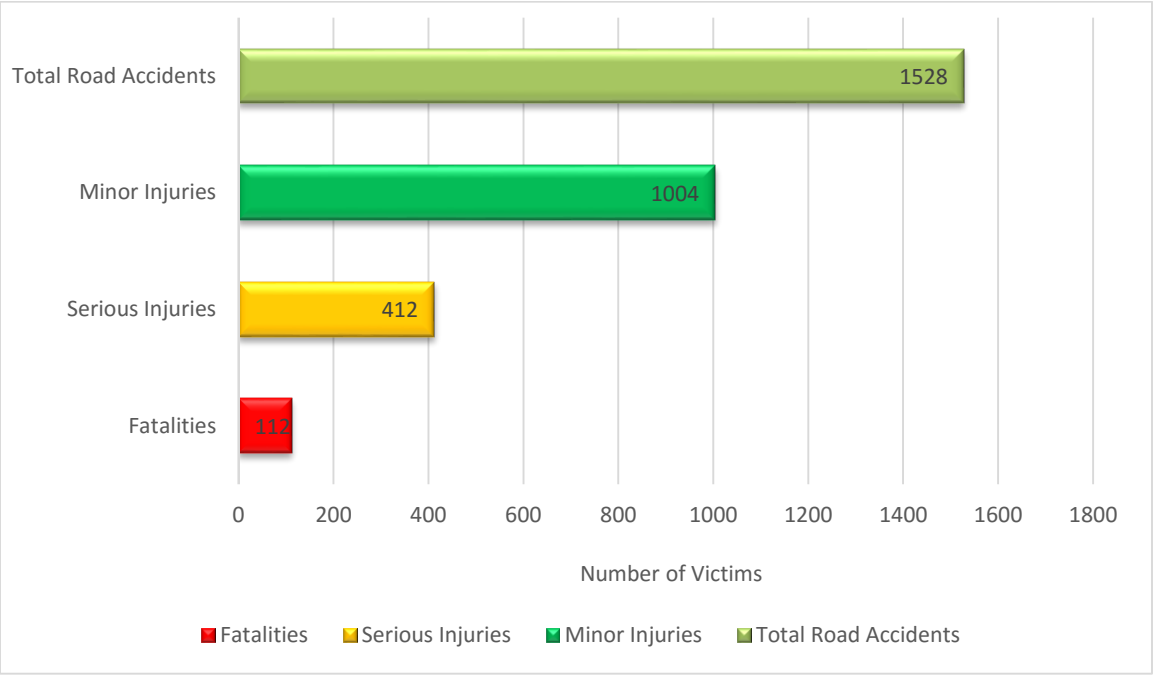
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fatalities	11	5	14	4	0	14	22	5	10	0	8	19
Serious Injuries	26	27	56	36	2	65	56	46	45	3	21	29
Minor Injuries	97	44	66	80	12	114	68	111	244	18	67	86

Source: LDRT Road Accident Daily Report, 2015

Figure 5: The composition of road traffic injuries and fatalities in VDM for 2011

The road traffic fatalities observed an upward trend in the month of July and December, while a downward trend was observed in May and October. Similarly, under road traffic injuries in relation

to serious injuries, the month of March and June observed an upward trend, while a downward trend was observed for May and October. Minor injuries saw an upward trend in September and a downward trend in May and October. The total number of road traffic casualties recorded for VDM in 2011 was 1528, of which 1004 were minor injuries, 412 and 112 were serious injuries and fatalities respectively (See Figure 6).

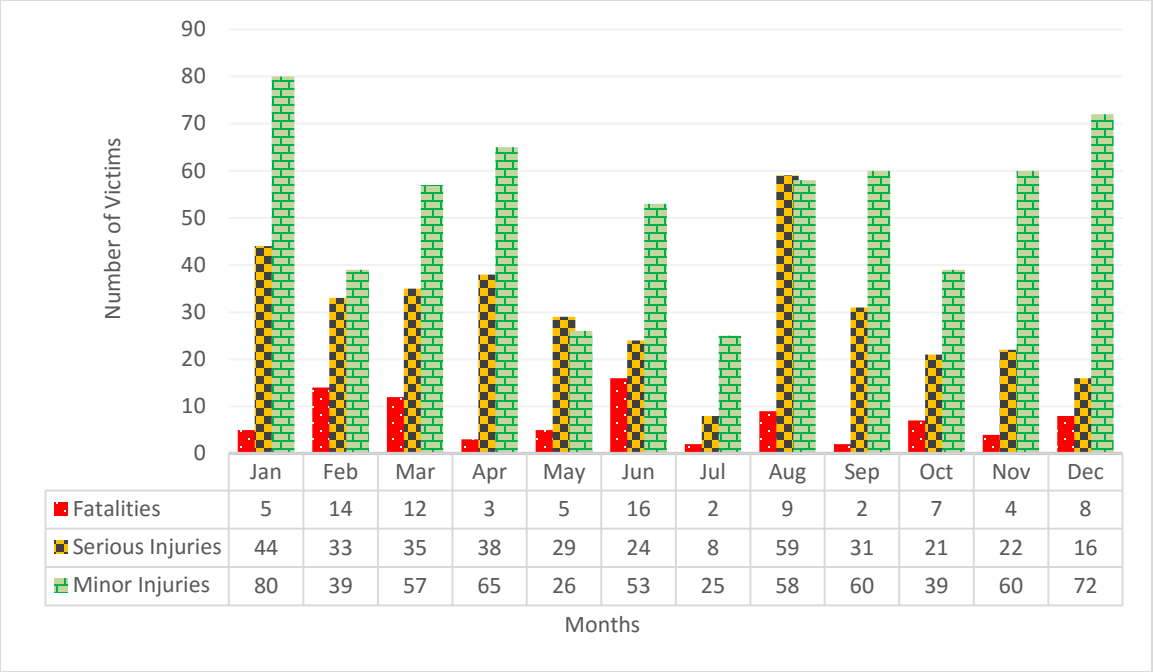


Source: LDRT Road Accident Daily Report, 2015

Figure 6: Overview composition of road traffic accidents in VDM for 2011

4.2.2 Road Traffic Injuries and Fatalities Composition for 2012

During 2012, there was a reduction in road fatalities and serious injuries with insignificant increase in the minor injuries category in the district. It was further observed that the month with the highest road fatalities changed, with June and February recording the highest fatalities rate, followed by August and December. There were low fatalities recorded in September, July and April, as well as serious and minor road injuries within the District. Looking at Figure 7, the monthly analysis of road traffic accidents provides an indication of which of the categories of road traffic injuries recorded the highest rate during the period of study. Observation from the analysis shows that the month with the highest fatalities might be relatively low on minor injuries.

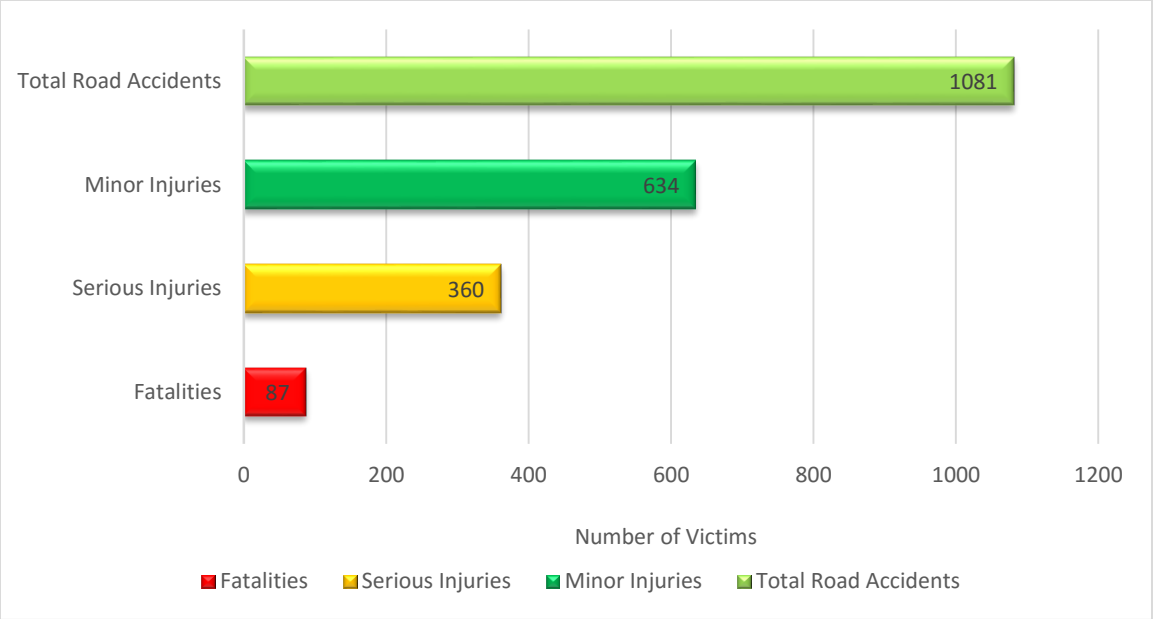


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fatalities	5	14	12	3	5	16	2	9	2	7	4	8
Serious Injuries	44	33	35	38	29	24	8	59	31	21	22	16
Minor Injuries	80	39	57	65	26	53	25	58	60	39	60	72

Source: LDRT Road Accident Daily Report, 2015

Figure 7: The composition of road traffic injuries and fatalities in VDM in 2012

The monthly analysis of the year 2012 road fatalities and injuries shows that the passenger category was the most affected, followed by driver and passenger categories. In Figure 7 above, January and December recorded the highest number of minor injuries, followed by April and September. The trend analysis off fatalities reflect changes in the upward peak in June and a downward low in July and September. The trend movement for serious and minor monthly injuries were similar There was a total of 1081 recorded road traffic casualties in 2012, with 87 fatalities; 360 and 634 being serious and minor injuries respectively (see Figure 8).

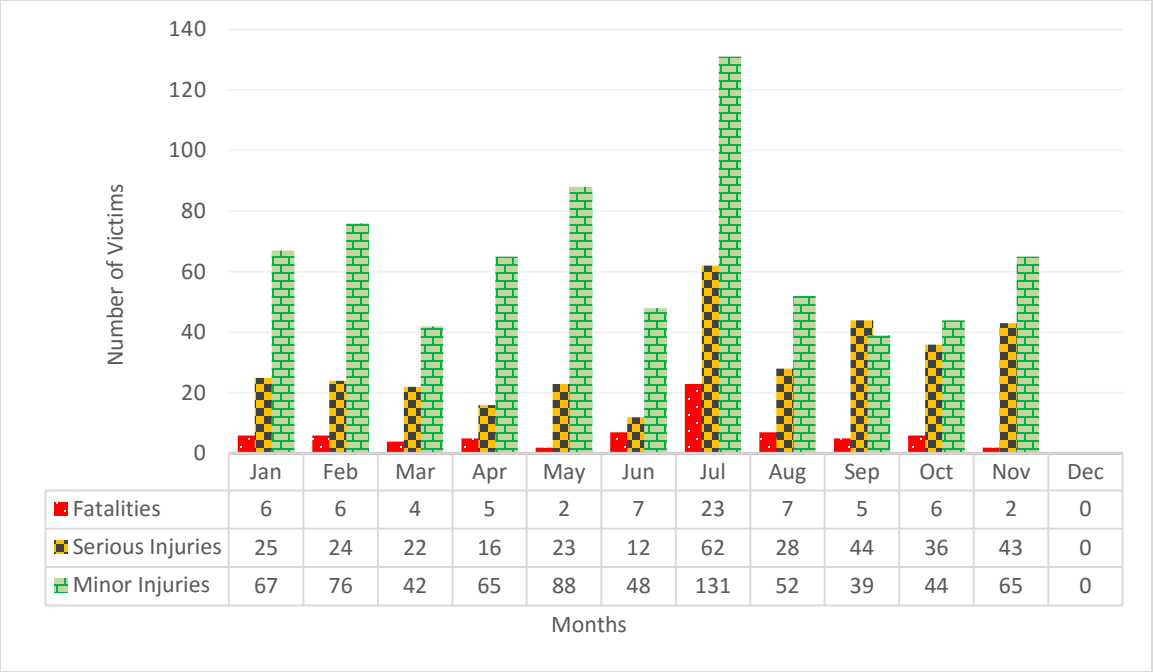


Source: LDRT Road Accident Daily Report, 2015

Figure 8: Overview composition of road traffic accidents in VDM for 2012

4.2.3 Road Traffic Injuries and Fatalities Composition for 2013

The composition of road traffic injuries and fatalities for Vhembe District Municipality in 2013 is shown in Figure 9, excluding the month of December due to no data available. The month of July recorded the highest fatalities, while May and November recorded the lowest fatalities. Other months ranged from 4 to 7 fatalities recorded. The categories of road users which were involved in road traffic injuries and fatalities within the district on a monthly basis showed the month of July recorded 16 drivers' fatalities, followed by June and August.

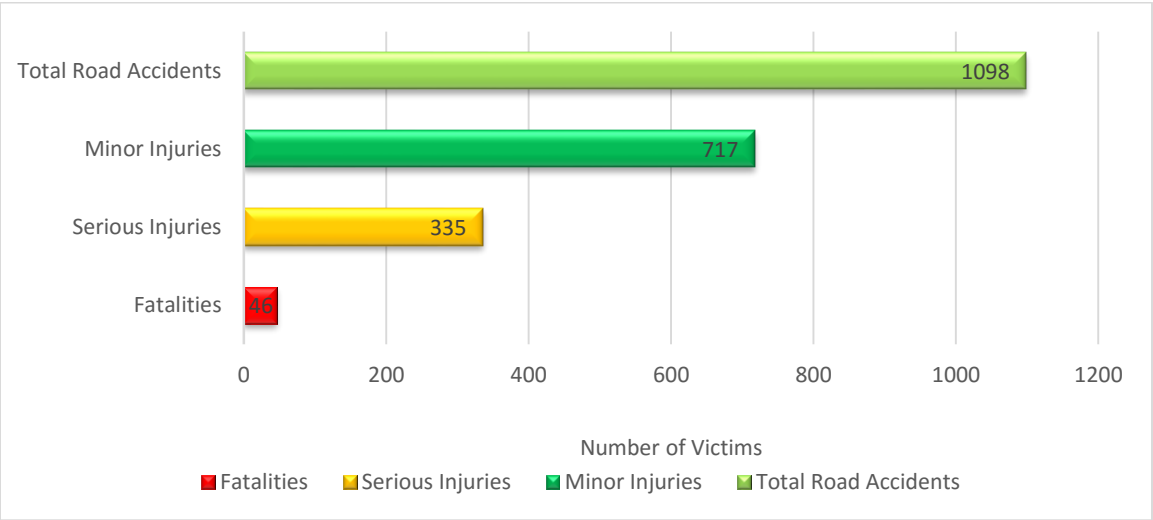


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fatalities	6	6	4	5	2	7	23	7	5	6	2	0
Serious Injuries	25	24	22	16	23	12	62	28	44	36	43	0
Minor Injuries	67	76	42	65	88	48	131	52	39	44	65	0

Source: LDRT Road Accident Daily Report, 2015

Figure 9: The composition of road traffic injuries and fatalities in VDM in 2013

An upward trend was observed in July which is the peak of road fatalities in 2013. There was a downward trend in May and November. A similar trend movement was observed in the serious and minor injuries category with July being the peak and June the lowest. The total number of road traffic casualties recorded for VDM in 2013 was 1098, of which 717 were minor injuries; 335 and 46 were serious injuries and fatalities, respectively. The figures exclude the road accident data for December 2013 (See Figure 10).

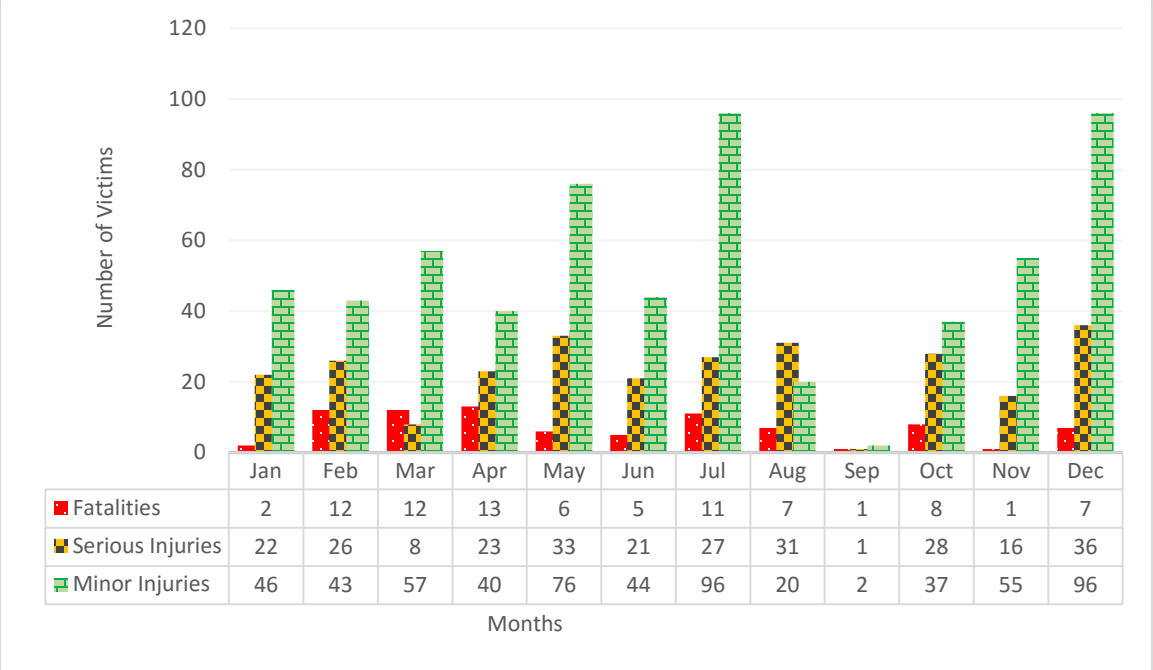


Source: LDRT Road Accident Daily Report, 2015

Figure 10: Overview composition of road traffic accidents in VDM for 2013

4.2.4 Road Traffic Injuries and Fatalities Composition for 2014

Figure 11 shows the composition of road traffic injuries and fatalities for Vhembe District Municipality in 2014. It shows that the highest fatalities were recorded in April, February, March and July, while September, November and January recorded the lowest fatalities. In other months, fatalities ranged from 5 to 8. The monthly analysis breakdown revealed that passenger's category were highly affected by fatalities, followed by the drivers and pedestrians category.

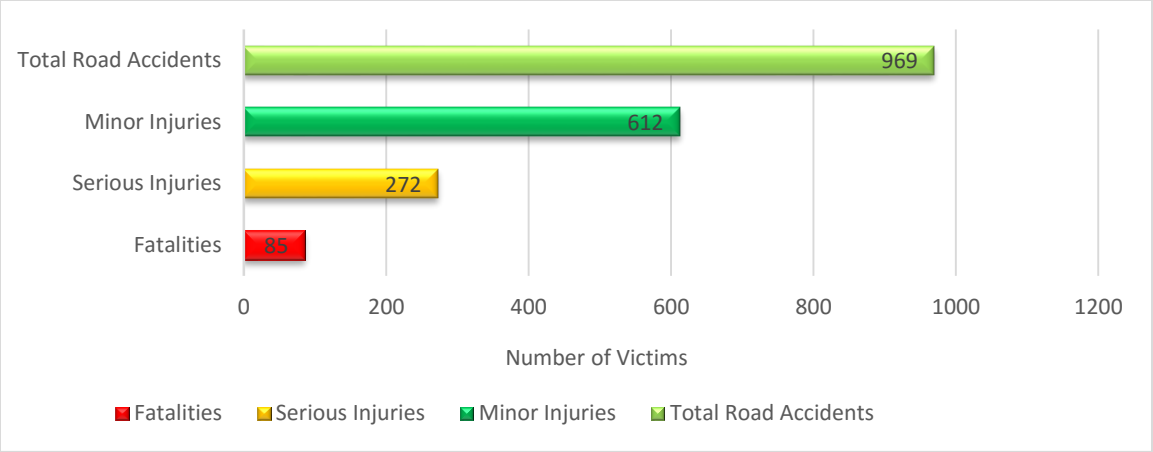


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fatalities	2	12	12	13	6	5	11	7	1	8	1	7
Serious Injuries	22	26	8	23	33	21	27	31	1	28	16	36
Minor Injuries	46	43	57	40	76	44	96	20	2	37	55	96

Source: LDRT Road Accident Daily Report, 2015

Figure 11: The composition of road traffic injuries and fatalities in VDM in 2014

The graph depicts that April showed an upward peak for fatalities, with a downward low in September and November 2014. However, the peak for serious injuries was in December and a low in September. An upward trend for minor injuries was in July and December with a downward trend in September. The total number of road traffic casualties recorded for VDM in 2014 was 969, of which 612 were minor injuries, 272 and 85 were serious injuries and fatalities respectively (See Figure 12).

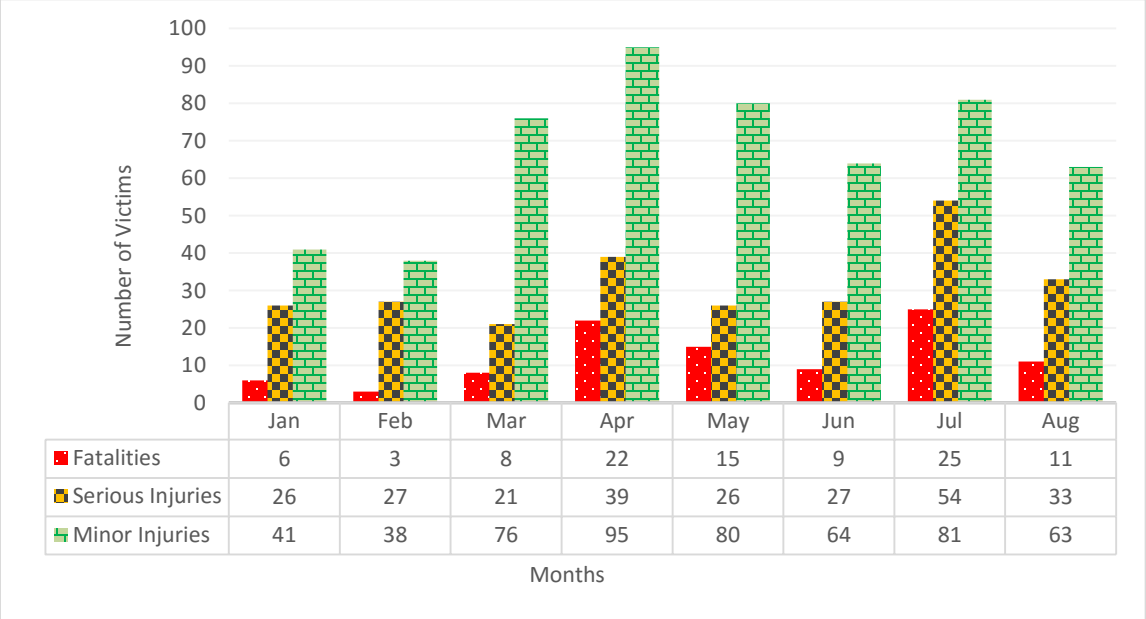


Source: LDRT Road Accident Daily Report, 2015

Figure 12: Overview composition of road traffic accidents in VDM for 2014

4.2.5 Road Traffic Injuries and Fatalities Composition for 2015

The road traffic accidents data report used for 2015 was up to August as shown in Figure 13. The graph shows that July recorded the highest fatalities, followed by April and May, while February recorded the lowest fatalities in that period. The other months ranged from 6 to 7 fatalities recorded against them. Figure 13 also revealed the categories of road traffic accidents which resulted in injuries and fatalities within the district on a monthly basis. It was observed that July recorded 25 fatalities, followed by April with 22 and May 15 respectively.

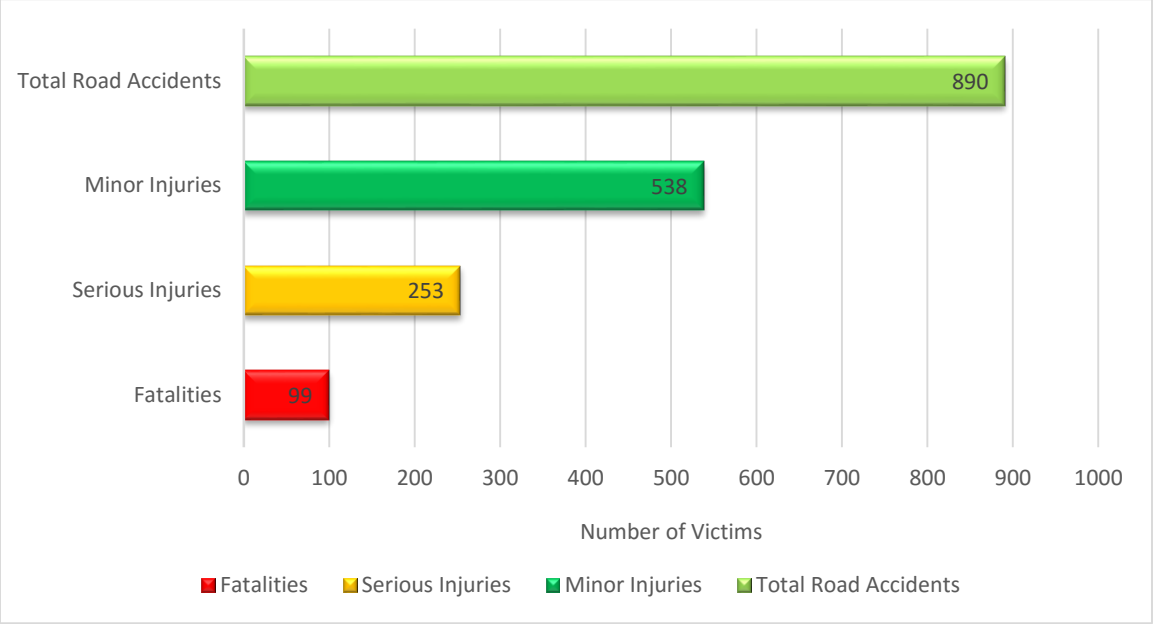


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Fatalities	6	3	8	22	15	9	25	11
Serious Injuries	26	27	21	39	26	27	54	33
Minor Injuries	41	38	76	95	80	64	81	63

Source: LDRT Road Accident Daily Report, 2015

Figure 13: The composition of road traffic injuries and fatalities in VDM in 2015

The graph above shows that July observed an upward trend of road fatalities, followed by April for the period considered in 2015. There was also a downward trend in the month of February. A similar trend was observed in the serious and minor injuries category, with July and April being the peak and February and March the lowest. The total number of road traffic casualties recorded for Vhembe District in 2015 up to August was 890, of which 538 were minor injuries; while 253 and 99 were serious injuries and fatalities respectively (see Figure 14).



Source: LDRT Road Accident Daily Report, 2015

Figure 14: Overview composition of road traffic accidents in VDM for 2015

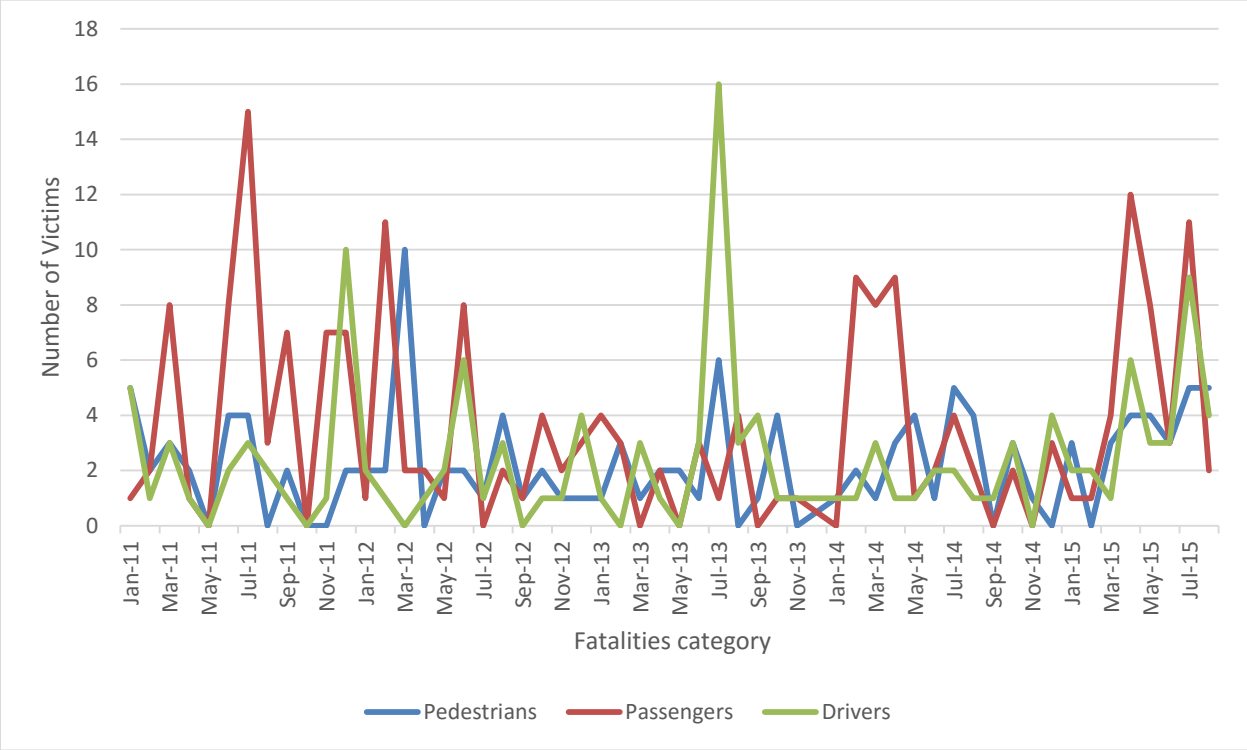
4.3 Road Users Categories Involved in Road Traffic Injuries and Fatalities in VDM

This was done to establish the trend of the different categories of road users and also make a comparative analysis of the study period, which also serves as the half way mark into the decade action for road safety. It was also necessary to study the dynamics of the categories of road traffic accidents that occurred within the district during the study period.

4.3.1 A Comparative Analysis of Road Traffic Fatalities Victims

The figures of passengers that were involved in fatalities for 2011 peaked at 62 and it decreased in 2012. The lowest fatalities rate at 18 was recorded for 2013. However, there was an upward

trend in 2014 going up to 42. It was also observed that skewness of some of the road accident data report might have contributed to the low figure of reported passenger fatalities in 2013.



Source: LDRT Road Accident Daily Report, 2015

Figure 15: Monthly composition of fatalities from Jan 2011 – Aug 2015 in VDM

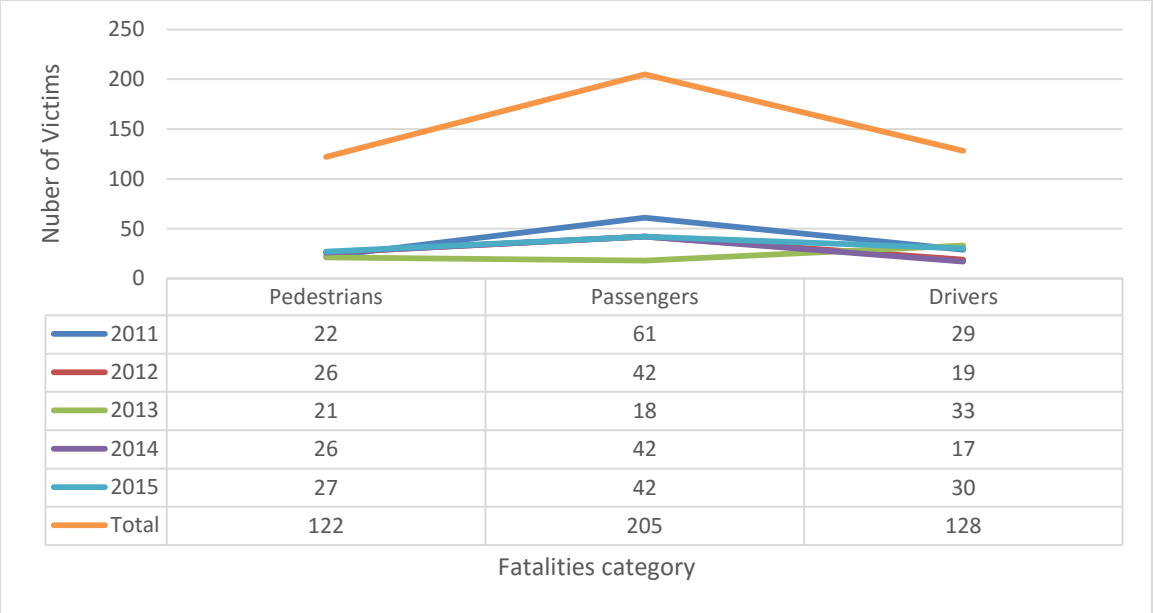
The one-way ANOVA (Table 6) implies that variations among categories of road users involved in road traffic fatalities are significant ($p < 0.05$). The differences observed were real and did not happen by chance for the 5year period studied.

Table 6: ANOVA for road traffic fatalities

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	55.96364	2	27.98182	3.393467	**0.035997**	3.051819
Within Groups	1335.818	162	8.245791			
Total	1391.782	164				

Looking at the comparative analysis of the road user fatalities category as observed in Figure 15 and Figure 16, we can deduce that the passenger category suffered the most fatalities over the studied period. This is closely associated with the usage of public transportation within the district as the commonly used mode of transport. Information from the field revealed that a larger percentage of people use buses because they are relatively cheaper than travelling by taxis.

Some of the people buy the discounted monthly bus tickets for their daily travelling within the district.

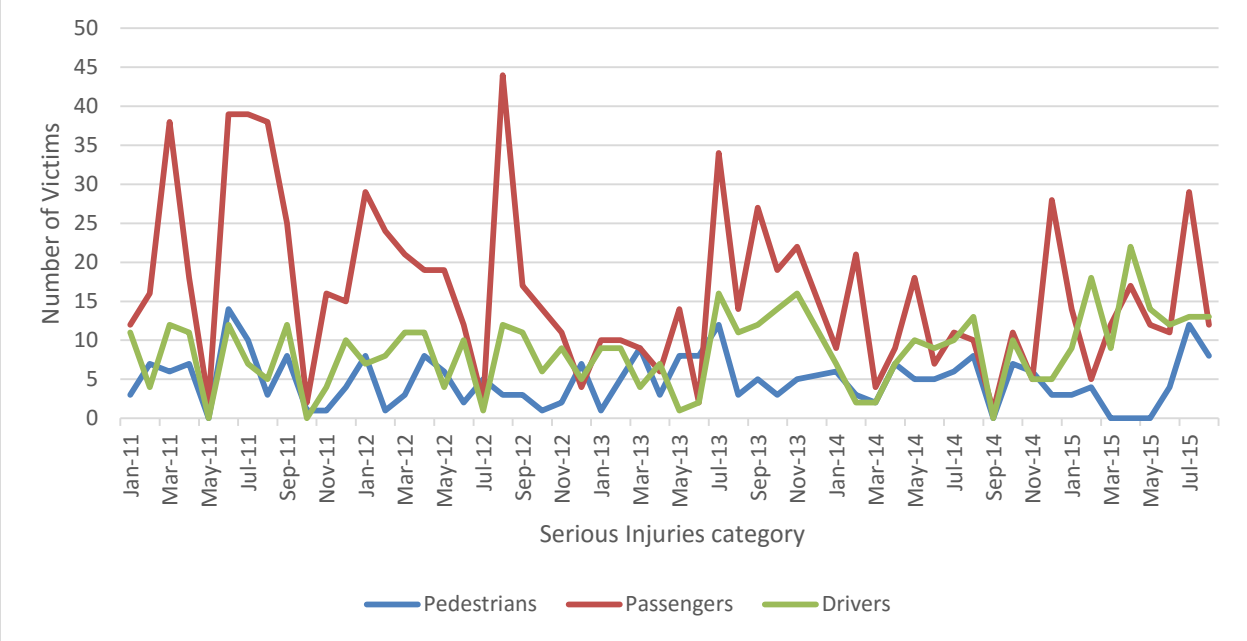


	Pedestrians	Passengers	Drivers
2011	22	61	29
2012	26	42	19
2013	21	18	33
2014	26	42	17
2015	27	42	30
Total	122	205	128

Source: LDRT Road Accident Daily Report, 2015

Figure 16: Yearly composition of fatalities of road users' category in VDM

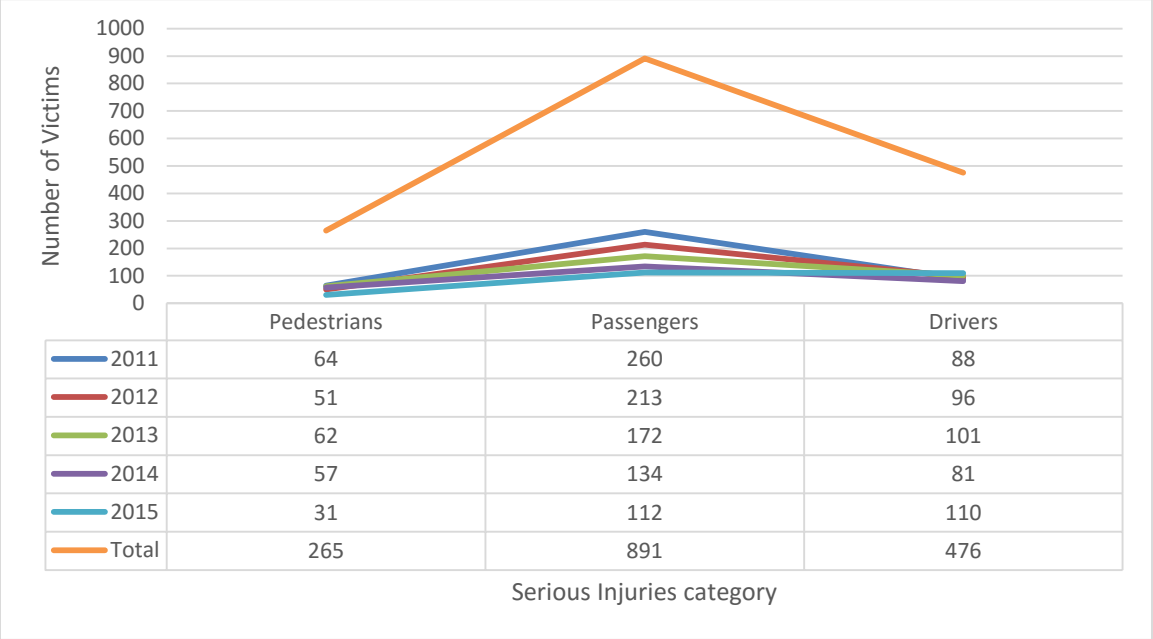
4.3.2 A Comparative Analysis for Road Traffic Serious Injuries Victims



Source: LDRT Road Accident Daily Report, 2015

Figure 17: Monthly composition of serious injuries from Jan 2011 – Aug 2015 in VDM

The comparative trend analysis curves for all the studied years were almost parallel to each other, except for an upward steep in the passenger category, which also depict the group of road users who are more vulnerable during road accidents. The passenger category constituted about 54.6% of the total people accounted for having serious injuries from road accidents within the district. This is followed by 29.2% for driver category and 16.2% for the pedestrian category (see Figure 17 and Figure 18).



Source: LDRT Road Accident Daily Report, 2015

Figure 18: Yearly composition of serious injury of road users' category in VDM

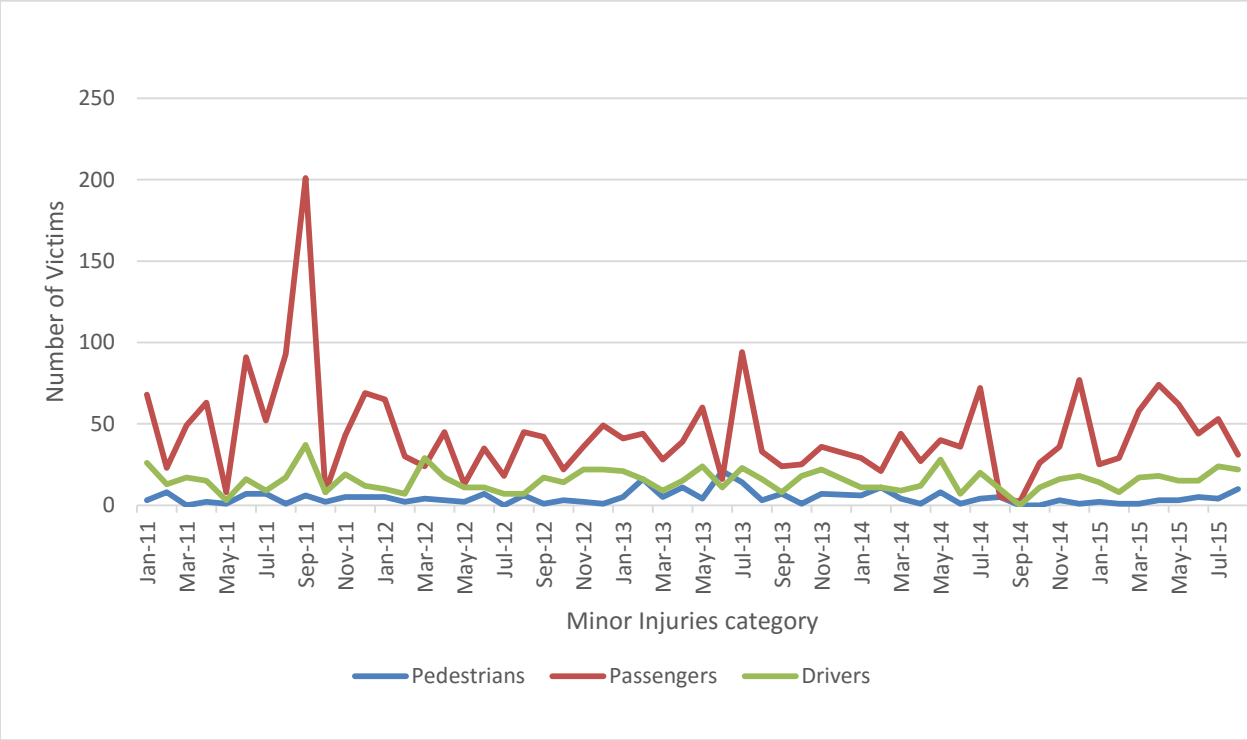
Looking at the one-way ANOVA (Table 7) for road traffic serious injuries for the 5year studied period, it was observed that variation among the categories of road users was highly significant ($p < 0.05$). This also implies that the recorded observed serious injuries were real and did not happen by chance.

Table 7: ANOVA for road traffic serious injuries

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3678.485	2	1839.242	37.27584	**4.82E-14**	3.051819
Within Groups	7993.309	162	49.34141			
Total	11671.79	164				

4.3.3 A Comparative Analysis for Road Traffic Minor Injuries Victims

According to Figure 20, the total number of people with minor injuries from road accidents within the district was about 3505, out of which 69% falls in the passenger category. Next was the driver category with 23.8% and 7.2% for the pedestrian (see Figure 19). Most of the minor injuries were from road accidents that included car side wipes and other less impact road accidents. From field observations and interview testimonies of traffic officers, most of the less impact road accidents are settled between drivers and some of such road accidents never get to be reported.



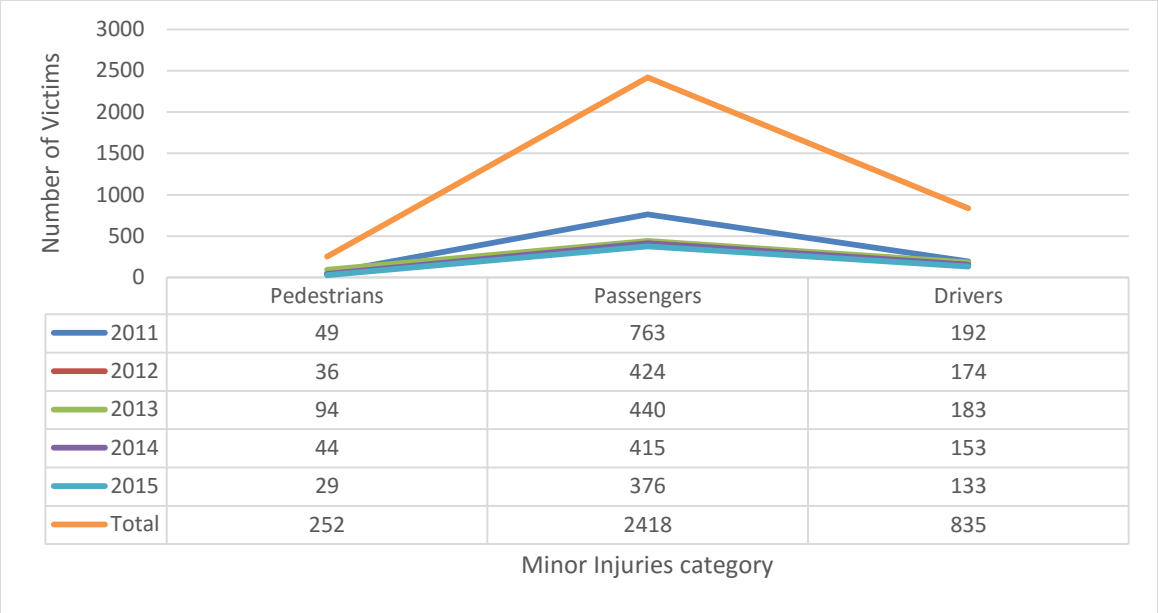
Source: LDRT Road Accident Daily Report, 2015

Figure 19: Monthly composition of minor injuries from Jan 2011 - Aug 2015 in VDM

Table 8 shows the ANOVA for the road minor injuries with high significant value ($p < 0.05$) for all categories of road users. The differences observed were real as recorded in accident report.

Table 8: ANOVA for road traffic minor injuries

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	45975.14	2	22987.57	68.3568	**2.99E-22**	3.051819
Within Groups	54478.65	162	336.288			
Total	100453.8	164				



	Pedestrians	Passengers	Drivers
2011	49	763	192
2012	36	424	174
2013	94	440	183
2014	44	415	153
2015	29	376	133
Total	252	2418	835

Source: LDRT Road Accident Daily Report, 2015

Figure 20: Yearly Composition of minor injuries of road users' category in VDM

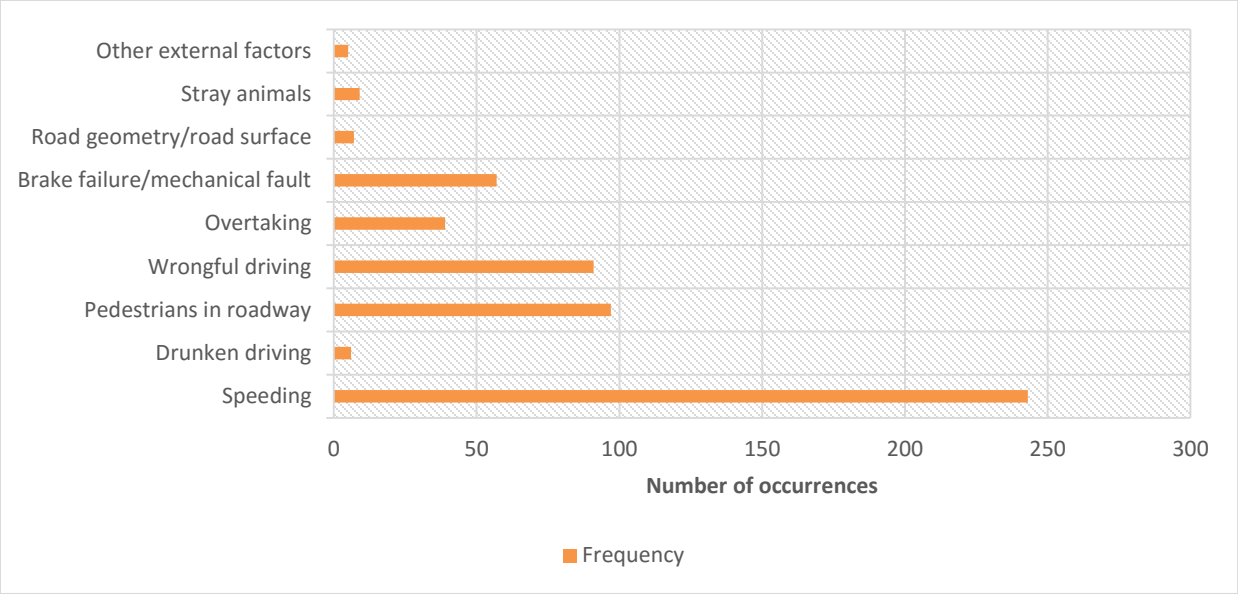
4.4 Factors Contributing to Road Traffic Injuries and Fatalities in VDM

There are many factors responsible for road traffic accidents. These vary between locations of occurrences. An overview of contributing factors to road traffic injuries and fatalities in Vhembe District Municipality, as documented by the traffic department, is described and analysed below.

4.4.1 Factors Contributing to Road Traffic Injuries and Fatalities in VDM in 2011

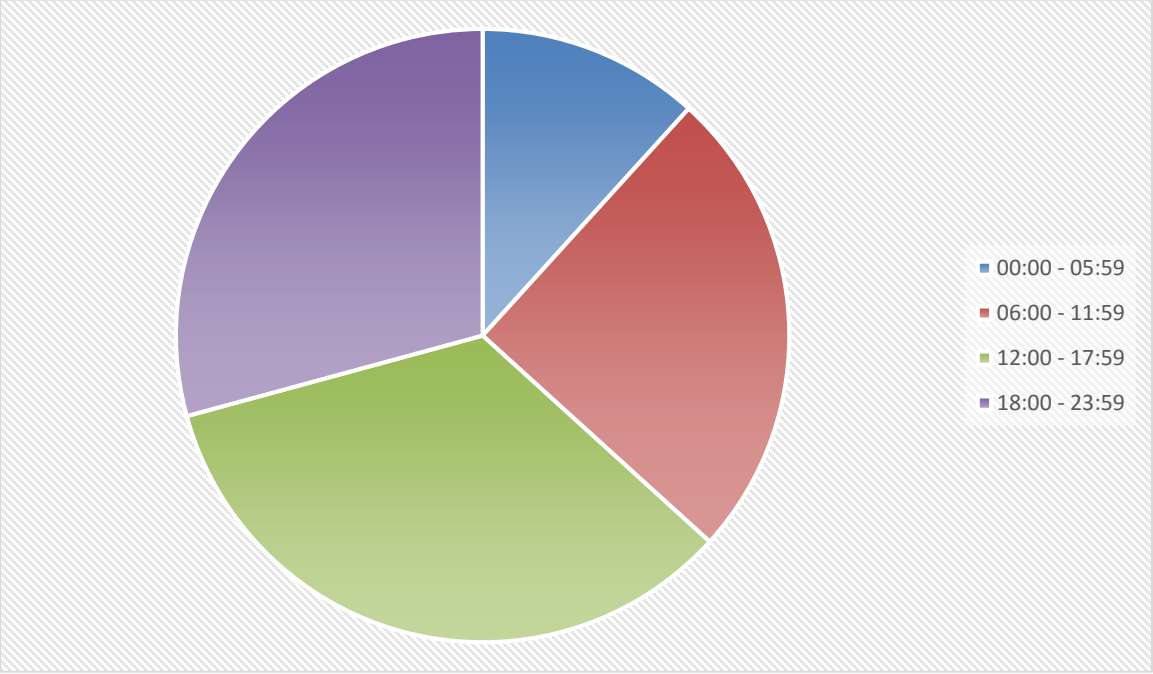
As shown in Figure 21, a total of 554 road traffic accidents occurred within VDM in 2011. Out of these 243 were a result of speeding, 97 and 91 due to pedestrian in roadways and wrongful driving, respectively. Brake failure/mechanical fault accounted for 57 accidents and 39 were due to reckless overtaking. On average 7 accidents were due to other factors, such as road geometry/road surface, stray animals, drunken driving and other external factors. Some of the road traffic injuries and fatalities were as a result of two or more contributing factors.

Time occurrence of the road accidents was also taken into consideration and studied. This was classified into four blocks of 6 hours intervals to determine which block recorded the highest number of road accidents. It was observed that 34% of the road accidents occurred between 12:00 and 17:59 followed by 29% from 18:00 to 23:59, 25% from 06:00 to 11:59 and 12% from 00:00 to 05:59 respectively (see Figure 22).



Source: LDRT Road Accident Daily Report, 2015

Figure 21: An overview of contributing factors responsible for road traffic accidents in VDM for 2011



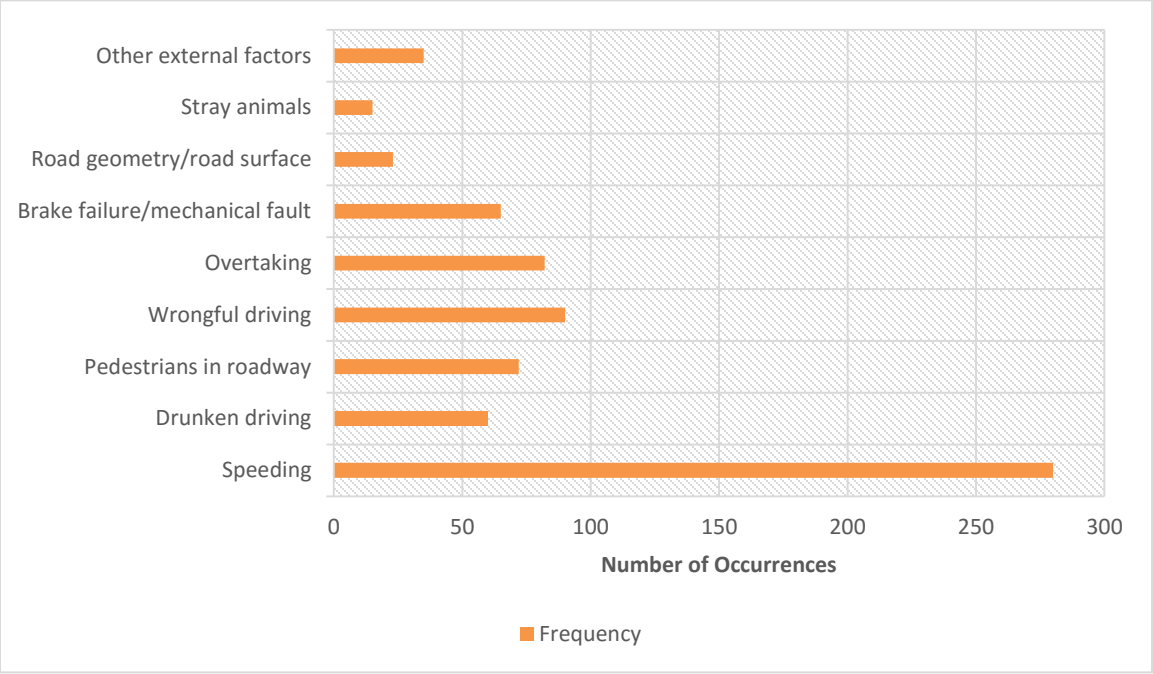
Source: LDRT Road Accident Daily Report, 2015

Figure 22: Percentage time occurrence overview of road traffic accidents in VDM for 2011

4.4.2 Factors Contributing to Road Traffic Injuries and Fatalities in VDM in 2012

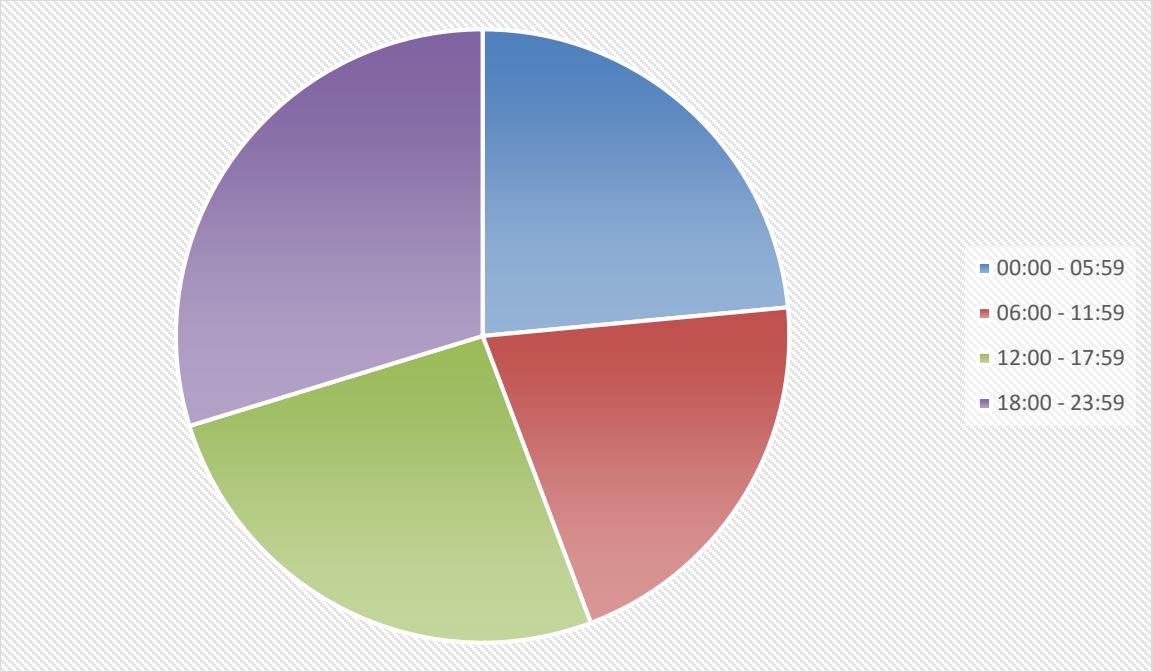
The total accidents that occurred in Vhembe District for 2012 was 722, out of which 280 were a result of speeding-related causes; 90 due to wrong driving, 82 was from reckless overtaking, 72 was attributed to pedestrian jay walking in roadways, 65 from brake failure/ mechanical fault of the motor vehicle. Drunken driving also contributed to 60 with road geometry/ road surface causing 23 of the road traffic injuries and fatalities. The various factor categories responsible for road traffic injuries and fatalities are tabulated in Figure 23.

Time factor was also taken into consideration and presented in Figure 89. The time block of 18:00 – 23:59 was responsible for 30% of the road traffic injuries and fatalities, while 26% occurred during 12:00 – 17:59, with 23% within 00:00 – 05:59 and 21% occurred during 06:00 – 11:59 (see Figure 24).



Source: LDRT Road Accident Daily Report, 2015

Figure 23: An overview of contributing factors responsible for road traffic accident in VDM for 2012

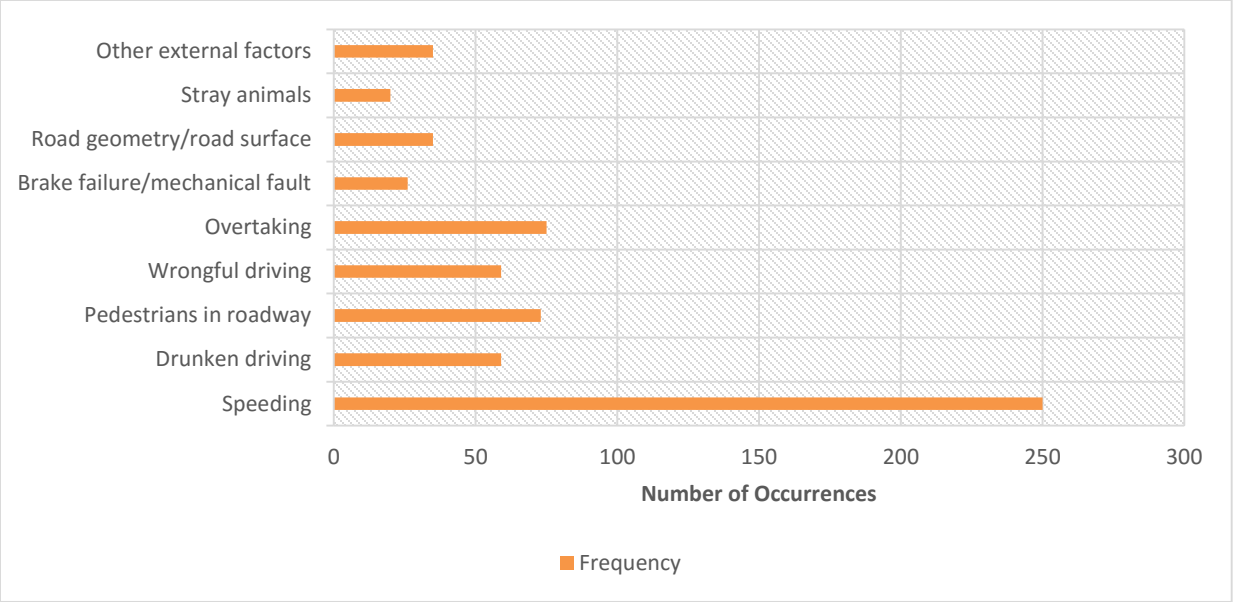


Source: LDRT Road Accident Daily Report, 2015

Figure 24: Percentage time occurrence overview of road traffic accidents in VDM for 2012

4.4.3 Factors Contributing to Road Traffic Injuries and Fatalities in VDM in 2013

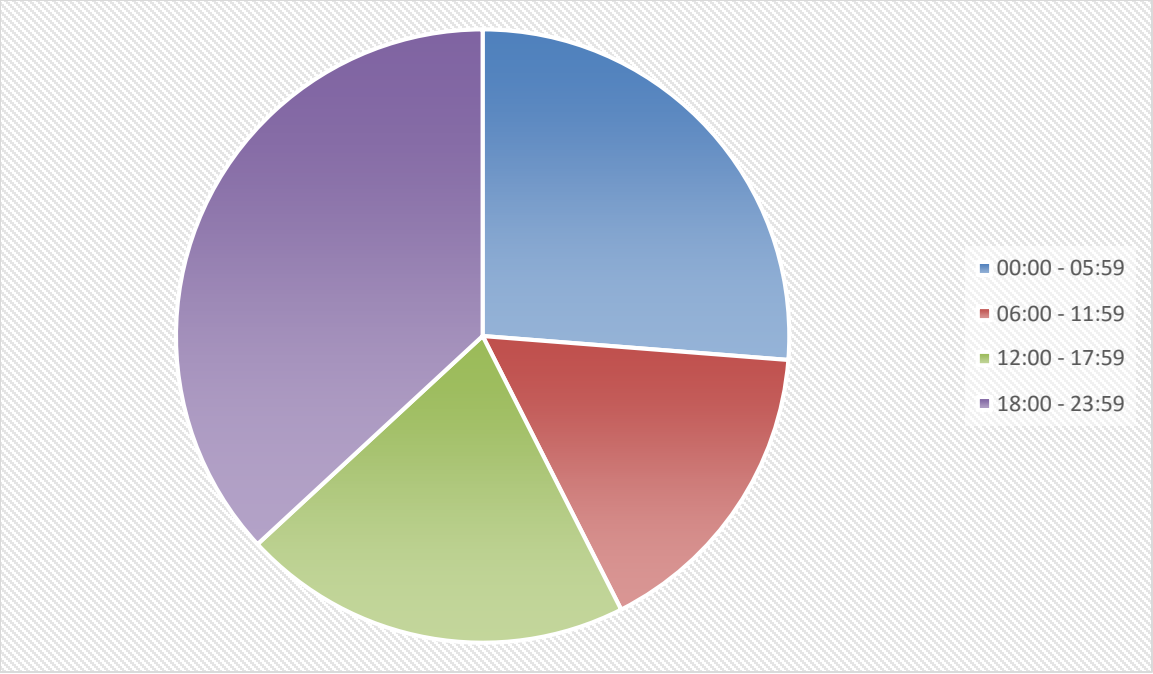
Figure 25 shows that a total of 617 road traffic accidents occurred within VDM in 2013. Speeding by motorists resulted in 250 road accidents, 73 accidents were due to pedestrian jay walking, 75 were as a result of reckless overtaking, 59 accidents were caused by wrongful driving and drunken driving, with 20 attributed to road geometry/road surface, while other external factors were responsible for 35 of the road traffic injuries and fatalities.



Source: LDRT Road Accident Daily Report, 2015

Figure 25: Overview of contributing factors responsible for road traffic accident in VDM for 2013

The time of occurrence of the road traffic injuries and fatalities for 2013 was observed as 37% occurring during 18:00 – 23:59, with 26% and 21% occurring from 00:00 – 05:59 and 12:00 – 17:59 block hours respectively, while 16% occurred from 06:00 – 11:59 hours of the day (see Figure 26).

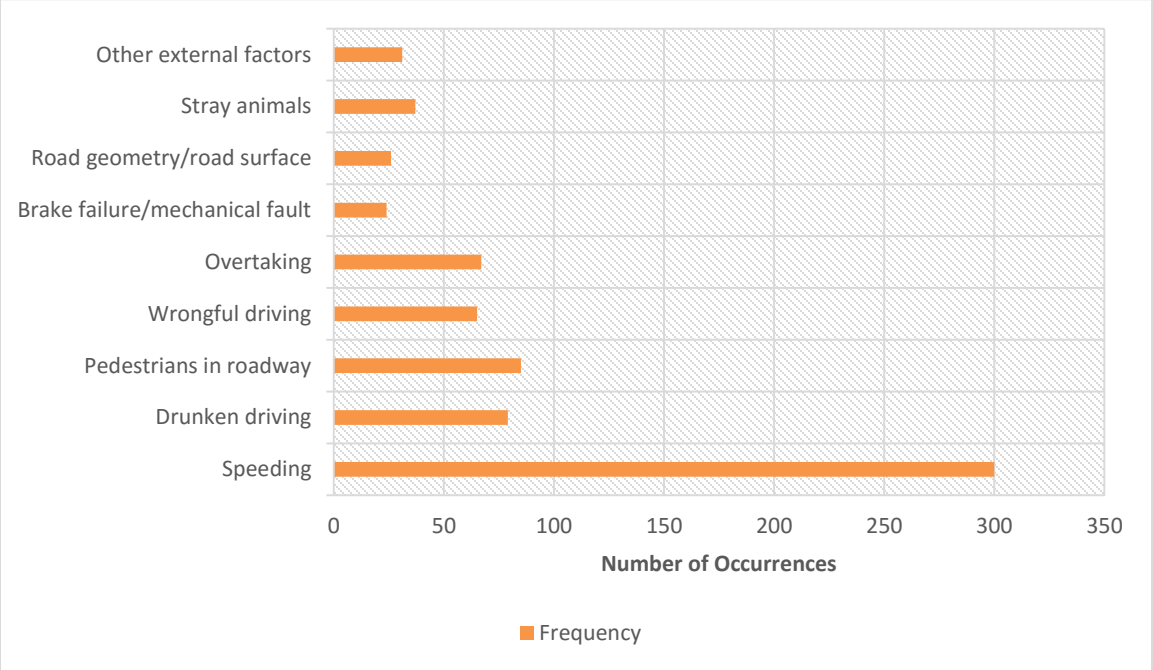


Source: LDRT Road Accident Daily Report, 2015

Figure 26: Percentage time occurrence overview of road traffic accidents in VDM for 2013

4.4.4 Factors Contributing to Road Traffic Injuries and Fatalities in VDM in 2014

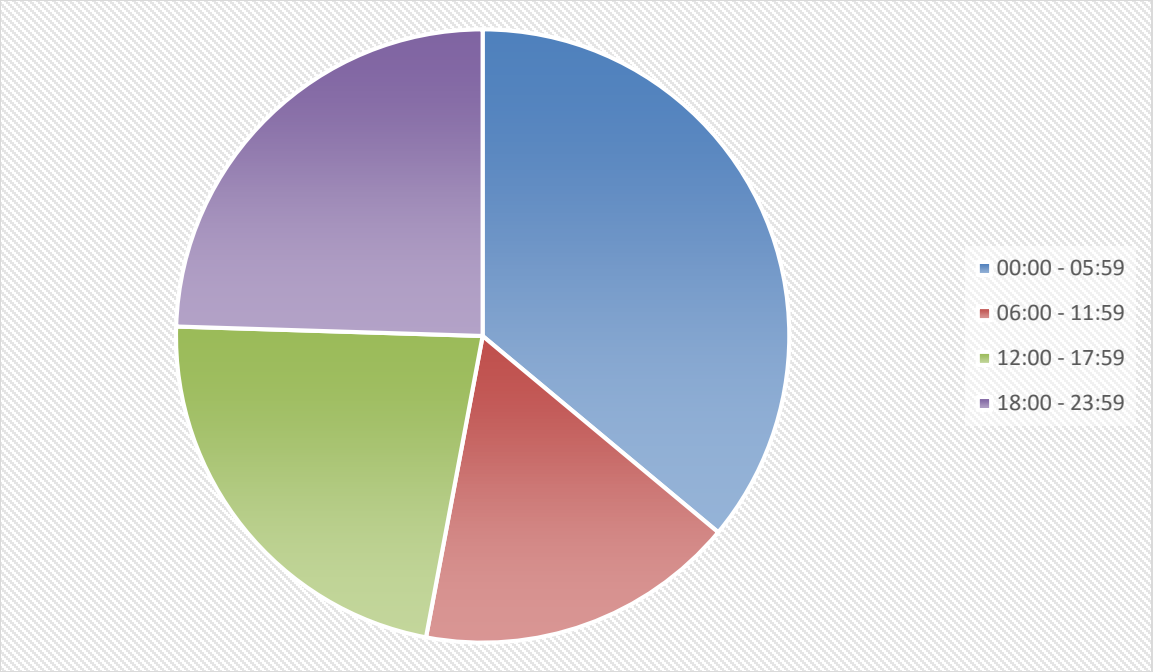
Figure 27 shows that a total of 714 road traffic accidents occurred within the VDM in 2014. Speeding accounted for 300 and 85 accidents were as a result of pedestrians in roadways, 79 and 67 were due to drunken driving and reckless overtaking, respectively. Wrong driving by motorist resulted in 65 of the road traffic injuries and fatalities with 24 attributed to brake failure/mechanical fault; 26; 37 and 26 from stray animals on highway and road geometry/road surface respectively. Other external factors were responsible for 31 accidents.



Source: LDRT Road Accident Daily Report, 2015

Figure 27: An Overview of contributing factors responsible for road traffic accident in VDM for 2014

It was observed that 36% of road accidents occurred from 00:00 – 05:59 block hours of the day, followed by 24% from 18:00 – 23:59, while 23% occurred from 12:00 – 17:59 and 17% from 06:00 – 11:59 block hours (see Figure 28).

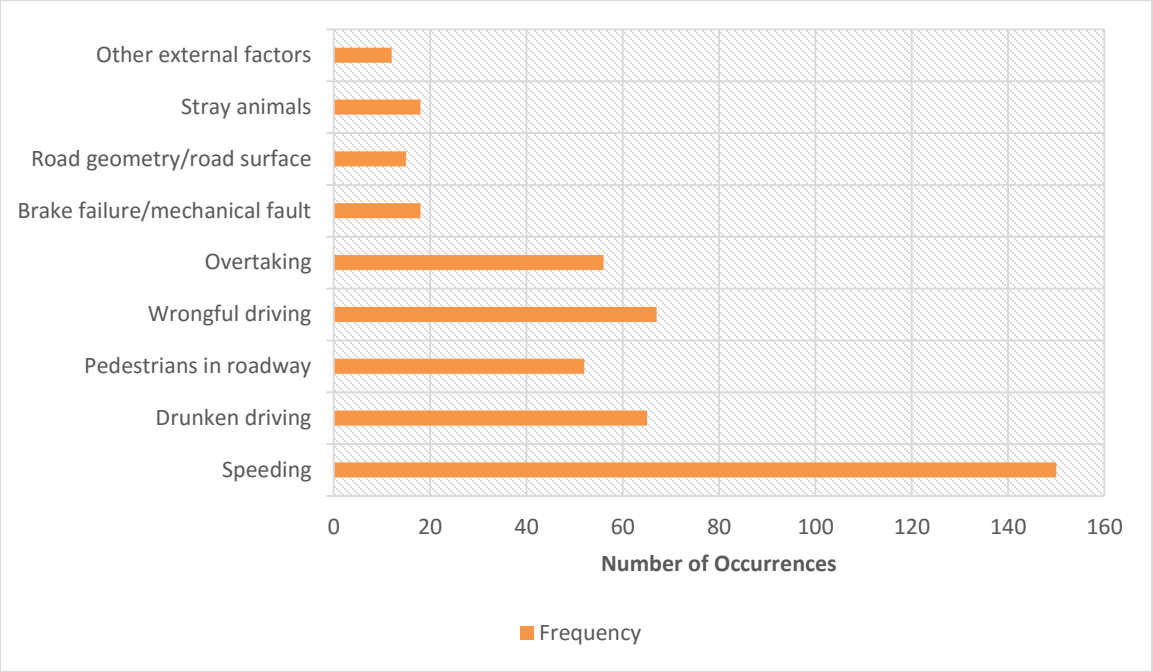


Source: LDRT Road Accident Daily Report, 2015

Figure 28: An overview of percentage time of occurrence of road traffic accidents in VDM in 2014

4.4.5 Factors Contributing to Road Traffic Injuries and Fatalities in VDM in 2015

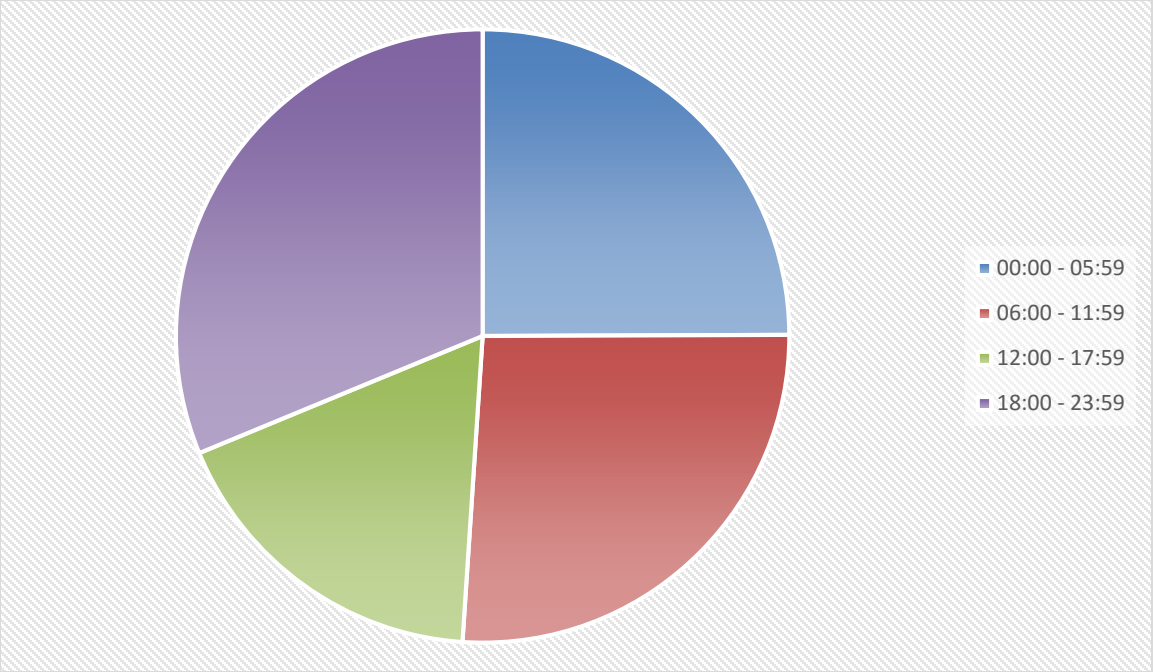
The data available for 2015 was up to August. Therefore they do not represent for the entire 2015. Figure 29 shows that a total of 554 road traffic accidents occurred within VDM in up to August 2015. Out of these 150 were as a result of speeding, 67 were linked to wrongful driving and 65 were due to drunken driving. Reckless driving caused 56 accidents and 52 were from pedestrian jay - walking in roadway of motorist. Brake failure/mechanical fault and stray animals on highway accounted for 18 accidents. Twelve were due to other external factors resulting from a combination of two or more contributing factors.



Source: LDRT Road Accident Daily Report, 2015

Figure 29: An Overview of contributing factors responsible for road traffic accidents in VDM for 2015

A time occurrence of the road traffic injuries and fatalities during this period was showed that 31% occurred during 18:00 – 23:59, with 26% occurring between 06:00 – 11:59 block hour, and 25% occurring from 00:00 – 05:59 hours. The 12:00 – 17:59 block hour experienced 18% of the road traffic injuries and fatalities for 2015 (see Figure 30).



Source: LDRT Road Accident Daily Report, 2015

Figure 30: Percentage time occurrence overview of road traffic accidents in VDM for 2015

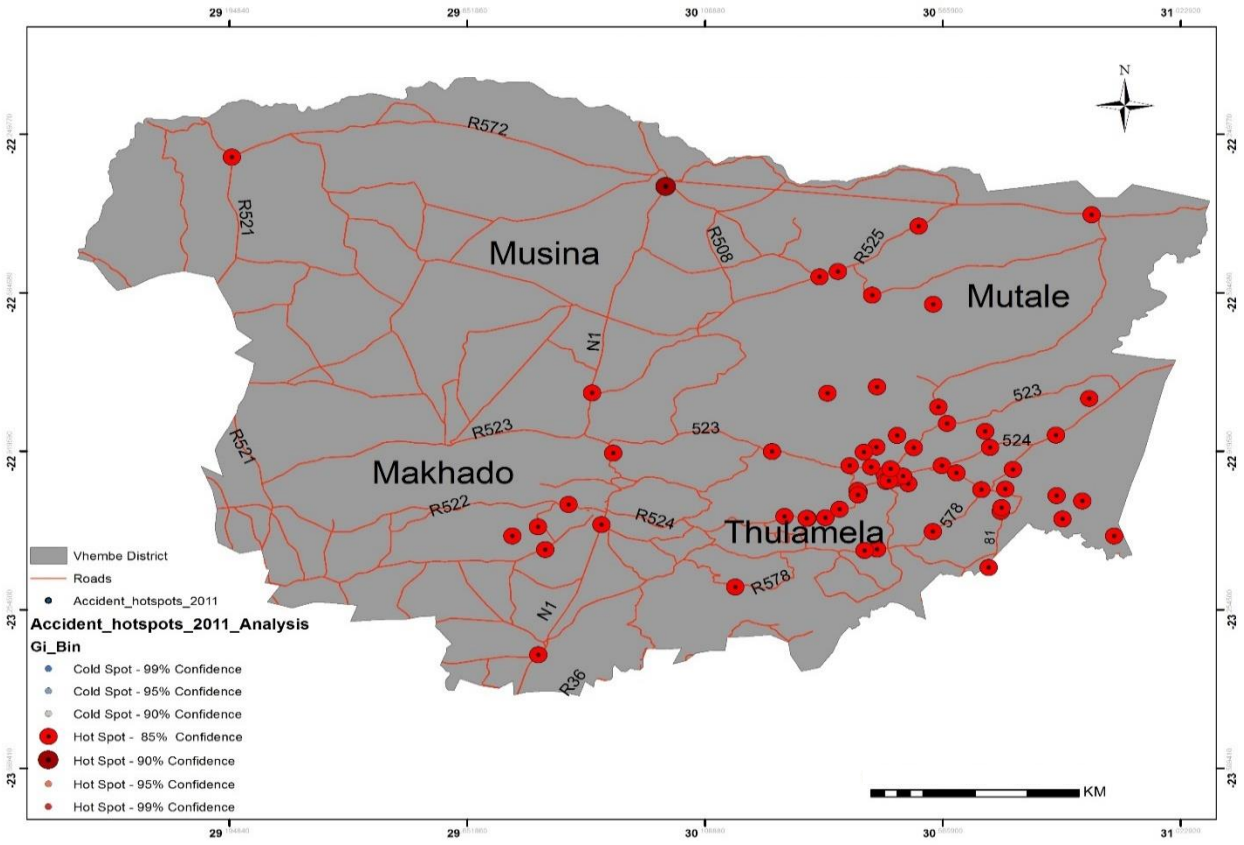
4.5 Road Traffic Injuries and Fatalities Spots and Hotspots within VDM

The road traffic injuries and fatalities hotspots within Vhembe District were identified based on the location where the road accident occurred within the district. These were extracted from the accident report collected between 2011 and 2015. These spots were double checked during field survey to collect GPS coordinate which was processed using Microsoft Excel and converted from degree second and minutes (DMS) to a suitable decimal degree (DD) to be used in ArcGIS 10.2. The coordinate points were then exported from Microsoft Excel into shapefiles for Getis hotspots analysis. There was different level of confidence that was derived from Getis hotspots analysis based on the shapefiles of each particular year. The different maps generated from the shapefiles and Getis hotspots analysis are presented below under sub-years. There were some locations that appeared throughout the study period as hotspots area within the district.

4.5.1 Road Traffic Injuries and Fatalities Hotspots within VDM for 2011

Over 150 different locations were recorded as road traffic accidents spots in 2011 and about 56 were identified by the researcher as hotspots due to the numbers of people involved in road traffic injuries and fatalities at that spot. For a location to be identified as a hotspot it was supposed to

have at least 4 or more people involved in road traffic accidents at each spot. Major road accident hotspots were along the major roads within the district. On R524 about 20 hotspots were identified for 2011, which is one of the major road into Vhembe District. Other hotspots identified were along arterial roads connecting surrounding villages to the central business district in Thohoyandou. There were about 8 hotspots identified on R523, with 9 hotspots identified on R578. Only 5 hotspots were identified on N1 and other arterial roads within the district. Roads such as R508, R522, R81, R527 and R525 have an average of 3 hotspots each. All the identified hotspots in 2011 were of 85% level of confidence and only one hotspot along N1 came out to 90% level of confidence after Getis hotspots analysis was carried out on the 2011 road accident spots within Vhembe District. Figure 31 shows the 2011 exported map of Getis hotspots analysis from ArcGIS 10.2. There was cluster of hotspot locations in Thulamela Municipality. The reason was attributed to the role of Thohoyandou town serving all the nodal villages within the district and also serving as both administrative and commercial centers of Vhembe District.

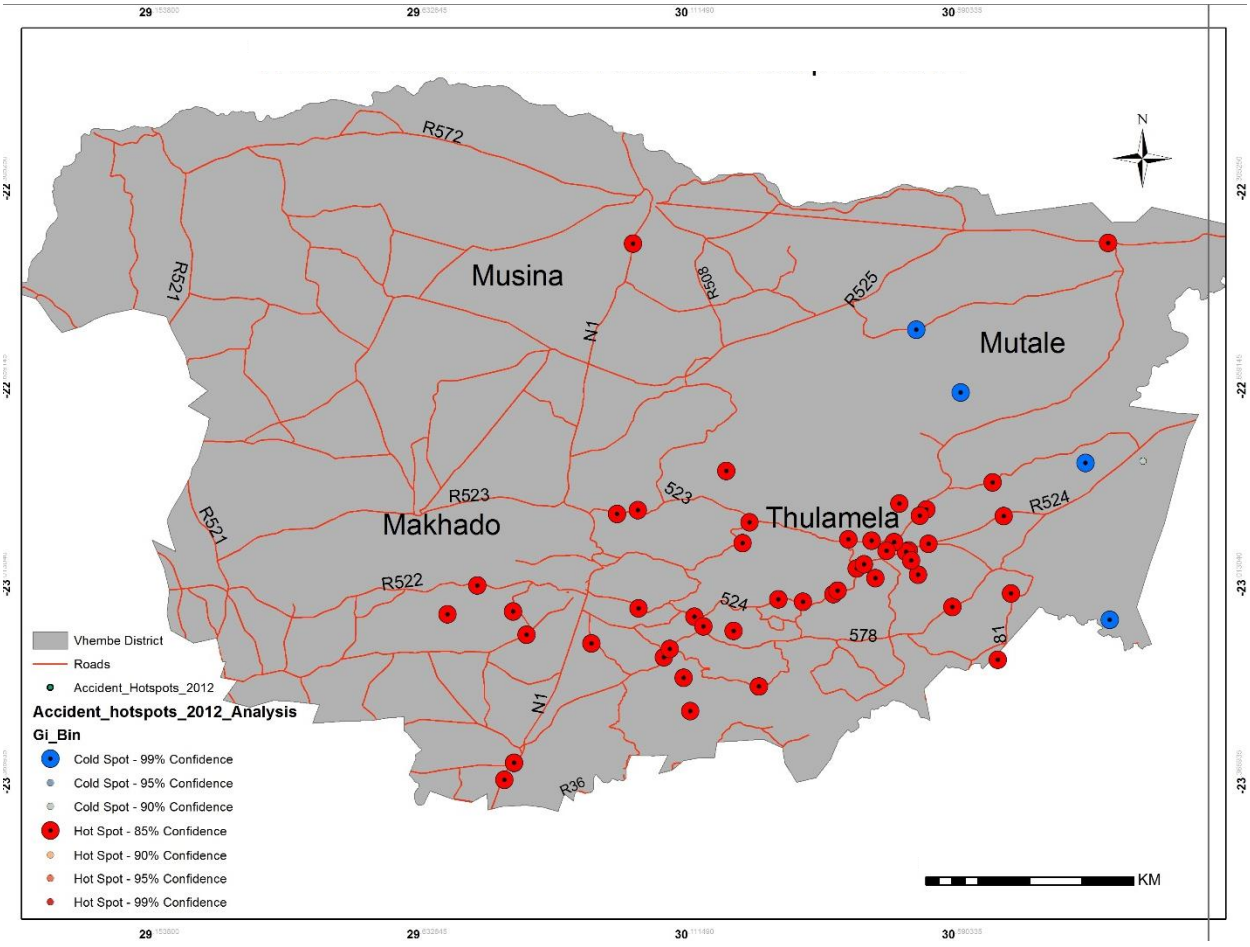


Source: Researcher's ArcMap analysis, 2015

Figure 31: Road Traffic Injuries and Fatalities Hotspots in Vhembe District for 2011

4.5.2 Road Traffic Injuries and Fatalities Hotspots within VDM for 2012

The total road traffic accident spots for 2012 was about 135, which were not necessarily from the same locations as those of the previous years. After taking into consideration the required minimum persons to be involved in road traffic injuries and fatalities a total of about 52 hotspots were identified in 2012. The areas with the highest numbers were found on R524 with 18 hotspots locations, followed by R523 with 11 hotspots. Other major roads have an average of 3-5 hotspots areas. The outcome of Getis hotspot analysis revealed 4 cold spot areas with 90% level of confidence and 48 hotspots with 85% level of confidence. Figure 32 shows the exported map of Getis hotspots analysis from ArcGIS 10.2 for 2012. On the N1, which is a national road, 3 locations were identified as hotspots and most of the hotspots areas were clustered in Thulamela Municipality as observed in 2011.

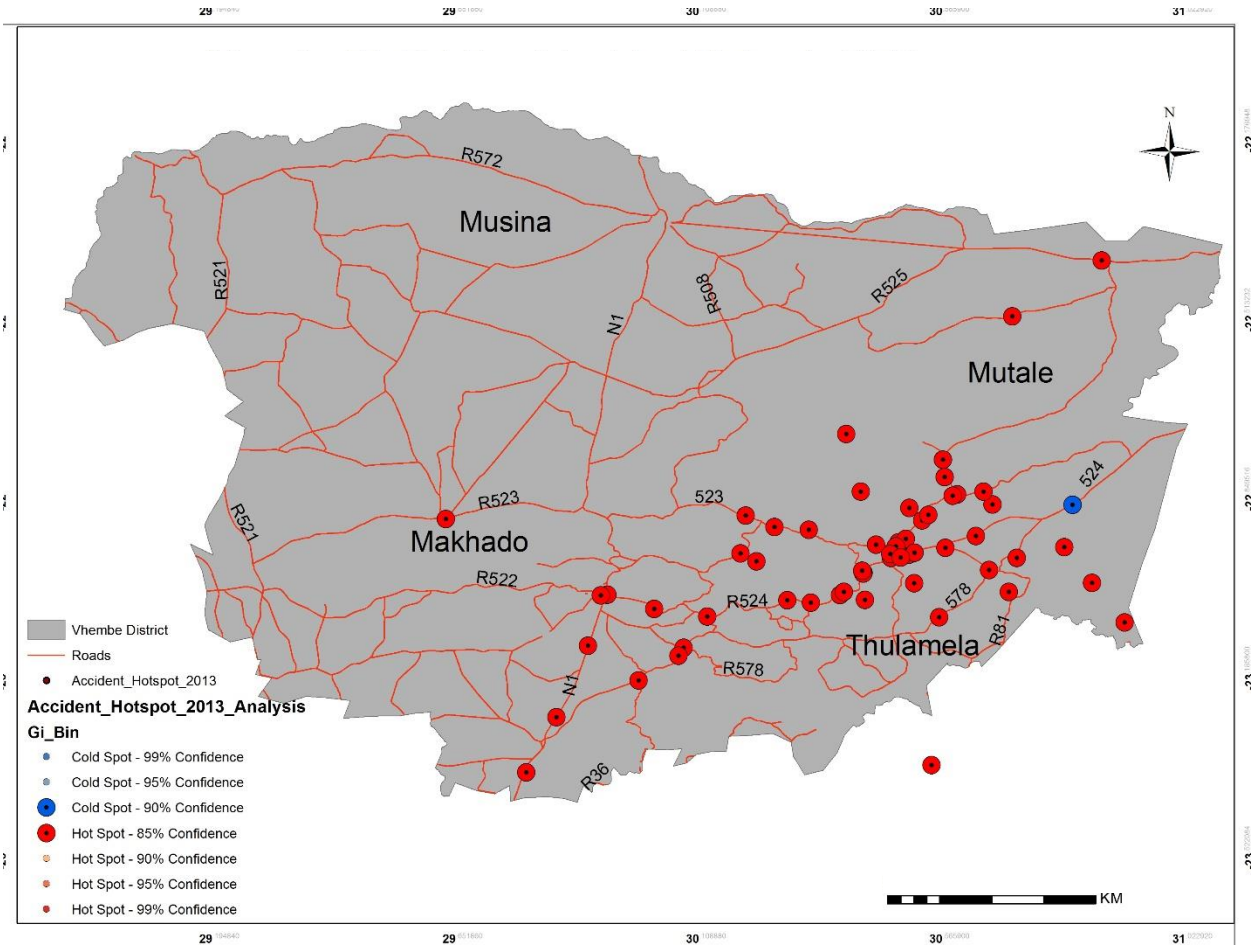


Source: Researcher's ArcMap analysis, 2015

Figure 32: Road Traffic Injuries and Fatalities Hotspots in Vhembe District for 2012

4.5.3 Road Traffic Injuries and Fatalities Hotspots within VDM for 2013

In 2013 the total road accident areas observed was about 140 locations which resulted in 55 hotspot locations within the district. These figures exclude the December period. Clusters of hotspot areas were located in Thulamela with R524 having 14 hotspots and R523 having 10 hotspots, which were the roads with the highest number of traffic accidents. Other roads, such as R578, N1, R81 and R522 were those with few road traffic injuries and fatalities hotspots. There was one cold spot area with a 90% level of confidence on R524. All identified hotspots were of 85% level of confidence in the Getis hotspots analysis extracted from ArcGIS 10.2, using coordinates points of the locations obtained from road accident reports of the district (see Figure 33).

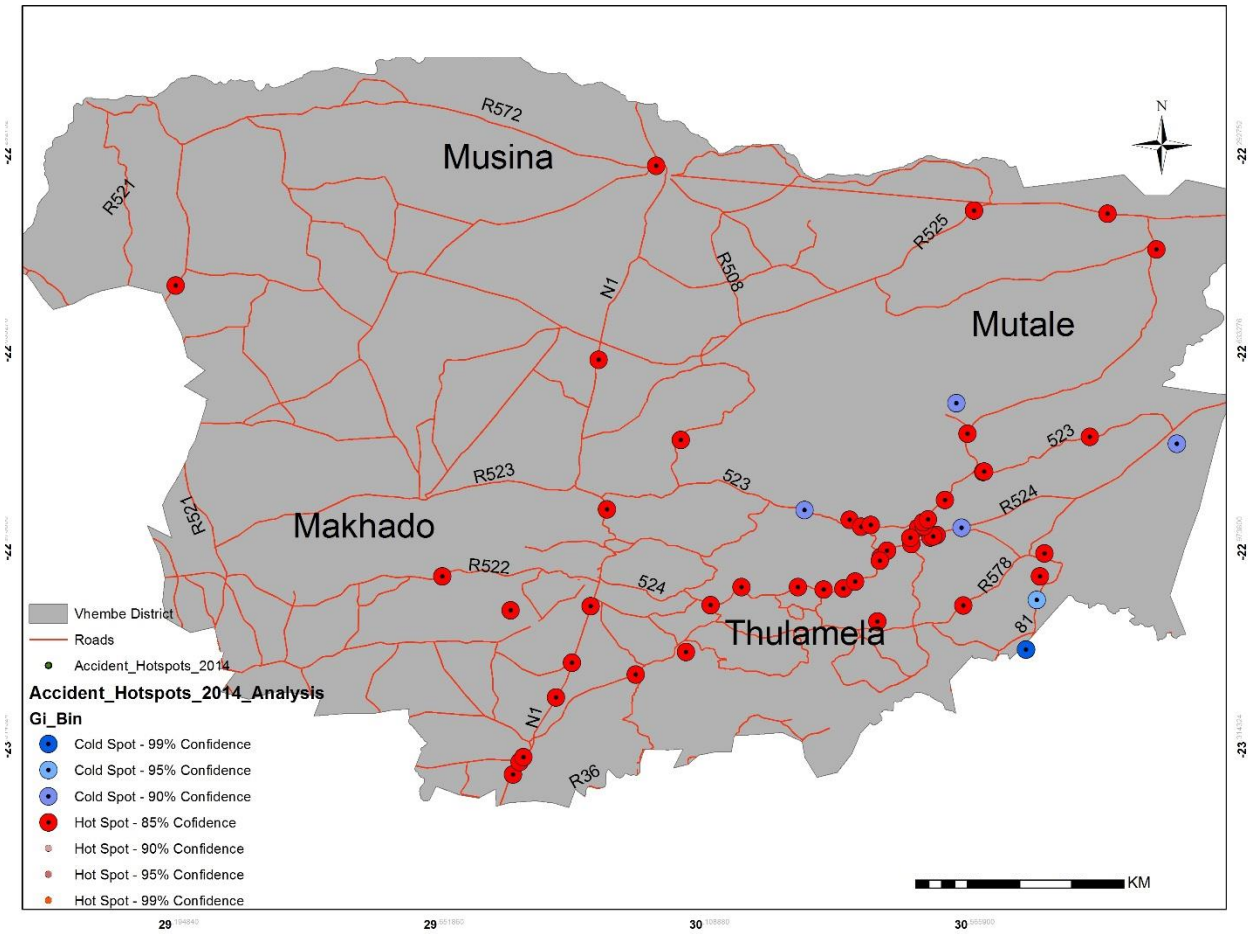


Source: Researcher's ArcMap analysis, 2015

Figure 33: Road Traffic Injuries and Fatalities Hotspots in Vhembe District for 2013

4.5.4 Road Traffic Injuries and Fatalities Hotspots within VDM for 2014

Road traffic accident locations for 2014 as observed from the traffic accident records totaled 157. However, the total road traffic injuries and fatalities hotspots were about 42, with 6 cold spots identified. All identified hotspots were of 85% level of confidence. The cold spots were of different levels of confidence. One of the cold spots had 99% and another had 95% level of confidence based on the outcome of Getis hotspot analysis. There were also 4 cold spots with a 90% level of confidence. It was observed that 8 hotspots were on the N1 while other major road leading to the district had the following: 14 hotspots on R524, 10 hotspots on R523 and 5 hotspots on both R578 and R81. The overall outcome of 2014 Getis hotspots analysis can be seen in Figure 34. As in the previous years there were clusters of hotspots in the Thulamela area of the district.

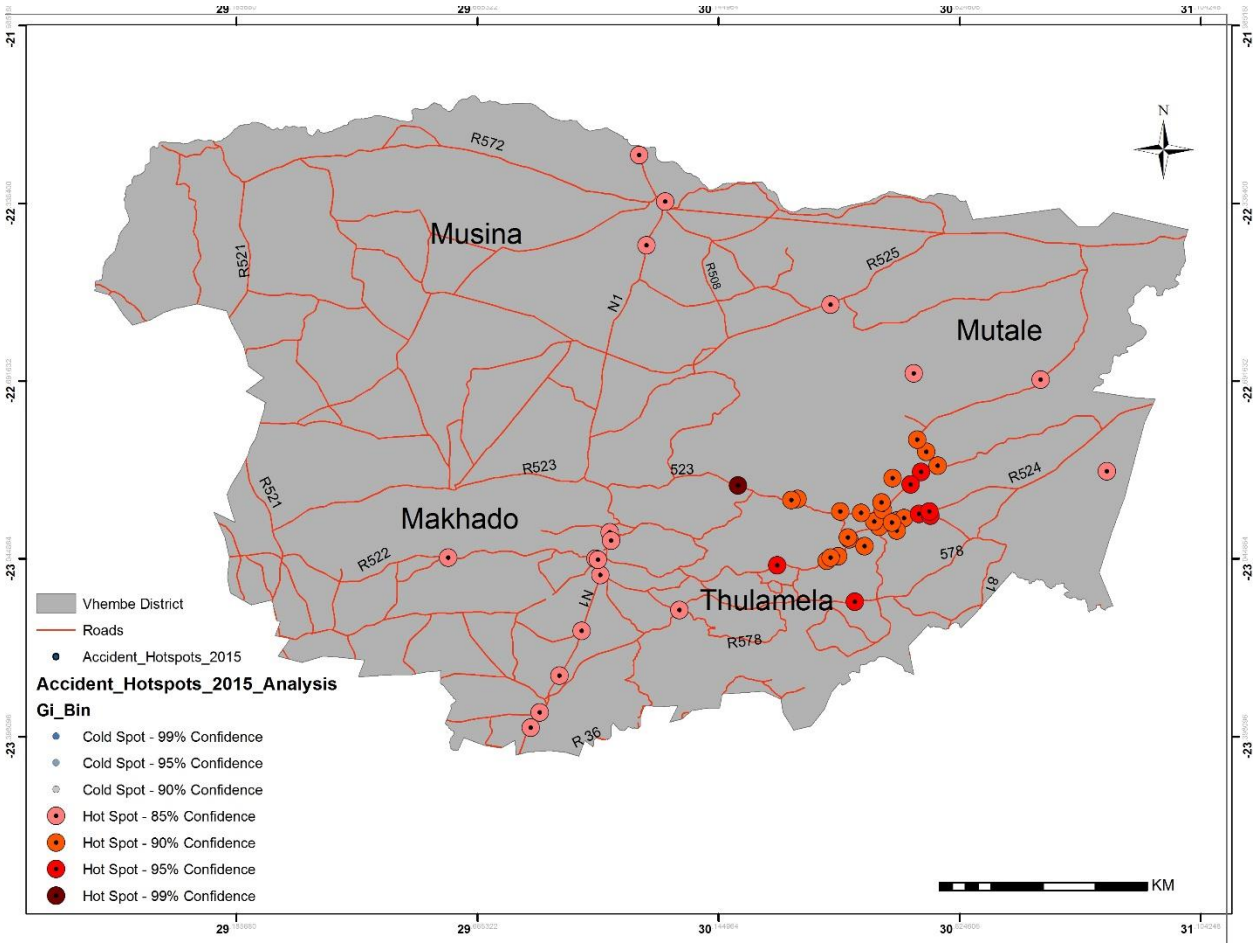


Source: Researcher's ArcMap analysis, 2015

Figure 34: Road Traffic Injuries and Fatalities Hotspots in Vhembe District for 2014

4.5.5 Road Traffic Injuries and Fatalities Hotspots within VDM for 2015

The road traffic accident spot for 2015 covered the January to August period, due to the road accident data available. A total of 100 road accidents locations were observed out of which 43 were identified as hotspots. The identified hotspots were of different levels of confidence. There were 17 hotspots with 85% level of confidence, 19 hotspots with a 90% level of confidence, 7 hotspots with 95% level of confidence and 1 hotspot with 99% level of confidence. There were 13 hotspot areas on R524 and 11 on N1. On the R523 there were 10 hotspots with a 99% level of confidence. Figure 35 shows the exported map of Getis hotspots analysis from ArcGIS 10.2 for the studied period in 2015. The hotspots were clustered within Thulamela Municipality.



Source: Researcher's ArcMap analysis, 2015

Figure 35: Road Traffic Injuries and Fatalities Hotspots in Vhembe District for 2015

4.6 Road Users Attitudes towards Road Safety Preventive Measures in VDM

There are several road safety preventive measures on the district roads. However, these measures which are in the form of traffic signs, stops, regulated speed limit, are not adequately adhered to by road users. During the field survey on the major roads within the district, motorists and pedestrians struggle for the right of way, especially in areas where there were few traffic officers to enforce adherence to road safety measures. Likewise, behavioural attitudes of road users varied depending on the age of the motorists and pedestrians.

4.6.1 Behavioural Attitude of Motorist in Vhembe District Municipality

The behavioural attitude of motorists within Vhembe District Municipality was evaluated from the questionnaires distributed to motorists during field surveys. Responses were based on guided questionnaire for motorists within all four municipalities of the District. When asked how often they observe road traffic speed limit(s) while driving, about 52% responded that they sometimes do, 26% said they always adhere to the stipulated speed limit and 22% of the respondents said they were not sure if they adhered to the stipulated speed limit (see Table 9).

Table 9: Motorists' Response on Observing Road Traffic Speed Limit(s) within VDM

VDM	Always	Sometimes	Not Sure	Total
Thulamela	10	25	5	40
Makhado	12	23	5	40
Musina	10	20	10	40
Mutale	10	15	15	40
Total	42 (26%)	83 (52%)	35 (22%)	160 (100%)

Source: Researcher's field data collection 2015

On giving pedestrians the right of way at zebra-crossings or stop streets, 31% of the respondents said they give pedestrians the right of way, 50% said they did sometimes and 19% were not sure if they did (see Table 10). In light of the attitude of the motorists, only 45% agreed that they always wear their seat belts while driving, and 55% attested that they pretended to be wearing seat belts to fool traffic officer and also to keep silent the alarm system of the car they are travelling in from further disturbance.

Table 10: Motorist Response on Giving Pedestrians the Right of Way at Zebra Crossings or Stop Streets

VDM	Always	Sometimes	Not Sure	Total
Thulamela	15	20	5	40
Makhado	15	20	5	40
Musina	10	20	10	40
Mutale	10	20	10	40
Total	50 (31%)	80 (50%)	30 (19%)	160 (100%)

Source: Researcher's field data collection 2015

4.6.2 Behavioural Attitude of Pedestrian in Vhembe District Municipality

Road safety preventive measures for pedestrian include constructing pedestrian bridges to assure proper safety when crossing the major roads/high-ways. However, some pedestrians do not make use of these bridges that may guarantee their safety. Rather, they prefer to cross the major roads carelessly by first standing in the middle of the road which is not safe at all. Most pedestrians set a bad precedent for others and tend to allow themselves to be lured into the bad act of jay-walking and jay-crossing on major road within the District.

Among the reasons they do not use the pedestrian bridges is due to the fact that some pedestrian bridges are deserted and thugs use them as hide-outs at night. Some attested that the design of the pedestrian bridges made it difficult and inconvenient to use. Table 11 shows the attitude response of pedestrians when it comes to complying with pedestrian road safety preventive measures. About 19% of the respondents said they adhered to using the pedestrian bridges, 45% did so when they felt like and 36% were not sure.

The general attitude of pedestrians on roads is worrisome as they are referred to as the most vulnerable of all road users. The survey shows that 65% of the respondents preferred to jay-walk rather than use the pedestrian bridges when crossing the road and only 35% anticipated being knocked down by motorists when standing on the median of the road before crossing. However,

about 85% of the respondents said they make use of traffic light spots when crossing which gives hope for the safety of the pedestrians.

Table 11: Pedestrians Response on use of Pedestrian Bridges during road crossing

VDM	Always	Sometimes	Not Sure	Total
Thulamela	5	25	10	40
Makhado	10	22	8	40
Musina	10	15	15	40
Mutale	5	10	25	40
Total	30 (19%)	72 (45%)	58 (36%)	160 (100%)

Source: Researcher's field data collection 2015

The respondents were asked why they did not use the pedestrian bridges to ensure good and safe road crossing. Some of the pedestrians responded by saying the design of some the pedestrian bridges was too steep for them to climb and the location is often inconvenient for them. Table 12 shows that 64% of the respondents are not satisfied with the design of the pedestrian bridges, 15% are afraid of being attacked by thugs and 21% consider the pedestrian bridges to be located in deserted places.

Table 12: Pedestrian response on disregard usage of Pedestrian Bridge

VDM	Design	Shady	Hoodlums	Total
Thulamela	27	8	5	40
Makhado	20	10	10	40
Musina	30	5	5	40
Mutale	25	10	5	40
Total	102 (64%)	33 (21%)	25 (15%)	160 (100%)

Source: Researcher's field data collection 2015

When the pedestrians were asked about the risks of being knocked down while attempting to jay-walk; about 82% of the respondents said they were sure they would not be knocked down by

motorists. Only 9% said that they are afraid of being knocked down by motorist speeding on roads. Also 9% said they were not sure if they are afraid when they were crossing the road within the district (see Table 13).

Table 13: Pedestrian anticipation of being knocked down by motorists during road crossing

VDM	Yes	No	Not Sure	Total
Thulamela	2	30	8	40
Makhado	3	35	2	40
Musina	5	33	2	40
Mutale	5	33	2	40
Total	15 (9%)	131 (82%)	14 (9%)	160 (100%)

Source: Researcher's field data collection 2015

Awareness of road traffic regulations by pedestrians within the district was also investigated. About 66% of the interviewed pedestrians responded that they were aware of the traffic signs they needed to observe while on the road. Close to 25% said they were not aware what traffic signs they should look out for while using the road and 15% were not sure of the road traffic signs they needed to observe when using the road (see Table 14).

Table 14: Pedestrian Response on traffic regulations they needed to observe while on the road

VDM	Yes	No	Not Sure	Total
Thulamela	25	10	5	40
Makhado	28	8	4	40
Musina	31	5	4	40
Mutale	22	7	11	40
Total	106 (66%)	30 (19%)	24 (15%)	160 (100%)

Source: Researcher's field data collection 2015

4.6.3 Road Traffic Officers Perspective about Road Safety in Vhembe District

Some traffic officers who were interviewed during this research explained that much has been done by their authorities to ensure that all road users comply with the all existing rules and regulations while making use of the road. They added that even though they had some challenges in terms of human capacity, most of the district roads were regularly patrolled to enforce compliance by road users. The traffic officers stated that traffic offenders are regularly fined and arrested in cases of reckless driving and drunken driving. On issues relating to who should be held liable for road traffic injuries and fatalities on the road, their response was most of the road traffic accidents can be attributed to social behaviour of road users. According to their records almost 80% of the causal factors of road traffic accidents are negligence and non-compliance of traffic rules by road users in particular motorists.

The traffic officers emphasised that they were visible on the road during the morning and afternoon peak periods. Also during weekends, when they believe road users indulge in some undesirable social behaviours and late hours for alcohol indulgence. They stated that most of their tiring working hours were on weekends and festive periods, when the district roads became very busy throughout the day and many arrests were made during these times. They lamented the need to constantly work with the Police to effect spot arrests for all traffic offenders. Their suggestions on measures that need to be taken include proper education of all road users before being allowed to drive on the District roads. Some of the officers agreed that road geometry plays a minimal role and contributes minimally to road traffic injuries and fatalities. However, others believe that road design does not have any causal effect on road traffic injuries and fatalities; rather road users should be responsible for their actions on the road.

Furthermore, they pointed out some challenges of getting the dominant causal factors of most road accidents because they only arrive at the scene of the crash minutes after it would have occurred and mostly they record what eye witnesses tell them. The traffic officers added that they have a good working relationship with EMS and ambulance services to transport road accident victims to the nearest hospital for prompt medical attention and care.

4.6.4 SWOT Analysis of Road Safety Measures in Vhembe District

SWOT was conducted to evaluate successes and failures of these known road safety measures. The Traffic officers interviewed recommend that more can be done to improve the road safety

measures and awareness for all road users. Table 15 evaluates road traffic safety measures to determine which areas need to be reviewed.

The road safety awareness and campaigns in the District are driven and organised during festive season and holiday periods. Providing opportunity for self-test breathalyzer for drivers to check themselves before driving. The safety awareness campaigns also provide information in the print media which are distributed to all road users to raise the level of consciousness while on the roads. However, campaigns are not taken to rural areas with some motorist not reading billboard adverts and print information. The interviewed traffic officers shared lights on the low participation and compliance by motorist during the festive season which often resulted into high numbers of carnages on the district roads.

Traffic lights within the district are easily controlled and assist in the coordination of vehicle direction and passages most especially at four way stops and T-junctions. It also communicate to other road users about the right of way when at a mixed up. It is challenging as most of the traffic lights rely on electricity. Hence, when there is a power outage then the traffic lights stop working creating confusion among all road users. Also some motorist damages traffic lights during road accidents.

Usage of pedestrian bridges to guarantee safety of pedestrians at all times remains challenging within the district. During field observation of the study area, most the pedestrian bridges had been abandoned and remains are hide out for thugs during the night. This leads to high rate of jay-walking on the district roads. Demarcation of Zebra crossings to ensure pedestrian have safe road crossing are present on the district roads, but motorists tend to be adamant on complying with road traffic rules and regulations. The side-walks for pedestrians in the CBD are being used by street vendors, hindering pedestrians from walking free along the road, which give rises to struggle of right of ways between motorists and pedestrians.

Traffic officials assist with direction and orderliness during traffic peak period. They ensure and enforce traffic rules and regulation by apprehending and arresting traffic offenders. Even though, much focuses are on motorists with less attention towards pedestrians who violates traffic rules and regulations. They are often labelled as corrupt and inconsiderate when they are diligently discharging their duties on the roads. These officials do generate revenue for government through the issuance of spot fines and traffic tickets to over speeding motorists.

Some motorists claimed that traffic laws are not widely circulated and claim ignorance of the law. The use and installation of speed cameras on highways and speed traps to constantly take reading of over speeding motorists during late hours have being assisting the traffic authority to monitor the roads during late hours.

Due to the nature of the geographical landscape, the road geometry consist of uphills and downhills with bends that needs careful approach when driving. These influences the road designs within the study area and visible points where to place road signage for motorists to observe while driving. Some road signage which are to guide motorists are often not well place in points visible to drivers while on the road. There are some intersections where the road geometry will not allow road signage be of good visibility to drivers. Area location like these are blind spot for road traffic accident occur and motorists need to be extra careful at these points.

Table 15: SWOT Analysis on Road Safety Measures within Vhembe District Municipality

Road Traffic Safety Items	**Strength**	**Weakness**	**Opportunities**	**Threats**
Road Safety Awareness and Campaign	- Road safety campaign along major highways and main route within the district. - Arrive Alive campaign during festive and holiday periods. - Traffic officer administering self-test breathalyzer to motorists to check themselves before driving. - Billboard adverts and outreach programmes on media. - Distribution of print information during traffic peak hours.	- Often done during holiday periods and festive season. - Campaigns are not taken to rural areas. - Some motorist do not use breathalyzer when given. - Some motorists do not read billboard adverts. - Paper print information can easily be discarded.	- The programme can be improved to run every month. - Campaigns can be instituted as part of grade 12 learners' curriculum. - Awareness can be introduced before obtaining/ renewal of driver's license.	- If not well planned repetitive campaign can be less effective. - Less participation and compliance by motorists.
Road Traffic Signage	- Assisting in coordination of traffic at different locations - Preventing traffic congestion at	- Some signage not visible from a distance. - Signs seen on few roads. - Motorists do not obey all the signage	- There can be improvement to new signage. - Encourage good use of signage by motorist.	- Some motorists do not obey road signage. - Some motorists choose which road signage to obey.

	crossroads and four-way stops. - Cautioning motorists and road users on what is on the road		- More signage can be put on roads.	- Poor visibility of road signage in bad weather conditions.
Traffic Officials	- They assist with traffic direction and orderliness during peak traffic period. - Ensure and enforce traffic rules and regulation. - Apprehend traffic offenders and road users who violate traffic laws. - Issuing out traffic fines to traffic offenders.	- Much focus is on motorists with less attention on pedestrians who violate traffic laws. - Routine patrols on road done occasionally. - Traffic officers issue fines to motorists only. - Less human capacity to cover all roads.	- More roads can be covered and all round traffic regulation. - Employment and job opportunities. - Effective training for traffic officers. - Traffic officers generate revenue from issuing traffic fines and tickets.	- They are often labeled as corrupt and inconsiderate. - Traffic officials do not arrest pedestrians who jay walk on roads. - Some motorists insult and disrespect traffic officers in their line of duty.
Traffic Law and Regulations	- It empower traffic officials and enable them to discharge their duties without fear. - The laws are protected under the Constitution of the Republic. - Instill discipline in the mind of motorist and other road users.	- Traffic laws are not widely circulated. - Not popular amongst all road users. - Can be easily violated with minimal punishment	- Allow for the installation of cameras on highways and speed traps to be used as evidence in the court of law. - Gives room for on the spot evidence to issue traffic fines. - Can be reviewed periodically.	- Road users tend to claim ignorance of the law. - There can be loopholes in the law that motorists can capitalise on.

Traffic Lights	- It is easily controlled. - Can be used to direct traffic on a particular road at a particular time, - It does not required heavy man power as it can be automated. - It communicate to all road users when at a point of mixed up. - Effective all year round.	- Can be easily damaged. - Often rely on electricity and in cases of power outage then it stops working.	- It can be improved to use alternate sources of power	- It can easily be ignored at night. - Can create confusion on who has right of way when it stop working. - Often times they have been knocked down by reckless motorists.
Pedestrian Safety Crossings	- Provision of side-walks when constructing roads - Demarcation of Zebra crossings on the road to allow pedestrian passage. - Allow construction of over -head pedestrian bridges. - Provision of pedestrian crossing traffic lights.	- Some of the side-walks in the CBD areas are often used by street vendors. - Some of the pedestrian bridges design are too steep and not user friendly. - No security personnel from shady pedestrian over-bridge.	- Side-walks can be monitored to avoid mixed usage. - Pedestrian crossing bridges can be redesigned to allow for wheelchair crossing and elderly people crossing. - Appointment of security personnel to safeguard lives.	- Some pedestrians are too lazy to use the crossing bridge. - Tendency to jay walk and discourage other pedestrian from using the pedestrian bridge.
Road Safety Education and Enlightenments	- Provide avenues for communities and tribal council meetings.	- Often conducted occasionally during	- There can be a curriculum set up in institutions of learning	- Road users tend to ignore this kind of

	- Allow for adult based education in form of teaching road signs meaning and actions. - Bring road safety consciousness to motorists and pedestrians. - Provide forums for community engagement to get clarity on road safety tips, rules and regulations.	festive season and high traffic volumes. - Inexistent of learning curriculum. - Can be introduced as part of training during issuance of driver licenses to motorist.	- It can be organised on a monthly basis to keep reminding people of the need for road safety. - It can be displayed in all forms of media.	gatherings if they are not attractive and exciting.

CHAPTER FIVE: DISCUSSION OF THE FINDINGS

5.1 Introduction

The objectives set out in the course of this study are stated above on page six of this dissertation and will serve as a guide to discuss findings of the research. Road traffic injuries and fatalities are a combined responsibility of human behaviour, vehicular and environmental induced factors. The resolution of the United Nation (UN) in 2010, was to reduce world death due to road traffic accident by 50% in year 2020, hence declaring 2011-2020 as action decade for road safety. This declaration was directed at providing individual country members platform to take proper steps and action in ensuring that road traffic accidents vis-à-vis road traffic injuries and fatalities are reduced to a minimum level so as to save more lives. The Department of Road and Transport and other relevant offices are responsible to monitor and ensure that the goal of road traffic death reduction is achieved by 2020. South Africa, which has the second highest number of road fatalities, will require concerted efforts to ensure the UN declaration is not just on paper but is translated to what is happening on the nation's road on a daily basis ((Shavhani, 2007:36, RTMC, 2011). Hence this study was done to analyse patterns and trends of road traffic injuries and fatalities at a district level within South Africa.

5.2 Composition of Road Traffic Injuries and Fatalities for Vhembe District

There was a slight reduction in road injuries and fatalities from the study period of January 2011 – August 2015. On the average 86 fatalities victims are recorded annual on the District roads. This observation was in conformity with STATSA road accident report of 2009, whereby 90 fatalities were recorded annually between 2001 and 2006. The year 2011 recorded a total number of 112 fatalities which decreased to 87 in 2012, and 46 in 2013, excluding the month of December; 85 in 2014 and 99 in 2015, which covers the period up to August (STATSA, 2009). The research findings show that 2013 recorded the lowest fatalities within the district, followed by 2014. This aligned with STATSA report, stating that Limpopo roads are to be considered second deadly in South Africa after Kwazulu-Natal roads (STATSA, 2009).

The same pattern was observed for serious injuries with an average of 326 victims per annum, which were 412 in 2011 and decreased to 360 in 2012, and 335 in 2013 excluding December;

272 in 2014 and 253 in 2015 which was up to the month of August. The same was observed for minor injuries, starting with 1004 in 2011, reduced to 634 in 2012; 717 in 2013 excluding December; 612 in 2014 and 538 for the year 2015 up to the month of August (see Table 16). The reduction in patterns and trends of road traffic injuries and fatalities can be associated to concerted efforts and actions of the Department of Road and Transport within the district towards responding to the mandate from United Nations (RTMC, 2011). Changes in social behaviour of motorist and pedestrian can also play vital role in the reduction trend. This correlated with a study done by Sebogo *et.al* (2014), they concluded that road traffic policies and change in human social behaviour due to change in alcohol policies can be effective in the positive direction including road traffic accidents.

Table 16: Summary of Composition of Road Traffic Injuries and Fatalities in Vhembe District

Year	Fatalities	Serious Injuries	Minor Injuries
2011	112	412	1004
2012	87	360	634
2013	46	335	717
2014	85	272	612
2015	99	253	538

Source: LDRT Road Accident Daily Report for Vhembe District Municipality, 2015.

The pattern of highest month for fatalities varies between the different studies years. In 2011 the months with the highest fatalities were July and December, whereas in 2012 it was observed in June and February. For the year 2013, it was in June and July, in 2014 it was in February and July, 2015 it was in April and July. The month of July was the deadliest road traffic month in this study because it occurred almost in all the studied years. In 2011 a similar pattern was observed for the highest serious injuries month in March and July; in 2012 it was January and August; in 2013 it was in July and September; in 2014 it was in May and December; and for 2015 it was April and July. Again the month of July appeared three out of five times. The same pattern was observed when considering highest minor injuries month for the study period. In 2011 it was June and September; in 2012 it was January and December; for 2013 it was May and July; in 2014 it was July and December; while for 2015 it was April and July. This findings relates to a study done by Oppong (2012) in Ghana, where he identified variations in the months of high road accident

occurrence and clearly showed that July is as deadly as the festive period of December. This can be attributed to the mid-year holiday period for institutions of learning all over the country.

The analysis done on the road traffic accident reports for the studied period indicates that the month of July requires critical attention and action need to be taken by the district Department of Roads and Transport in ensuring that traffic officials are more visible during this month on all the district roads (LDRT, 2013). More campaigns and road shows to enlighten people on the necessity and importance of adhering to road safety rules and regulation should be conducted frequently and in particular during the months of July and December (RTMC, 2011).

5.3 Factors Contributing to Road Traffic Injuries and Fatalities in Vhembe District

The factors contributing to road traffic injuries and fatalities identified from this study are human induced factors such as: speeding; drunken driving; pedestrian in roadway; wrongful driving; and overtaking. Vehicular induced factor such as brake failure, mechanical fault, and vehicle road worthiness. Road geometry and road surface, finally other external factors such as: stray animal and environmental related factors. All these factors were reiterated by Molla *et.al.* (2014) and Sebogo *et.al* (2014), in their studies on road traffic accident causal factors. However, some road accidents are caused by multiple factors, depending on the dominant occurrence factor. Speeding was identified as the most dominant contributing factor for road injuries and fatalities within the district. In 2011 out of the 554 road traffic that occurred, 243 were as a result of speeding. Similarly in 2012 there were 280 incidences of speeding from 722 road traffic accidents. For 2013, 250 cases of speeding out of 617 road accident that occurred were reported. In 2014 speeding contributed to 300 road accidents out of 714 and in 2015 there were 150 speeding-related road accidents out of 493 occurrences. About 245 road traffic accidents occurred annually from speeding my motorists (STATSA, 2009; RTMC, 2011). The advancement in the car technology of producing faster vehicles and sport cars could be associated with why motorists reasons for speeding on highways. Even though the national maximum speed limits is at 120km/h and there should be no need for cars speed to exceed 150km/h at most just in case of emergencies.

The next factor after speeding were pedestrians in roadways from jay-walking and careless road crossing by pedestrians. This accounted for 97 cases of road accidents in 2011, 72 in 2012, 73 in 2013, 85 in 2014 and 52 in 2015. This shows that there is a high level of pedestrian jay-walking on the District roads. This findings agrees with Anderson (2009) who pointed out that indulgence in some social vice leads to jay-walking of pedestrians. This requires urgent attention from traffic

officials, they should start issuing spot fines to pedestrians who do not take into consideration road safety preventive measures (RTMC, 2011). Another contributing factor that is worrisome is wrongful driving and reckless overtaking. These two contributing factors are responsible for motorists' failure to adhere to road signage and stipulated speed limit, thereby causing road carnages which often involve other innocent motorists and pedestrians. In 2011 wrongful driving and overtaking was responsible for 130 road accidents out of the 554 recorded for that year. Similarly in 2012 it was 172 road accidents out of 722 due to wrong driving and overtaking. For 2013, it was 134 out 617; for 2014 it was 132 out 714 and in 2015 it was 123 out of 493. The average of 138 occurrence of road accident due to wrong driving correlated with Li (2006) findings from his studies in Texas, relating most road accidents as a result of impatient and wrongful driving by motorists.

Time of occurrence was also identified as a contributing factor to the severity of the road traffic injuries and fatalities. In this research, it was found that most road accidents occur during the 18:00 – 23:59 time block. As seen from the data analysis chapter more than 34% of the road traffic injuries and fatalities occurred during the 12:00 – 17:59 time block in 2011. However, this changed in 2012 as 30% of road traffic injuries and fatalities for that year occurred during the 18:00 – 23:59 time block. In 2013 37% of road traffic injuries and fatalities occurred during 18:00 – 23:59. For 2014 it changed again to 36% during the 00:00 – 05:59 time block, while in 2015 it was 31% during the 18:00 – 23:59 time block, as determined by the researcher for this study. Findings from Sebogo *et.al* (2014) and Oppong (2012) studies correlates and elucidate to the 18:00 – 23:59 time block as the most time of the day when road accidents occurred.

5.4 Road Traffic Injuries and Fatalities Hotspots Area within Vhembe District

Most of the identified road traffic injuries and fatalities hotspots for the study period years are along the R524 road, followed by R523 and R578. These roads serve as routes which most surrounding villages use to go to Thohoyandou town which is the administrative and business capital of the district and other arterial roads have less hotspot locations. On R524 for year 2011, there were 20 identified hotspots and on R523 it was 9 with 5 hotspots on N1. The hotspots analysis conforms to LDRT (2011) report. In some cases a location can be identified as a hotspot due to the number of people involved in road traffic accidents at that spot even when such place do not record any fatality. Popular hotspots for 2011 include Shayandima junction, Tshakuma junction, Elim road, Levubu, Wylliespoort, Mutoti, Tshipise, Roadhuis, and JJ motors (Chakwizira,

2010:117). During field survey observation it was noticed that most of the roads are in good condition, except for a few potholes. However, the road geometry and road design do contribute to motorist inconsideration, leading to road accidents. Some parts along R524 and R523 are narrow with less visibility during harsh weather conditions (Chakwizira, 2010:117).

Furthermore, in 2012, 18 hotspots were identified on R524, 11 on R523 and 5 hotspots on R578 and 3 on N1. In 2013, there were 14 hotspots on R524, 10 on R523 and 5 on R578. Similar hotspots were identified in 2014 with 14 on R524, 10 on R523, 8 on N1 and 5 on R578. In 2015, 13 hotspot areas were identified on R524, 10 on R523 and 11 on N1. The researcher used the Getis hotspot analysis in ArcMap 10.2 to determine the different degrees of confidence for the hotspots. It was found out that most the hotspots locations have 85% confidence. Furthermore, some cold spots were also identified. In 2012, 4 cold spots were identified but only 1 cold spot was observed in 2013 and there was 6 cold spots in 2014. The cold spot locations are places were only minor injuries occurred (Anderson, 2009; Molla *et. al*. 2014). This implies that accident hotspot areas within the district are becoming coldspot areas reducing road deaths.

It was further observed that some of the hotspot locations happened to be points of road intersections, as some of the road traffic accidents are caused by motorists' inconsideration and wrongful driving. The landscape area of Vhembe District ensures that road design does have an effect on where the hotspots are observed (RTMC, 2011). Due to the landscape within the study area, most road curves are dangerous and if motorists make bad decisions of overtaking and excessive speeding, it will result in road fatal accidents with loss of lives. The landscape also affects distance visibility, especially during bad weather and at night because the roads do not have street lights (LDRT, 2011). There are bridges along the road where motorist are supposed to take extra caution when approaching. Public motorists who drive long shifts do get fatigued and end up becoming aggressive and erratic on the road, forcing innocent private drivers to engage in wrongful driving leading to road traffic injuries and fatalities.

5.5 Attitude of Pedestrian in Adhering to Road Safety Measures

Road safety preventive measures are meant to save road users lives whilst using the road. This study was able to evaluate how pedestrians adhere to road safety measures within the study area. Vhembe District is surrounded by villages and hence it is rural in terms of geographical and economical setting. The larger population of Vhembe District inhabitants live in the surrounding villages and commute every day to get to the CBD in Thohoyandou. Daily travelling using public

transport is common during traffic peak periods in the morning and evening. Pedestrians often struggle with motorists during this peak periods as well and if road safety preventive measures are not duly considered and practiced, it will result in road injuries and fatalities (LDRT, 2011).

Among the road safety measures is the construction of pedestrian bridge which is to be used to guarantee safe crossing by all pedestrians from one side of the road to another. However, many constructed pedestrian bridges in the study area have been abandoned by pedestrians. These bridges are now hide-outs for thugs and street urchins, which makes it unsafe for use at night. The pedestrian bridges are littered with human excreta which creates a foul smell, forcing pedestrians to abandon it and jay-walk. From the interviewed pedestrians 66% of them are aware of the traffic regulations they need to observe before crossing the road while 19% do not know what they should do before crossing the road and 15% are not sure of what to do before crossing. This explains why pedestrians on the roadways constituted as a second factor contributing to road traffic injuries and fatalities in the district (RTMC, 2011).

Likewise, when asked about the use of pedestrian bridges, only 45% sometimes used the pedestrian bridges, while 36% could not remember when they last used a pedestrian bridge when crossing. However, 19% claimed to always use the pedestrian bridges. About 64% of the pedestrian claimed the design of the bridge would not allow them to make use of it because of the steep slope and railings, 21% claimed that the secluded location of the bridge does not give them confidence to make use of it and 15% claimed they are afraid of being attacked by thugs while on the bridge. Also on anticipating to be knocked down by motorists, 82% said they are very sure they would not be knocked down, while 9% are skeptical of being knocked down and 9% were not sure of what they felt when they were crossing the road.

Furthermore, pedestrians in the study area did not take the road safety preventive measures seriously. During field observations, very few pedestrians practiced the look right, look left then look right rule before crossing the road. Some pedestrians even stopped in the median line of the road, which is completely unsafe as reckless motorists can hit and run. This was stressed out by pedestrians and conform to STATSA (2009) report on road accidents in South Africa.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The available road accident data reports from January 2011 – August 2015 as documented by the Limpopo Department of Road and Transport Vhembe District have been used to analysis patterns and trends of road traffic injuries and fatalities in Vhembe District, which was the aim of this study. The findings of the road accident reports were analysed and presented using both statistical and geographical information system techniques in producing graphs, tables, charts and maps. An analysis of the results revealed the followings:

- The composition of road traffic injuries and fatalities since the commencement of action decade for road safety in 2011 shows reduction in the numbers of victims recorded. An average of 86 fatalities, 326 serious injuries and 701 minor injuries occurred per annum within the study period. There was high significant value ($p < 0.05$) among all the categories of road users studied. The differences observed were real and did not occur by chance for the 5year period (2011 – 2015). There has been continuous down trends movement and patterns variation in the road traffic injuries and fatalities recorded for the study period. The month of July was the deadliest for road traffic injuries and fatalities in the five-year study period within the district. There was a 12% fatalities reduction and 38% serious injuries reduction from 2011 to 2015. The District is on track towards reducing road accident deaths by 50% in 2020, if future road traffic injuries and fatalities will keep decreasing in accordance to the observed trends and patterns from this study.
- Human induced factor: speeding was the leading contributing factor to road traffic injuries and fatalities in the District, followed by pedestrians on roadways, wrongful driving and reckless overtaking. Other contributing factors include drunken driving, brake failure/mechanical fault, road geometry/road surface, stray animals and other external environmental. Social behaviour changes and social vices indulgence was associated with these factors that contributed to road traffic injuries and fatalities. The time block of 18:00 – 23:59 dominated the occurrence periods for road traffic injuries and fatalities in the District with over 35% of all road traffic accidents occurring at that time of the day.
- Thulamela Municipality has the highest number of road accident hotspots within the District, with R524 and R523 being the highest road on which road traffic injuries and fatalities occur within the District. Places like Levubu Junction, Jimmyjones, Tshakuma

junction, Vuwani junction, and JJ motors roundabout, Wylliespoort, Tshipise, and Adams Apple on N1, Shayandima Junction, Muledane Junction, and Thohoyandou Unit C, Khoroni Junction along R523, have been identified as hotspots within the district road.

- Pedestrians do not have a good attitude towards road safety measures and regulations that are meant to assist in saving lives, especially during road crossing. Majority of the pedestrians do not make use of the pedestrian bridges that assures safe crossing within Vhembe District Municipality. They prefer to jay – walk and do not feel the need to consider their safety and follow the rule of the thumb for road crossing (look right, look left then look right again).

6.2 Recommendations

From the data analysis and findings of this research, the following recommendations are made to ensure road traffic injuries and fatalities are reduced by not just 50% but 75% or more by 2020:

6.2.1 Revised and Improved Road Accident Report Template

There is urgent need to revised the road accident report form/ template used by the Department to collect information from accident victims and accident locations. The revised report should have columns to enter GPS coordinate of the exact point of collision for the road traffic accident that occurred. Often the point of collision is a few meters away from where most of the road accident carnages are found. Also the road accident database of the Department of Road and Transport should have column for characteristics composition for age and gender of road accident victims as well as fatalities and injuries. This is to ensure adequate road accident mitigations are developed from research conducted using such generate data.

6.2.2 Road accident data synchronisation

There should be proper collation of road accident report for both fatalities and injuries from all relevant sources, departments and systems in a standardized format, quality and definitions should be compatible and user-friendly to all. There should be a web-based GIS hotspots for Vhembe District which will be updated every year to keep abreast with locations that might missed. This will assist traffic officials when they want to deploy their personnel for patrol duties.

6.2.3 In-depth research on road accident contributing factors

There is need for in-depth study and research on each of the identified contributing factor associated with road traffic injuries and fatalities to provide in-depth information which can be used to revise the present road traffic policies, intervention campaign programmes aimed at reducing road injuries and fatalities.

6.2.4 Road safety campaign and awareness

Road awareness campaigns should be carried out every month end to keep reminding all road users of the essence of road safety measures. Also there is need to adhere and comply with the regulations and road signage. There is a great need for more road safety awareness campaign to enlighten and educate the vast majority of pedestrians within the district. There is a great need for more road safety awareness campaign to enlighten and educate the vast majority of pedestrians within the district. There should be a curriculum on road safety to be taken in high school and part of driving lessons before issuance of driver license.

6.2.5 Recruitment of more traffic personnel

The Limpopo Department of Road and Transport should recruit and train more traffic officers to ensure an even distribution of traffic officials on all roads not only during peak traffic period but at all times. This came about from the interviewed with the traffic officials claiming they are short-staffed. Strict enforcement of speed limits in residential and high pedestrian areas. All traffic offenders in the area should be prosecuted by the law.

6.2.6 Acceleration on intelligent transport system implementation

There is a need to consider Intelligent Transport System (ITS) vehicles which will be produced with low speeds and engine capacity. Only emergency vehicle which will be stationed at all visible streets will be of high speeds and high engine capacity. The funds paid through Road Accident Fund (RAF) should be used to develop and subsidize intelligent vehicle which can detect potential road hazards 500 meters ahead and will make the driver pull over automatically.

6.2.7 Strict adherence to use of side-walks and pedestrian bridges

Mixed usage of road walkway and side – walk should not be allowed in the CBD, as this always creates problems for right of way between motorists and pedestrians. Pedestrian bridges should

be constructed in such a way that this will cater for all people and the passage should be kept clean and monitored by security personnel to ensure that it will not be used as hideouts by thugs.

6.2.8 Regularly checking of vehicular road worthiness

All traffic departments should ensure that cars older than 15 years should regularly undergo road worthiness tests before renewing their vehicle license. The practice of car sharing and carpooling should be promoted by government and overloading and non-roadworthy vehicles should be stamped out.

6.2.9 Installation of traffic lights

There is need for the traffic installation along the R524 and N1 intersection and also many other intersections within the District. This will help to duly coordinate the movement of vehicles at such points and impatient drivers can be held liable for disregarding the traffic signals.

6.3 Future Research Areas

- This research can still be expanded into in-depth studies on individual roads within the District, with emphasis on road segments and contributing environmental factors relating to road traffic injuries and fatalities.
- There can be a study on prediction analysis of segment roads in particular R524, taking into consideration all existing factors to be used as elements in the future crash prediction model.
- There should be research on using GIS to conduct and create web- based map of road accident locations within the district which will be updated monthly.
- Eco-mobility studies relating to sustainable transportation system need to be conducted in the District with more focus on the public transportation system.

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APPENDICES

APPENDIX 1: INTERVIEW GUIDE QUESTIONS WITH POLICE AND TRAFFIC OFFICERS

Personal details

Date…… Age…… Gender…….

Work experience …… Rank……

Q1. Can you describe in your own view if road traffic injuries and fatalities are significant problem in Vhembe District? …….. ……

Q2. How can you compare the pattern of road traffic injuries and fatalities within the four local municipality in Vhembe District? .....

Q3. Can you describe how you get information regarding road traffic accidents occurrence?.....

Q4. Can you describe problems that you encounter in getting immediate information after road traffic accidents occurred? ……..

Q5. How do you convene road traffic injured people from the scene of accident to the nearest hospital?.....

(a) Using an ambulance

(b) By police vehicle

(c) Requesting other motorists to assist with their vehicle

(d) The accident victims hire vehicles themselves

(e) Others specify……

Q6. Can you describe where you normally see road traffic accident victim's corpse in the case the victim died on the scene of accident? …….

Q7. What are the challenges you encounter in getting accurate information on road traffic accidents leading to injuries and fatalities within Vhembe District? ……..

Q8. Can you describe problems that you're currently facing in keeping adequate road traffic accidents reports in your office?.....

Q9. What are your recommendations and suggestions on measures to be taken in ensuring proper record keeping of road traffic accidents?.....

Q10. What will you propose as strategies on reducing road traffic injuries and fatalities within Vhembe District?.....

Q11. What measures do your office put in place in ensuring the reduction of road traffic injuries and fatalities in Vhembe District?.....

Q12. How do you ensure the implementation of road traffic safety measure within Vhembe District?.....

Q13. Can you explain who should held liable and responsible for road traffic injuries and fatalities within Vhembe District?.....

Q14. Can you describe if the present road traffic laws and rules can assist in reduction of road traffic injuries and fatalities within Vhembe District? ……

Q15. What factor (s) can you say contributes to frequent occurrences of road traffic injuries and fatalities within Vhembe District?.....

(a) Relating to the vehicle (s)……..

(b) In terms of environment (road network and design)……..

(c) Regarding peoples behaviours……..

(d) Relating to road traffic regulations and legislation……..

APPENDIX 2: QUESTIONNAIRE FORM TO BE USED FOR RETRIEVING ROAD TRAFFIC INJURIES AND FATALITIES FROM GOVERNMENT AGENCIES/ OFFICIALS

Section A: Personal Particulars

1). Age in years …….

(a) Below 18 …..... (b) 18-24 …..... (c) 25-34 …….. (d) 35-44 ……. (e) 45 and above……

2). Gender ……

(a) Male……. (b) Female ……..

3). Occupation …….

(a) Petty trader…… (b) Farmer/ farm worker…… (c) Government worker ……

(e) Self employed/ own business …… (f) Others (specify)…….

4). Residence local municipality …….

(a) Thulamela… (b) Makhado …… (c) Musina …..(d) Mutale…. (e) Outside Vhembe District……

Section B: Regarding the road traffic injury

5). When did it happen?

(a) Month …… (b) Day of the week…….. (c) Time (day or night) ……..

6). Total number of vehicles involved in the road traffic accident……..

7). The vehicle (s) involved in the road traffic accident……

(a) Light vehicle……. (b) Heavy vehicle…… (c) Cycles ……..

8). How many causality was recorded ……

(a) Injured…… (b) Fatality …… (c) Dead ……..

9). Structure of the injured personnel……..

(a) Driver…… (b) Passenger …… (c) Pedestrian…… (d) Cyclist……..

10). The locational description of where the road traffic accident occurred……..

GPS coordinates (if possible)…….

11). Climatic condition of the road on which the accident occurred? ……

(a) Dry…… (b) Wet…….. (c) Not specified……

APPENDIX 3: QUESTIONNAIRE FOR ROAD USERS (PEDESTRIAN)

Section A: Personal Particulars

1). Age in years …….

(a) Below 18 …..... (b) 18-24 …..... (c) 25-34 …….. (d) 35-44 ……. (e) 45 and above……

2). Gender ……

(a) Male……. (b) Female ……..

3). Occupation …….

(a) Petty trader…… (b) Farmer/ farm worker…… (c) Government worker ……

(e) Self employed/ own business …… (f) Others (specify)…….

4). Residence local municipality …….

(a) Thulamela… (b) Makhado …… (c) Musina …..(d) Mutale…. (e) Outside Vhembe District……

Section B: Road usage

5). How often do you make use of the pedestrian bridge when crossing traffic roads……..

(a) Always…… (b) Once a while……(c) Presence of traffic officials ……..

6). Do you prefer to jay-walk rather than use the pedestrian bridge……

(a) Yes…… (b) No……. (c) Not sure……

7). Reason for not wanting to use the pedestrian bridge …….

(a) Design …….. (b) Shady …… (c) Hoodlums ……

8). When crossing on the traffic road do you anticipate being knocked down while standing on the median……

(a) Yes…….. (b) No……. (c) Not sure ……

9). What do you think can be done to ensure pedestrian adhere to road safety measures…….

10). Are you aware of all the road traffic regulation that all pedestrian need to observe …….

(a) Yes…… (b) No…… (c) Not sure …….

APPENDIX 4: QUESTIONNAIRE FOR ROAD USERS (MOTORIST)

Section A: Personal Particulars

1). Age in years …….

(a) Below 18 …..... (b) 18-24 …..... (c) 25-34 …….. (d) 35-44 ……. (e) 45 and above……

2). Gender ……

(a) Male……. (b) Female ……..

3). Occupation …….

(a) Petty trader…… (b) Farmer/ farm worker…… (c) Government worker ……

(e) Self employed/ own business …… (f) Others (specify)…….

4). Residence local municipality …….

(a) Thulamela… (b) Makhado …… (c) Musina …..(d) Mutale…. (e) Outside Vhembe District……

5). How many years of driving experience do you have? ……

Section B: While on the road/ road usage

6). Do you observe stipulated road traffic speed limit (s) while driving ……

(a) Always …… (b) Sometimes …… (c) Not sure ……..

7). How many times have you been arrested for road traffic offences? ……

(a) Less than 10 times …… (b) More than 10 times …… (c) Lost count ……..

8). Do you give right of way to pedestrian when at a zebra-crossing? ……

(a) Always …….. (b) Sometimes …… (c) Not sure …….

9). Do you always put on safety seat belt when driving? …… (a) Yes…… (b) No…….

10). If No, can you give reasons ……..

Section C: Road traffic accident

11). Do you think road traffic injury and fatality is a major concern within Vhembe District? ….

(a) Yes……. (b) No…….. (c) Not sure…….

12). Have you been involved in road traffic accident leading to injury? ... (a) Yes…… (b) No……

13). Were you on conscious of what happened before and after the accident?.....

If Yes, what was the main cause of the road traffic accident? ……

(a) Reckless overtaking…….. (b) Pedestrian on the road……..

(c) Stray animal crossing…… (d) Vehicle break failure ……..

(e) Drinking and driving …….. (f) Road design ……

(g) Bad road weather …… (h) Others (specify) ……

14). Did you by-pass any traffic officer before the accident happened? ……..

15). How did you get to the hospital?.....

16). What factor do you think contributed to the road traffic injury occurrence? .....

17). Who do you in your opinion should be responsible for road traffic accidents within Vhembe District?.....

18). What will you recommend to reduce road traffic injury and fatalities within Vhembe District?.....

19). In your opinion do you think the present traffic laws and regulations can assist in the reduction of road traffic injury and fatality in Vhembe District? …….

20). Do you think there is possibility of correlation between the road traffic injury and present road design within Vhembe District?.....

APPENDIX 5: GRAPHICAL ANALYSIS OF ROAD TRAFFIC INJURIES AND FATALITIES ON MONTHLY BASIS FOR 2011

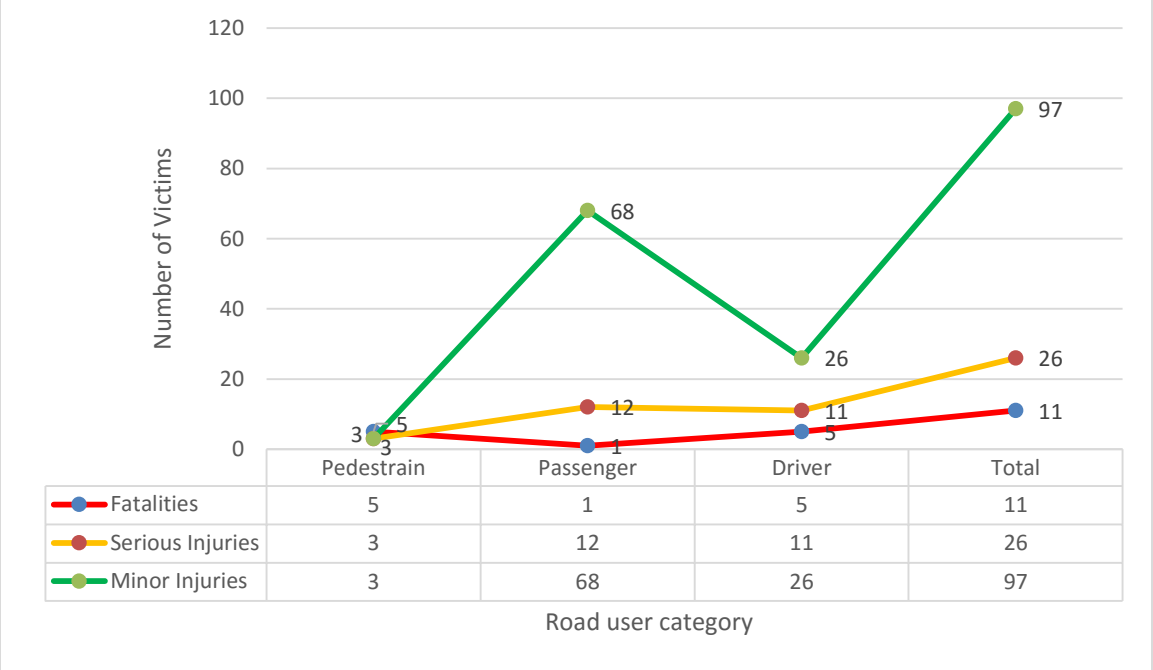


Figure 36: Composition of road traffic injuries and fatalities in VDM for Jan. 2011

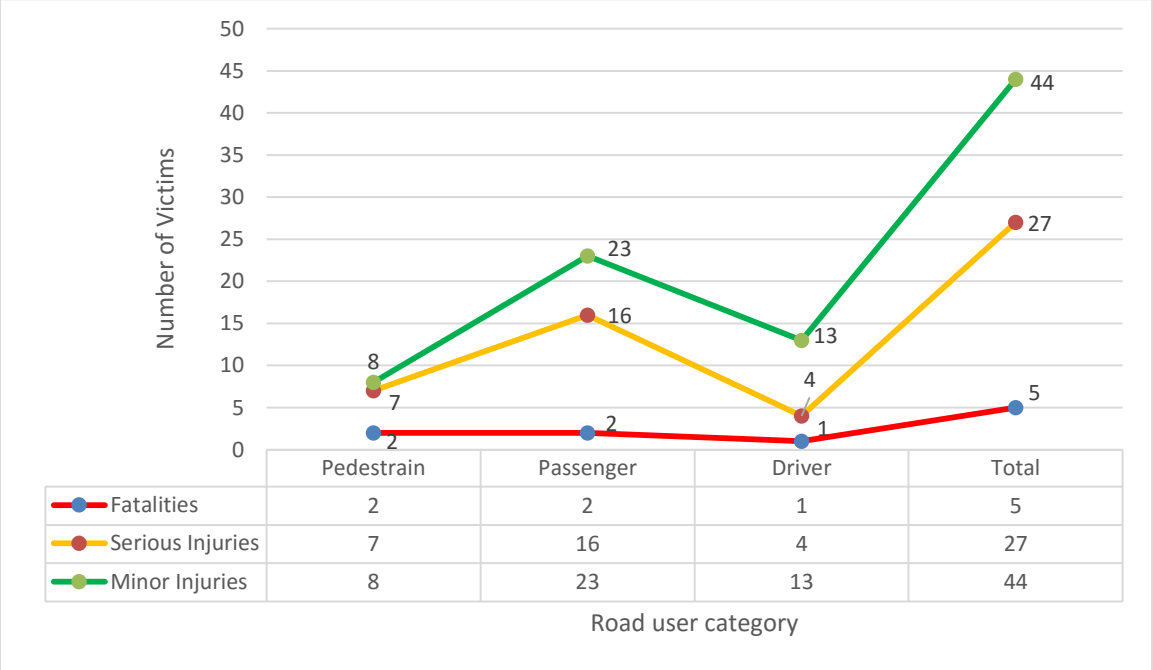


Figure 37: Composition of road traffic injuries and fatalities in VDM for Feb. 2011

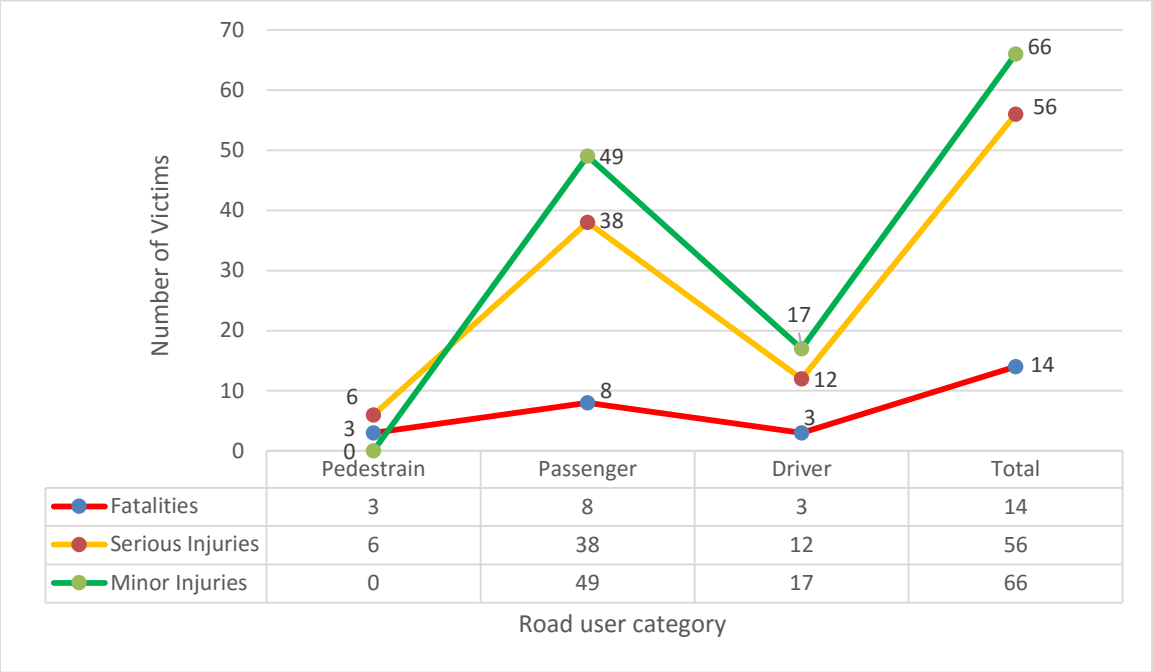


Figure 38: Composition of road traffic injuries and fatalities in VDM for Mar. 2011

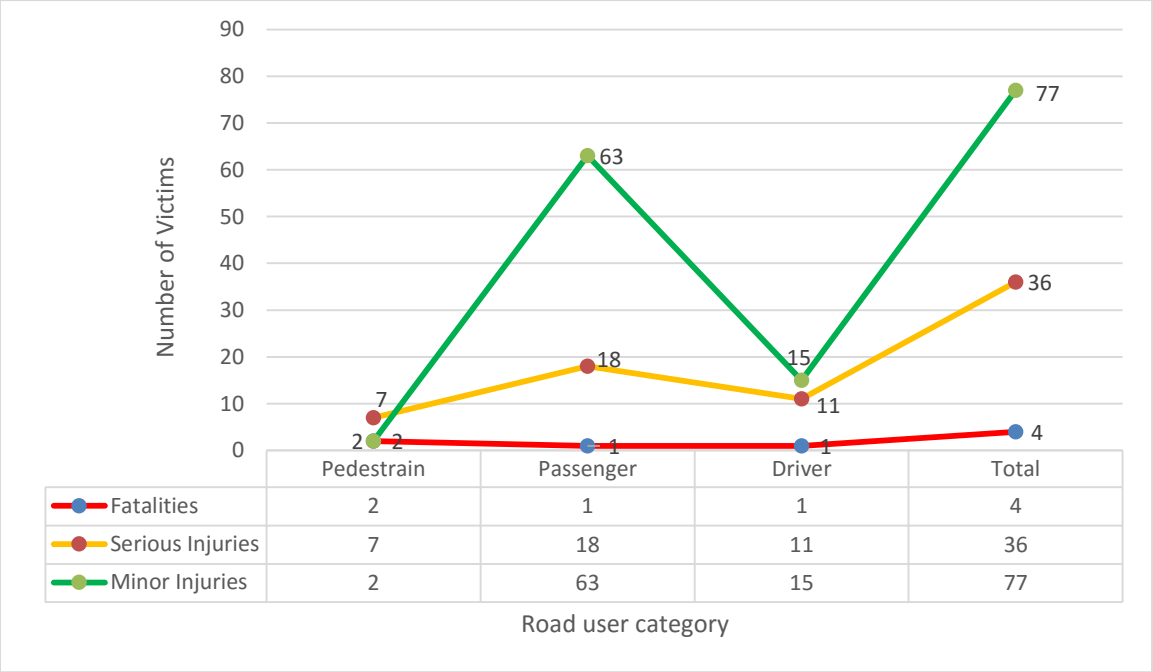


Figure 39: Composition of road traffic injuries and fatalities in VDM for Apr. 2011

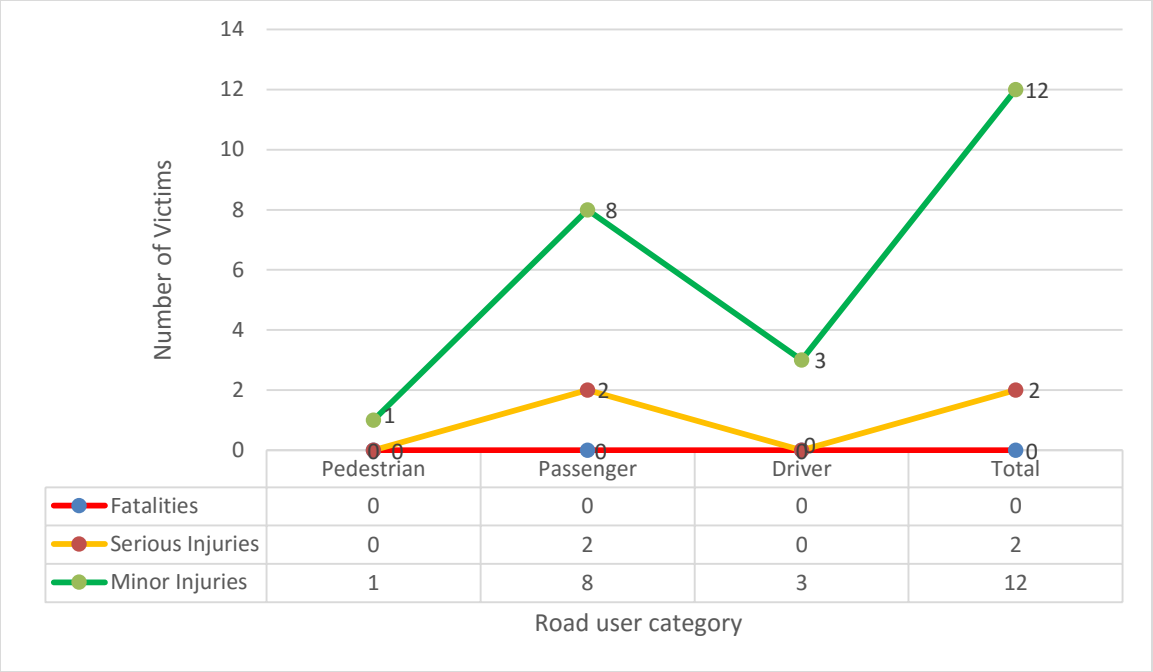


Figure 40: Composition of road traffic injuries and fatalities in VDM for May 2011

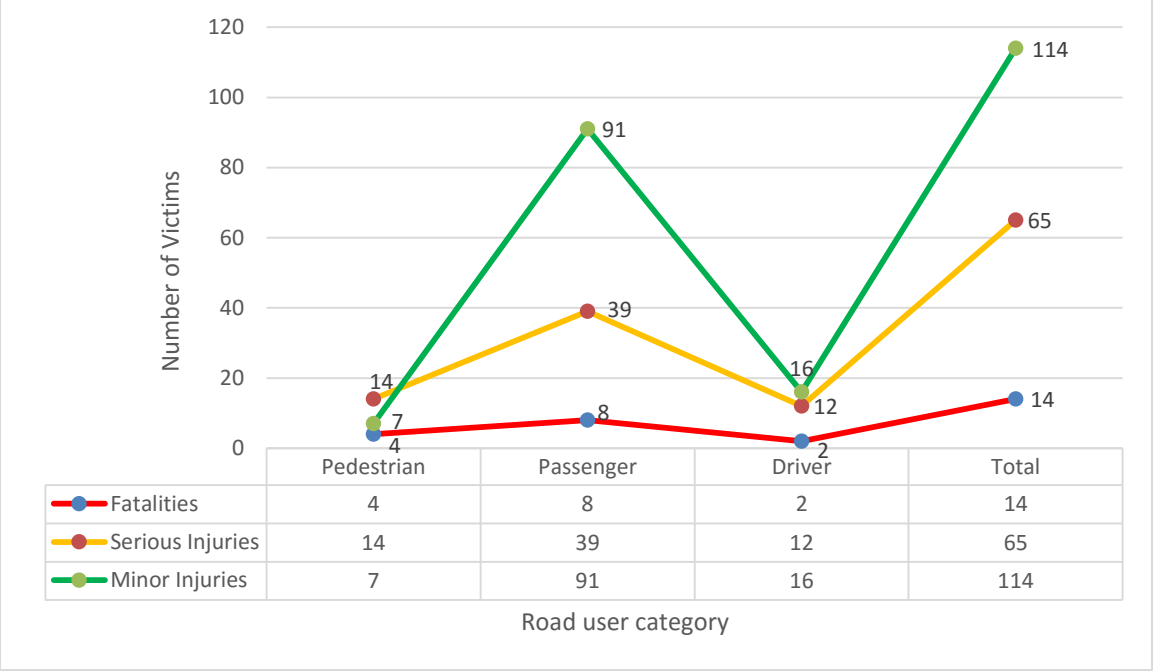


Figure 41: Composition of road traffic injuries and fatalities in VDM for Jun. 2011

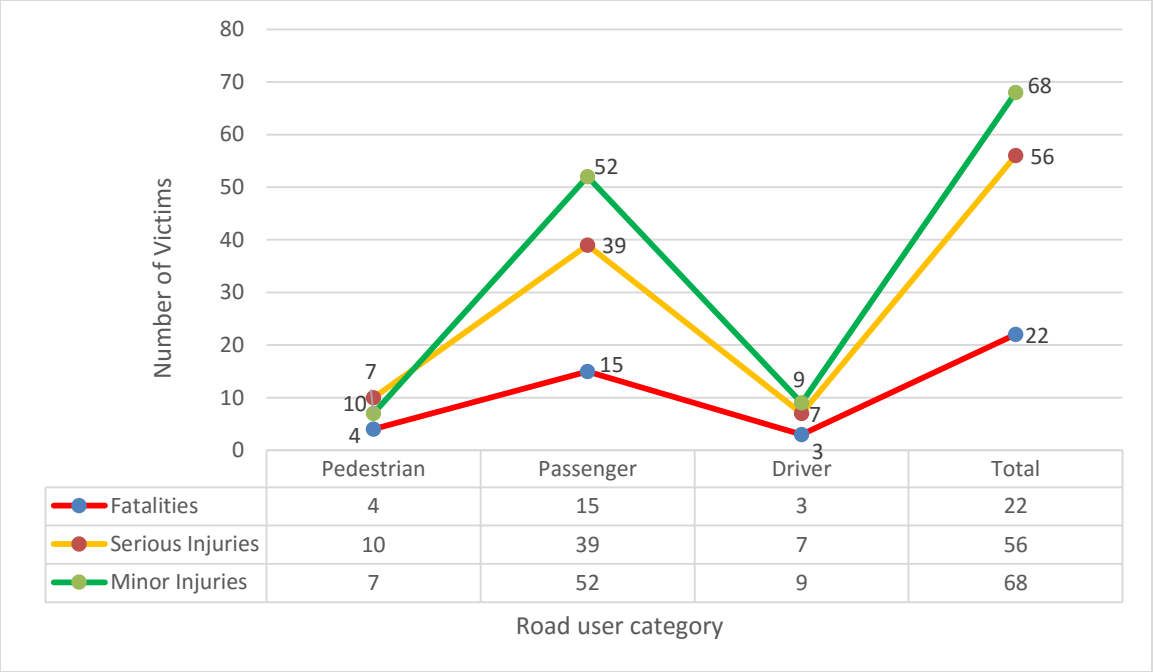


Figure 42: Composition of road traffic injuries and fatalities in VDM for Jul. 2011

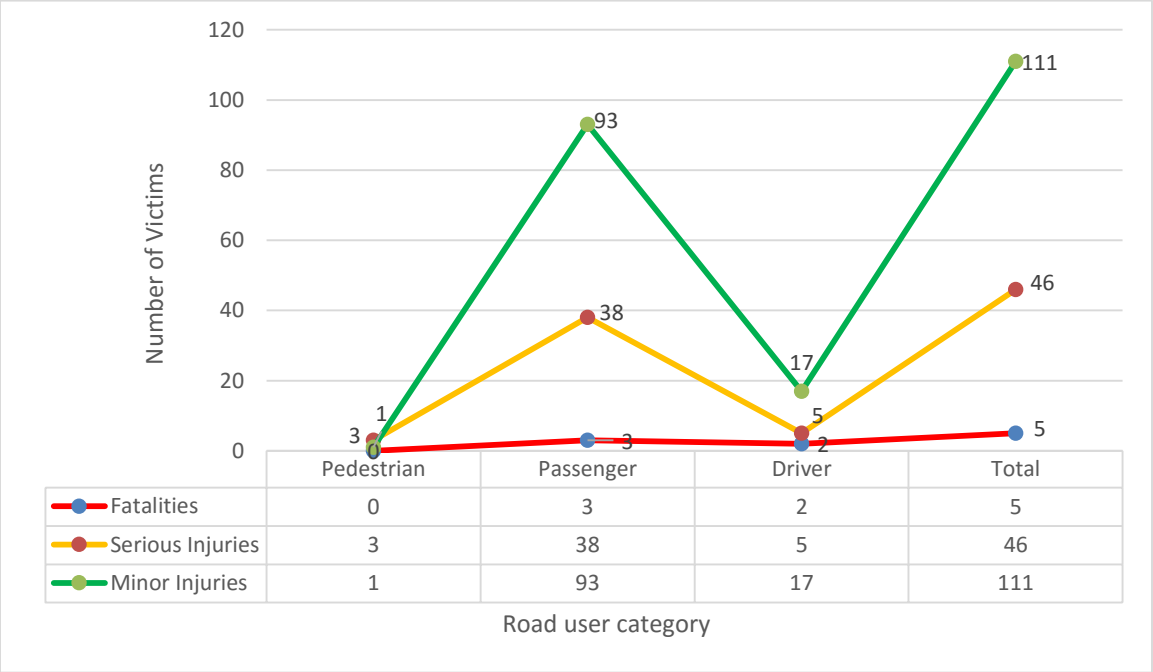


Figure 43: Composition of road traffic injuries and fatalities in VDM for Aug. 2011

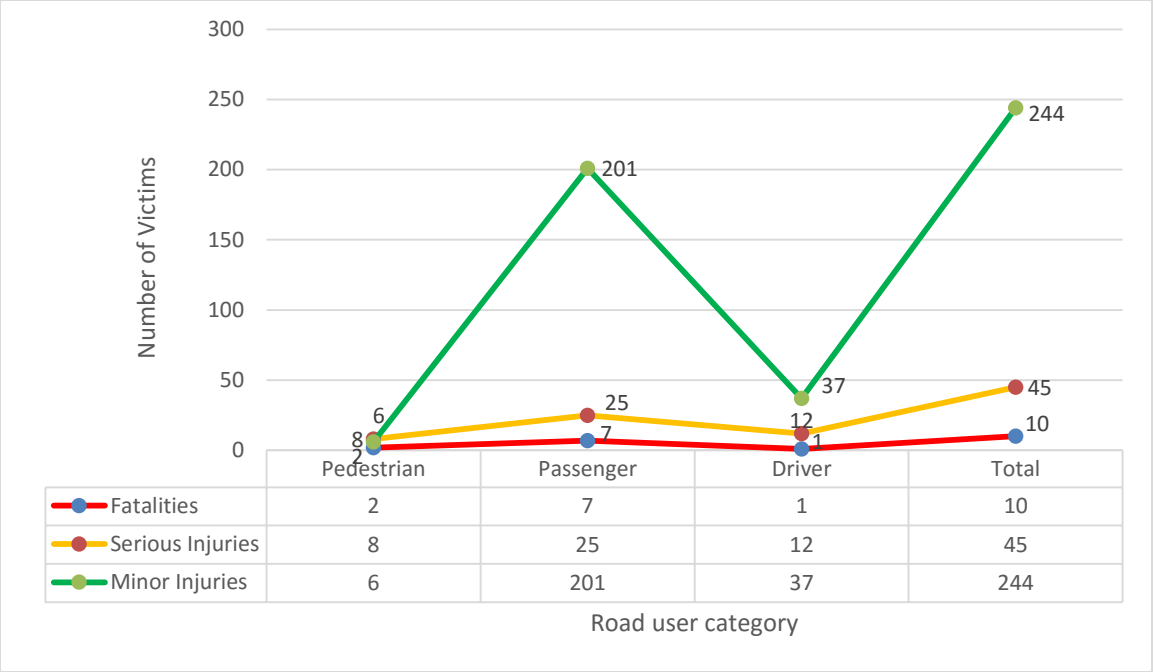


Figure 44: Composition of road traffic injuries and fatalities in VDM for Sep. 2011

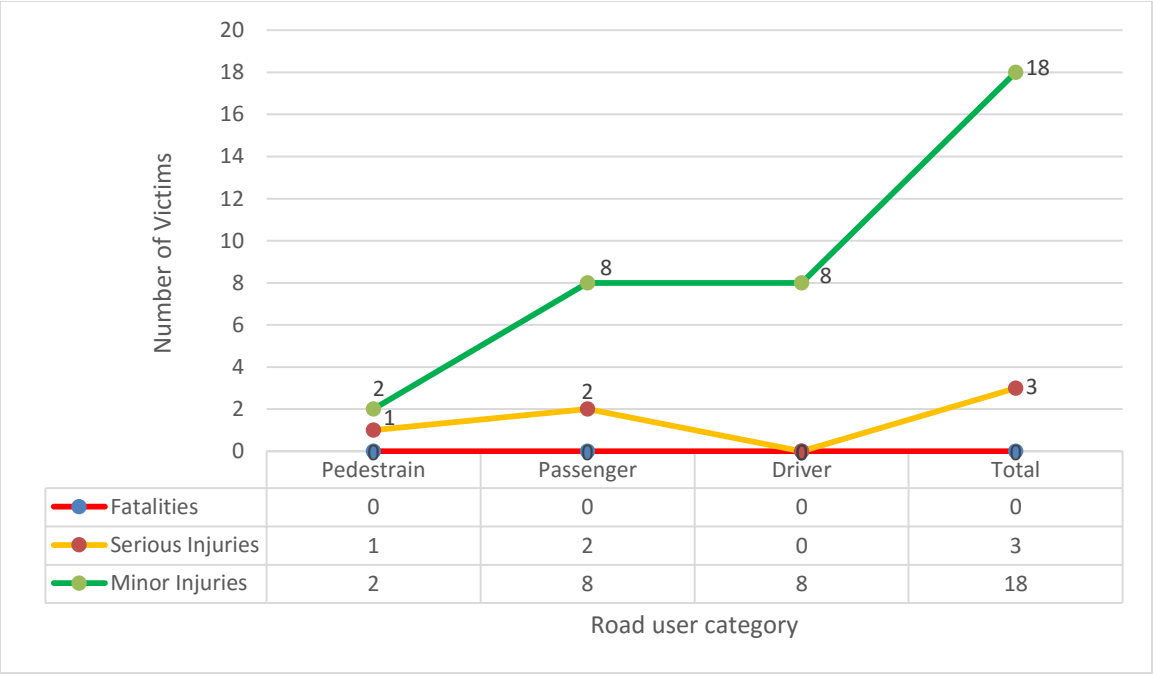


Figure 45: Composition of road traffic injuries and fatalities in VDM for Oct. 2011

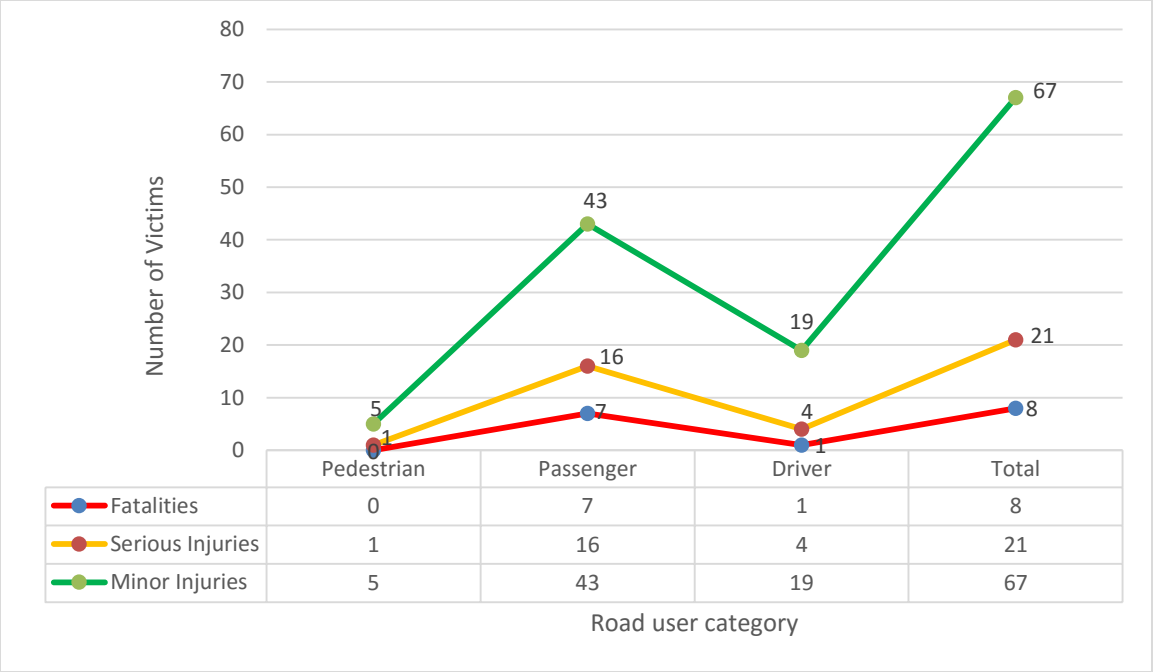


Figure 46: Composition of road traffic injuries and fatalities in VDM for Nov. 2011

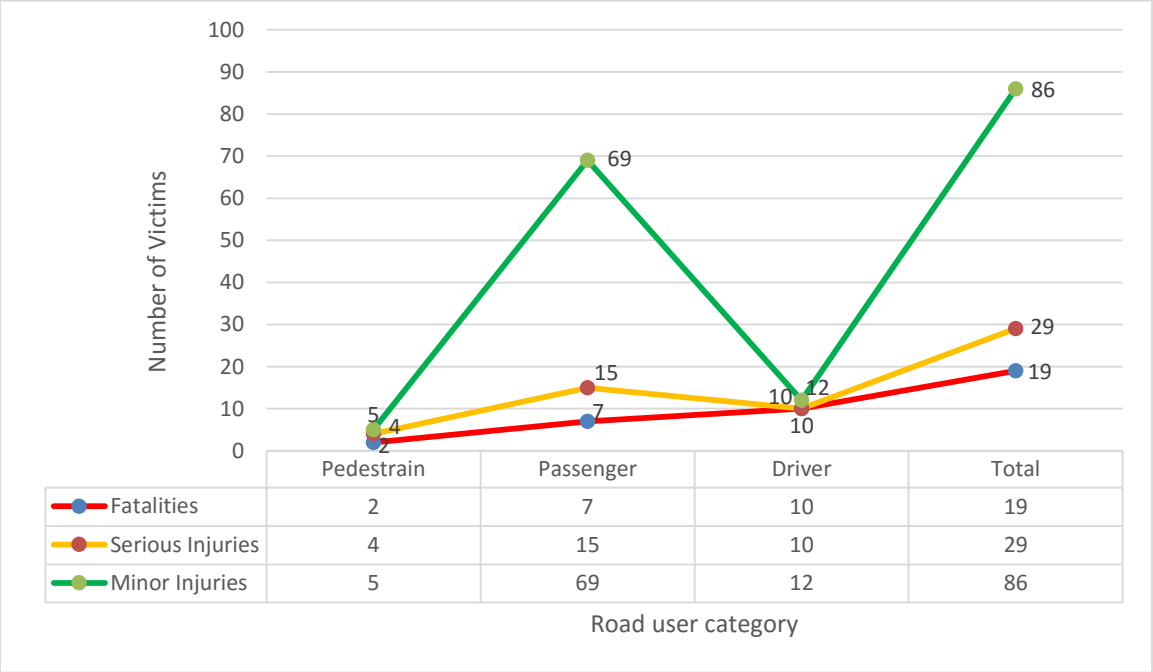


Figure 47: Composition of road traffic injuries and fatalities in VDM for Dec. 2011

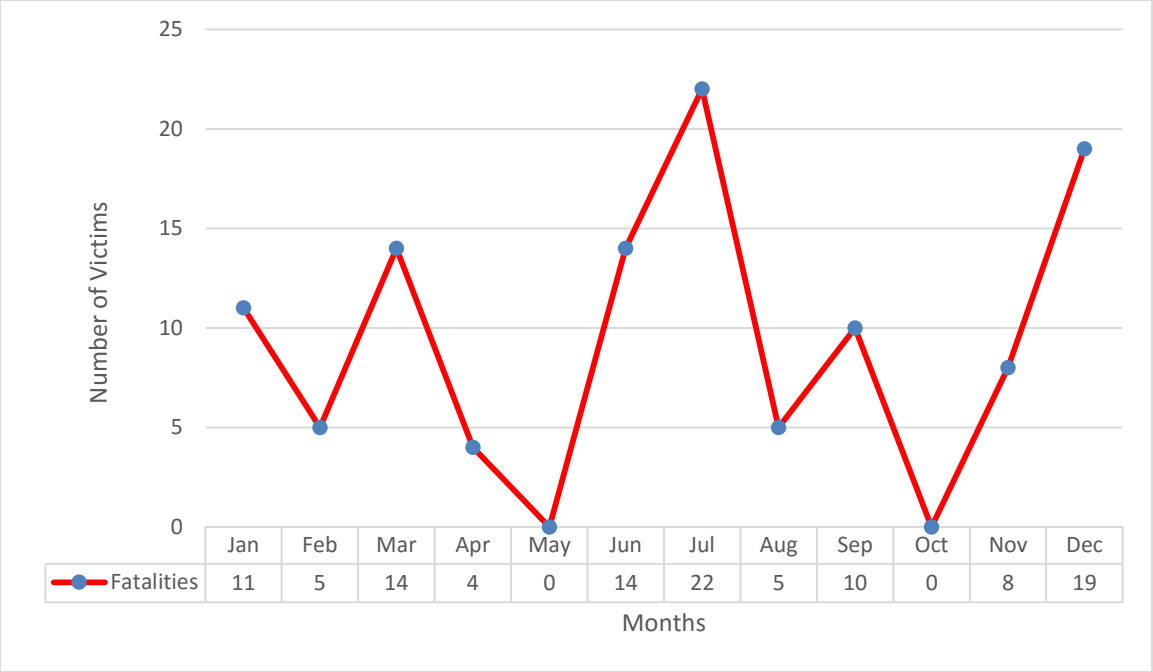


Figure 48: Road traffic fatalities trend for VDM in the year 2011

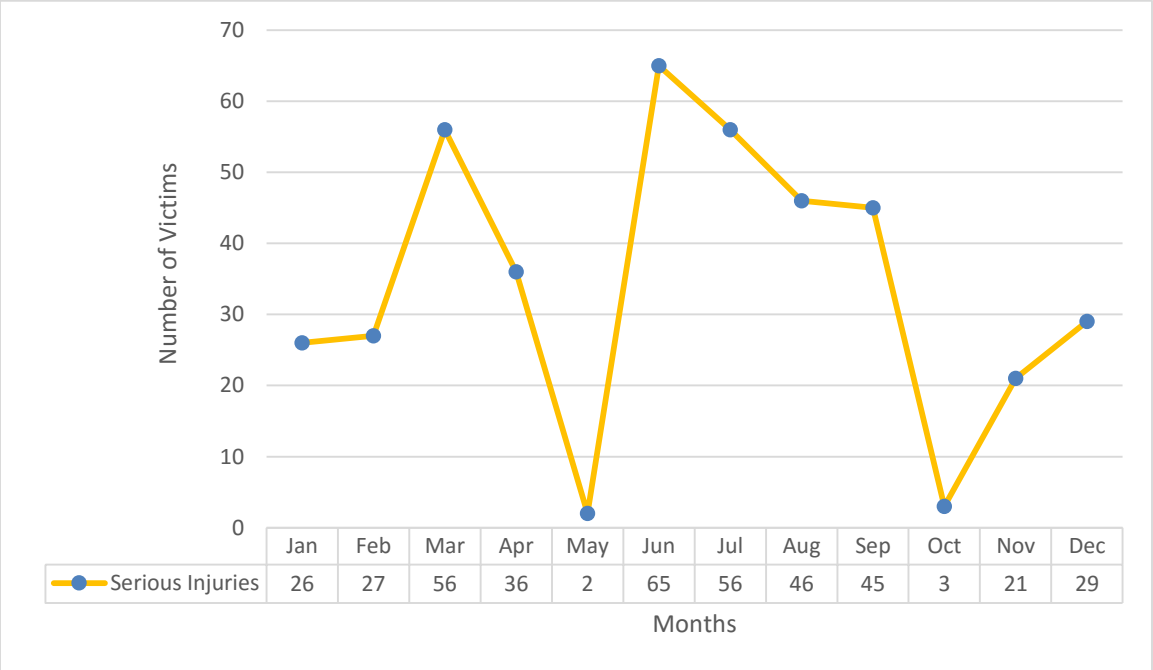


Figure 49: Road traffic serious injuries trend for VDM in the year 2011

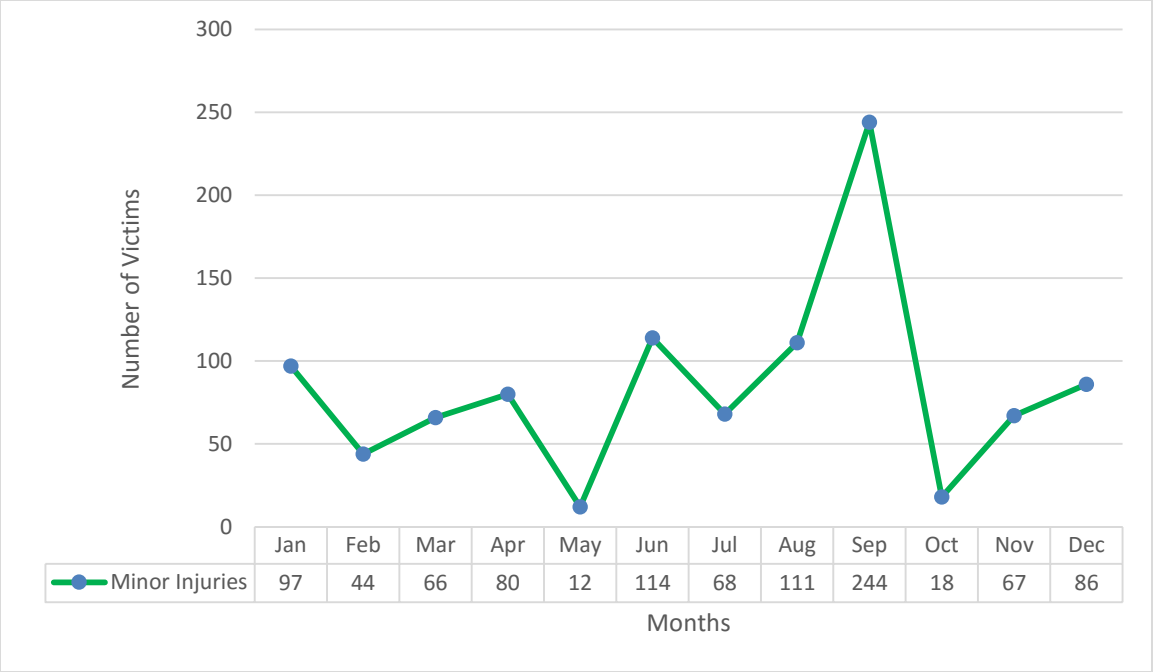
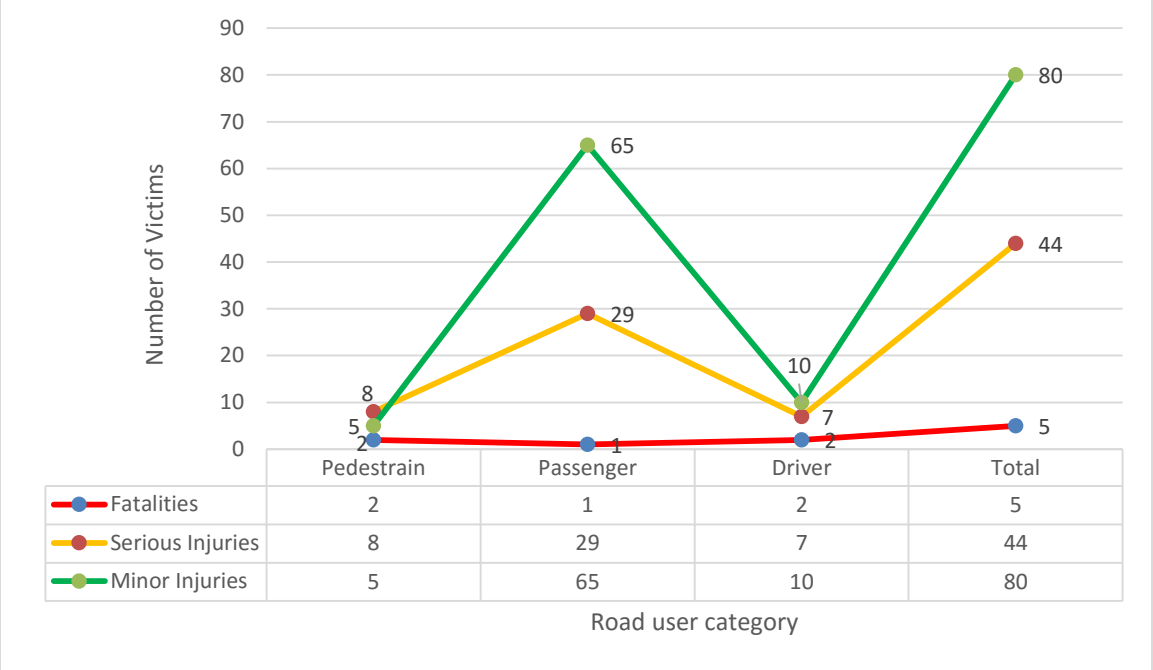


Figure 50: Road traffic minor injuries trend for VDM in the year 2011

APPENDIX 6: GRAPHICAL ANALYSIS OF ROAD TRAFFIC INJURIES AND FATALITIES ON MONTHLY BASIS FOR 2012



	Pedestrain	Passenger	Driver	Total
Fatalities	2	1	2	5
Serious Injuries	8	29	7	44
Minor Injuries	5	65	10	80

Figure 51: Composition of road traffic injuries and fatalities in VDM for Jan. 2012

	Pedestrain	Passenger	Driver	Total
Fatalities	2	11	1	14
Serious Injuries	1	24	8	33
Minor Injuries	2	30	7	39

Figure 52: Composition of road traffic injuries and fatalities in VDM for Feb. 2012

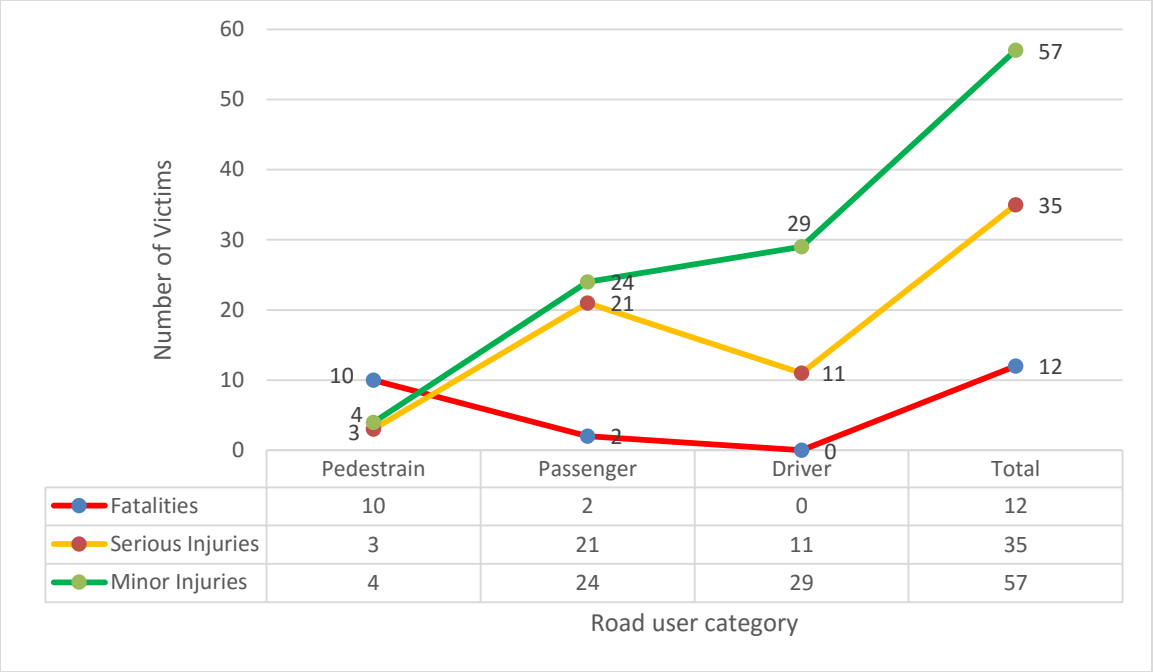


Figure 53: Composition of road traffic injuries and fatalities in VDM for Mar. 2012

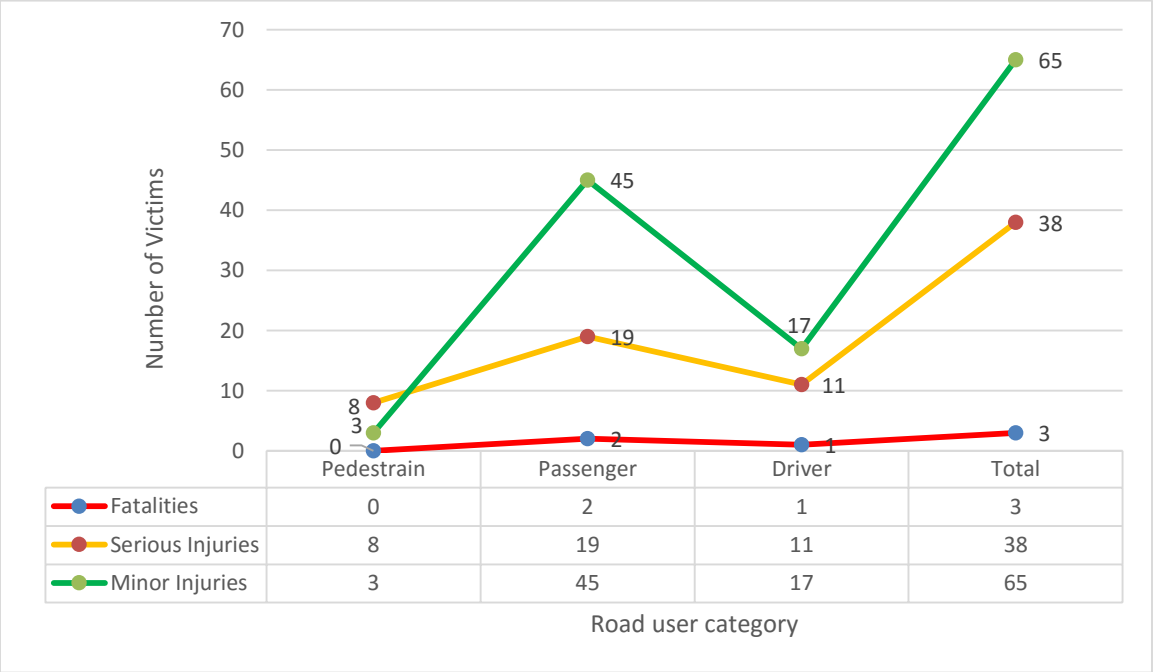


Figure 54: Composition of road traffic injuries and fatalities in VDM for Apr. 2012

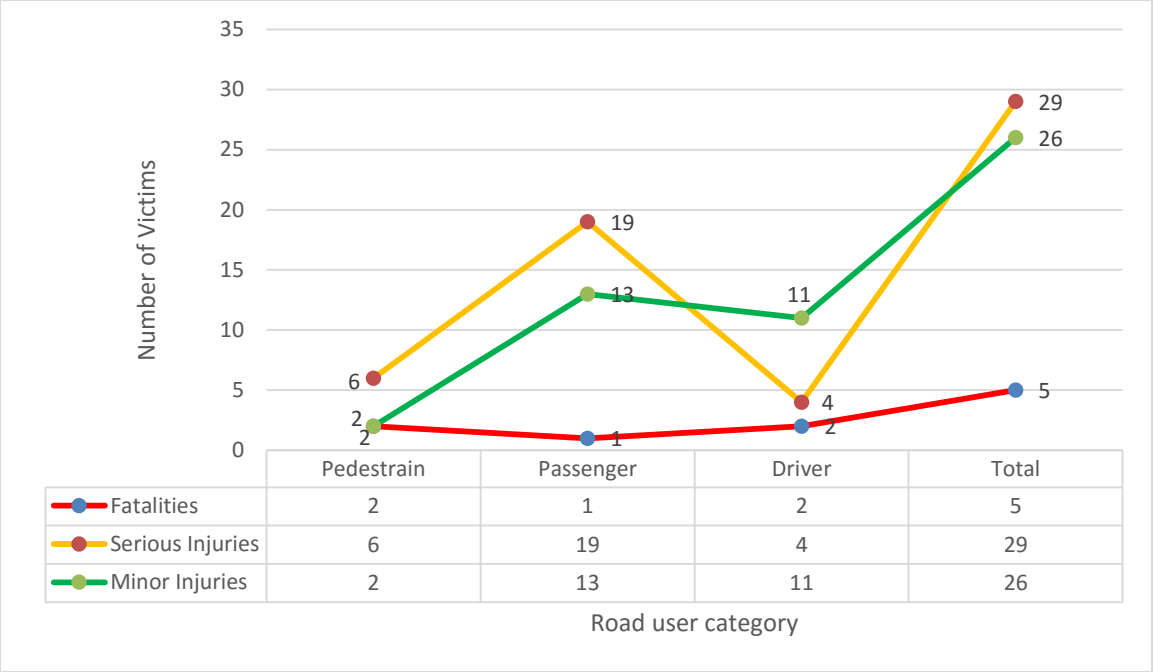


Figure 55: Composition of road traffic injuries and fatalities in VDM for May 2012

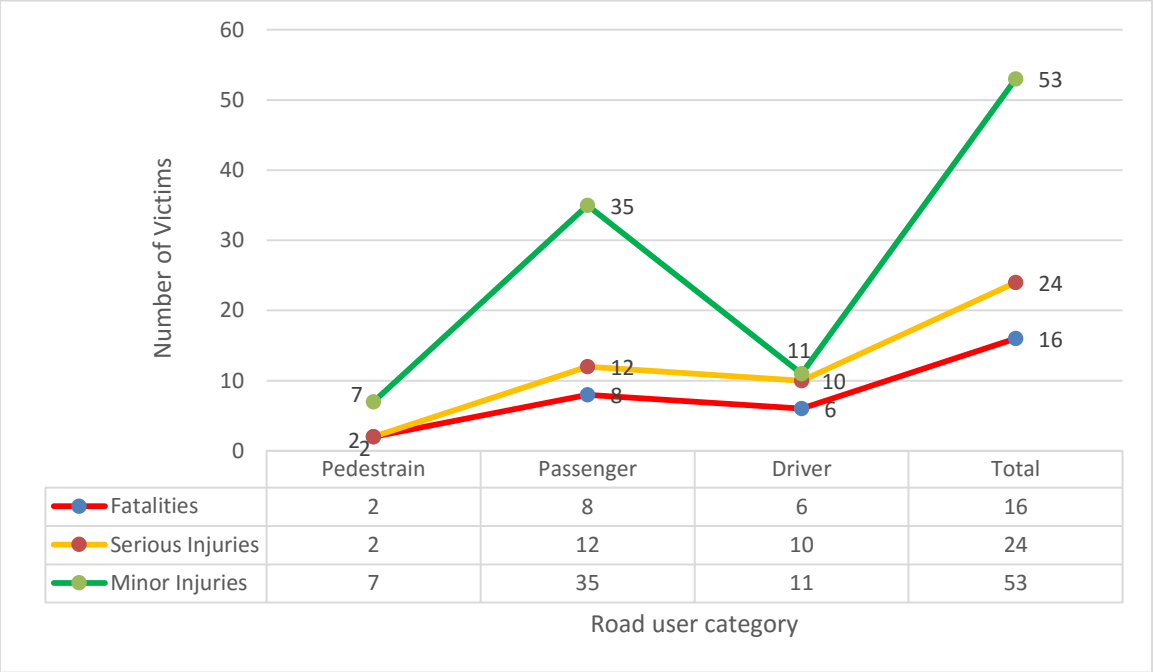


Figure 55: Composition of road traffic injuries and fatalities in VDM for Jun. 2012

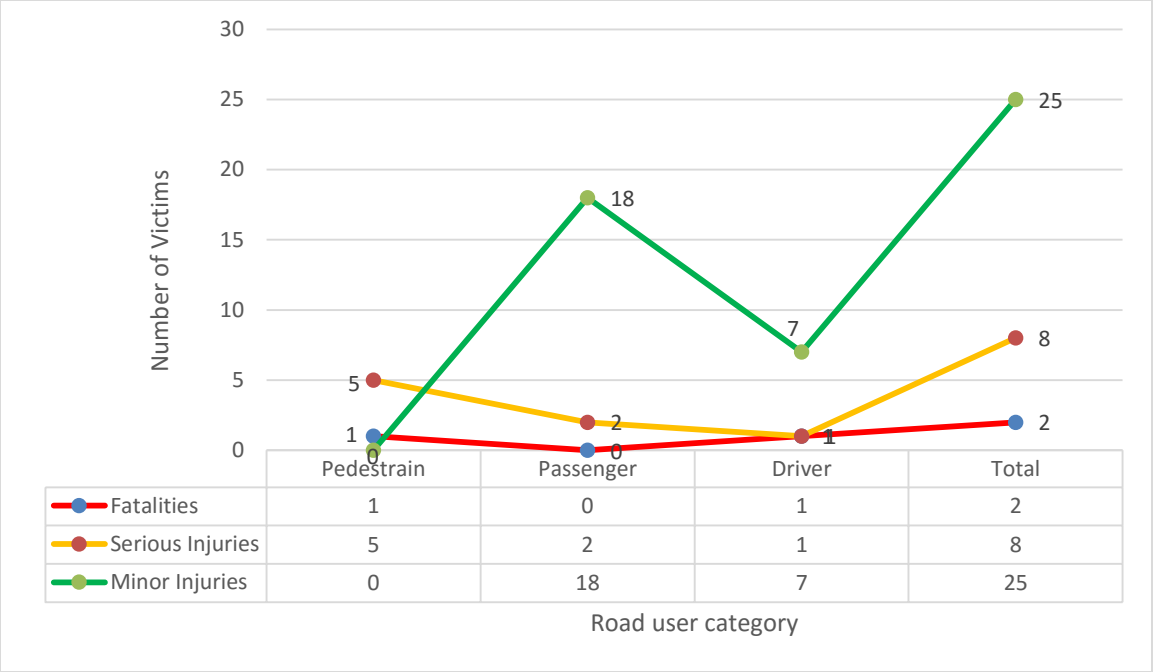


Figure 56: Composition of road traffic injuries and fatalities in VDM for Jul. 2012

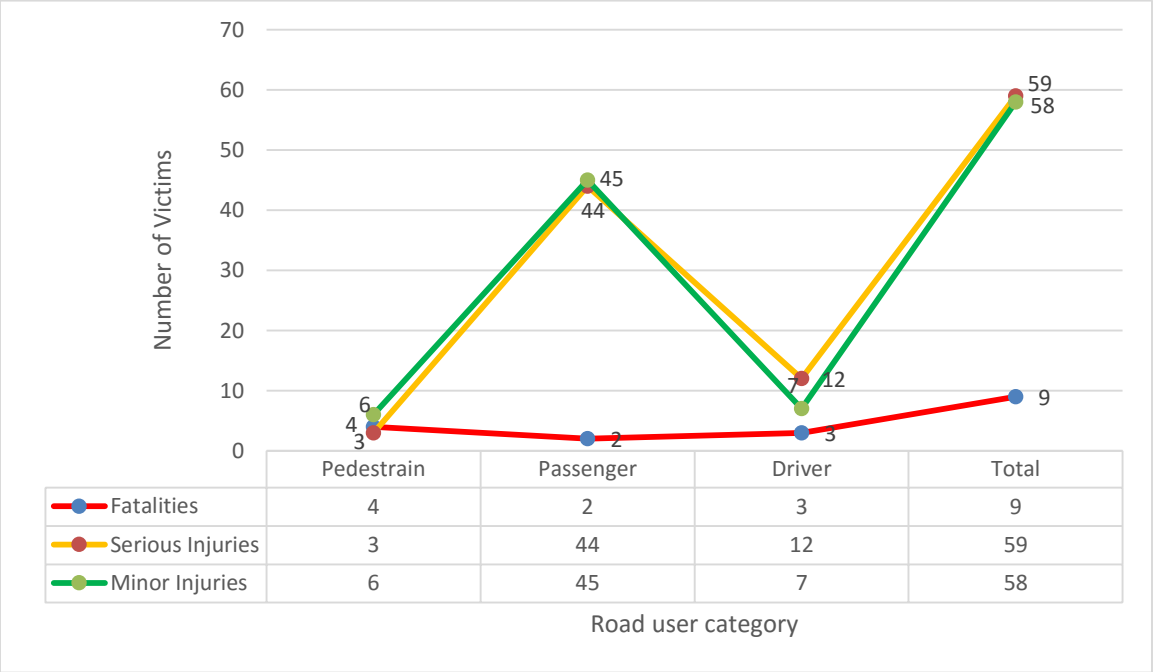


Figure 57: Composition of road traffic injuries and fatalities in VDM for Aug. 2012

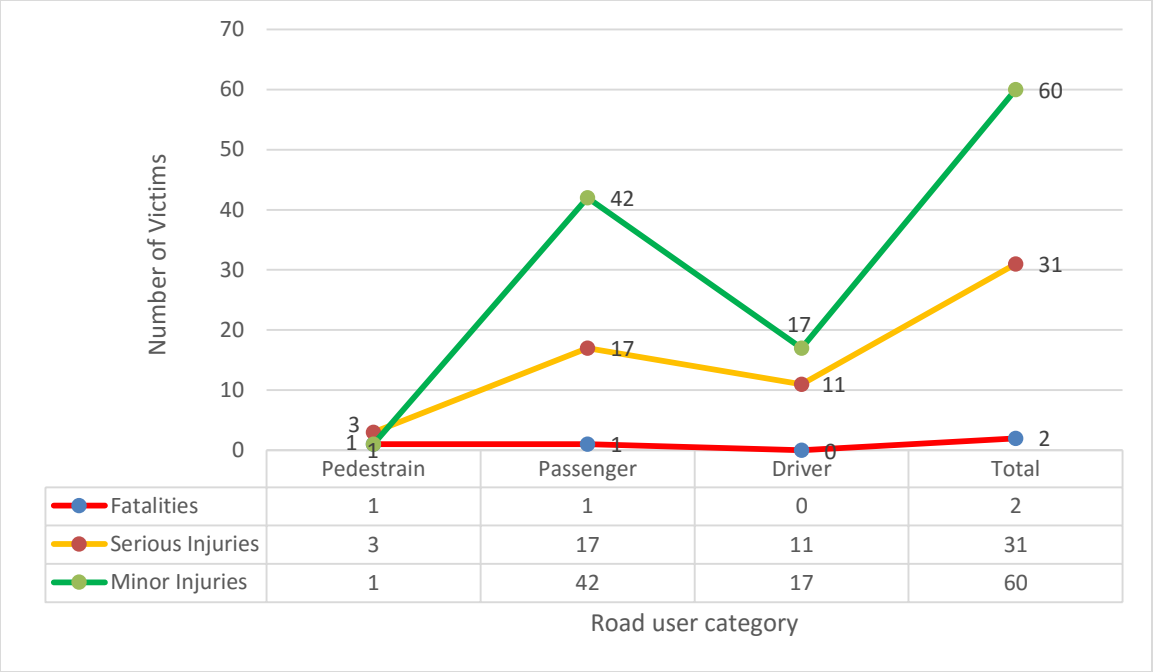


Figure 58: Composition of road traffic injuries and fatalities in VDM for Sep. 2012

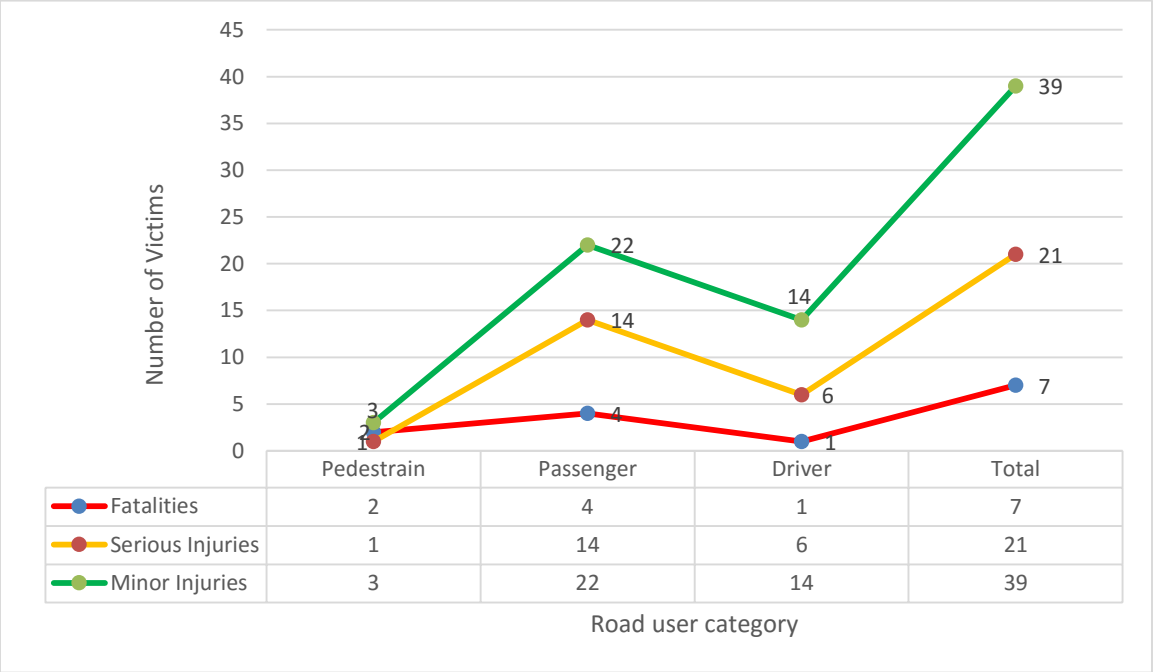


Figure 59: Composition of road traffic injuries and fatalities in VDM for Oct. 2012

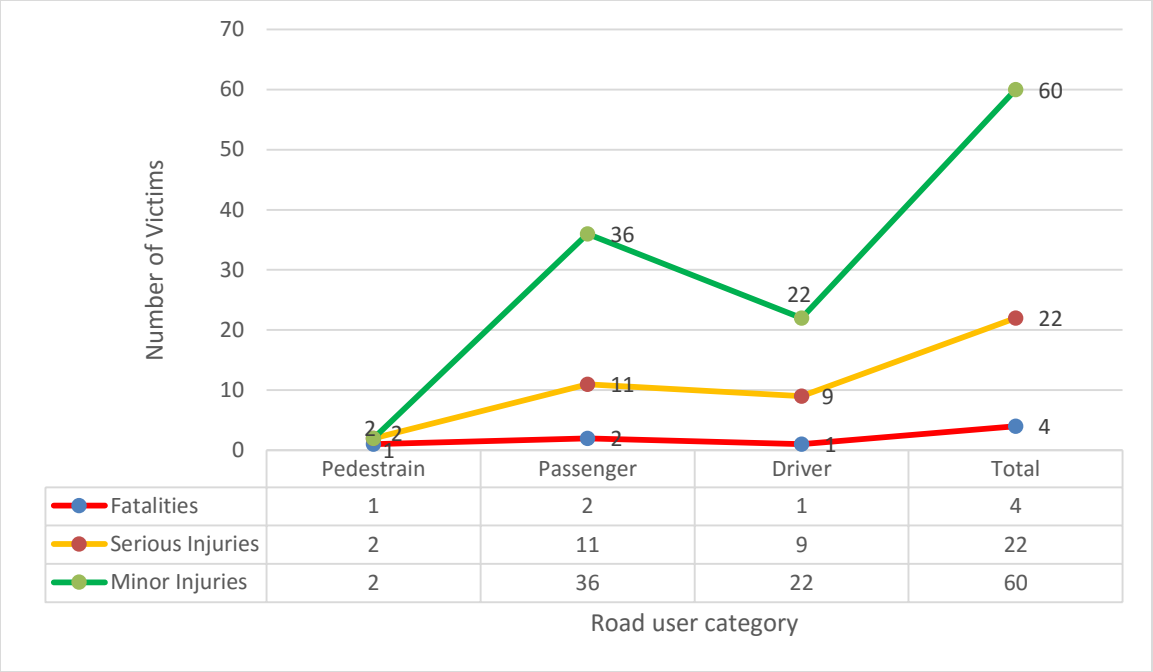


Figure 60: Composition of road traffic injuries and fatalities in VDM for Nov. 2012

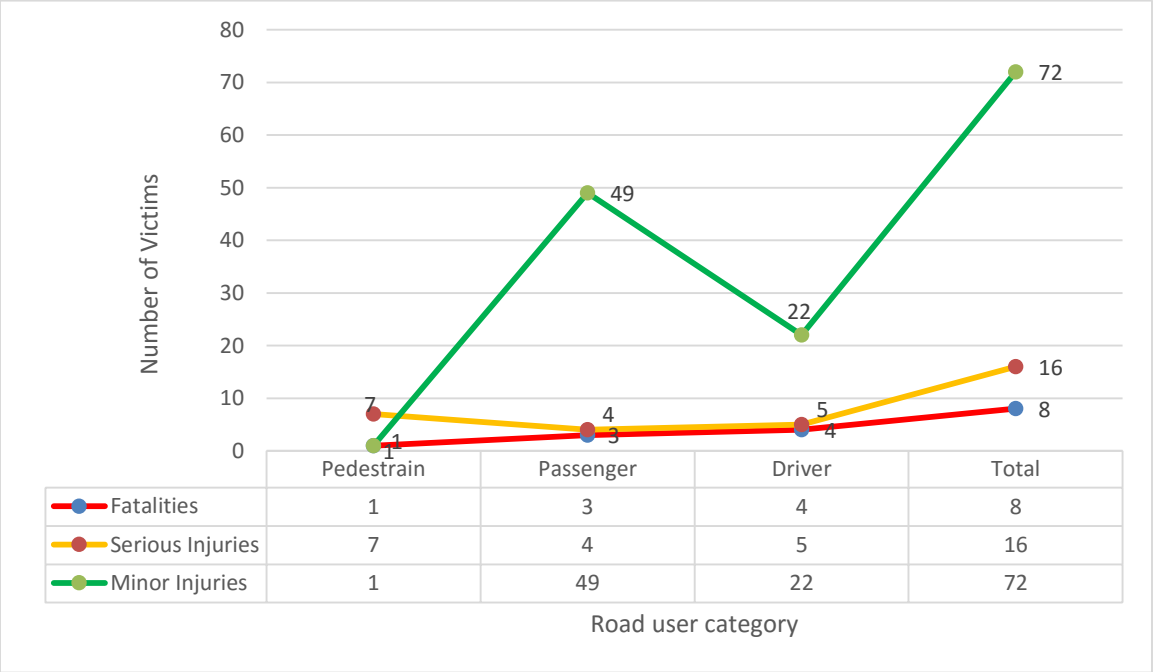


Figure 61: Composition of road traffic injuries and fatalities in VDM for Dec. 2012

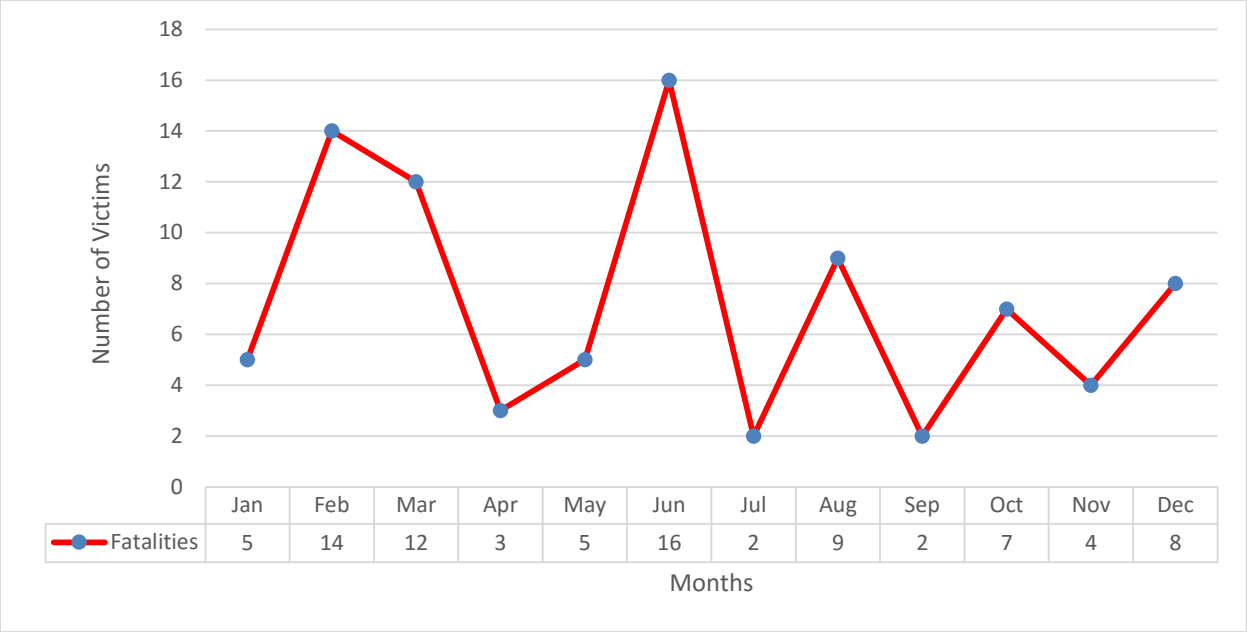


Figure 62: Road traffic fatalities trend for VDM in the year 2012

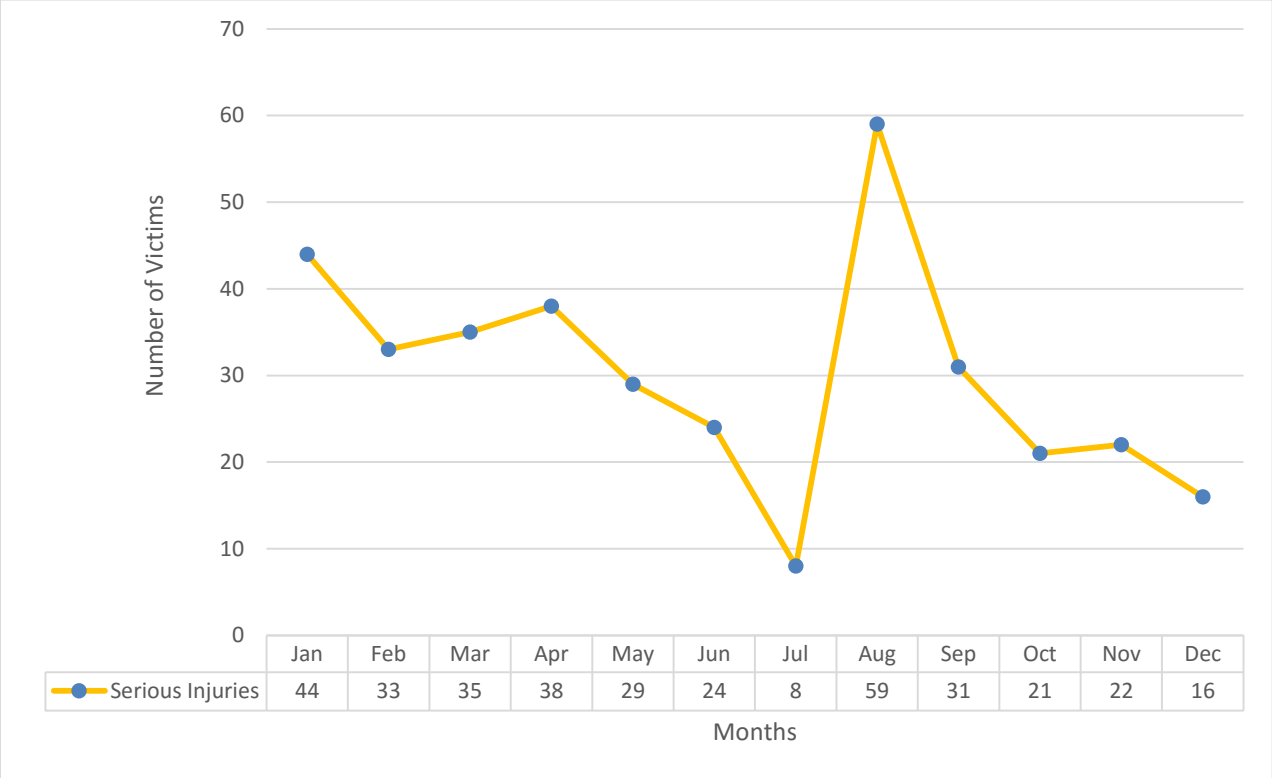


Figure 63: Road traffic serious injuries trend for VDM in the year 2012

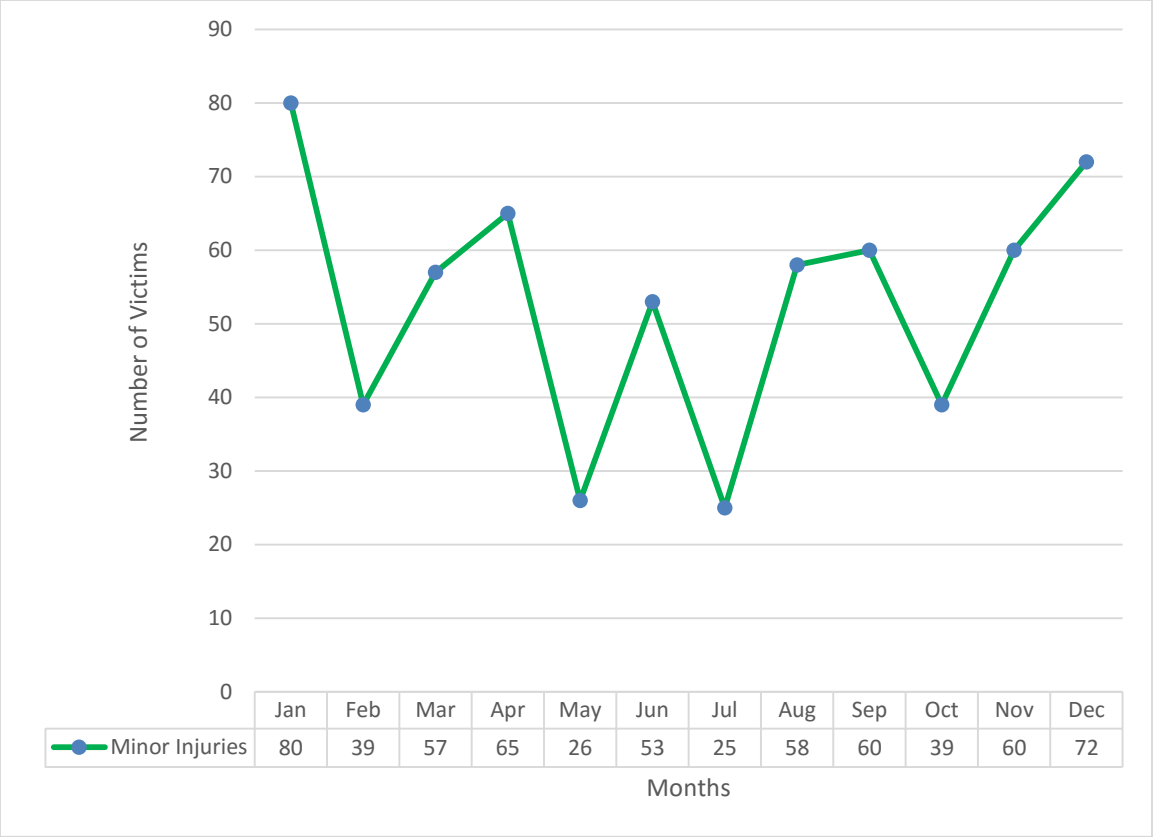


Figure 64: Road traffic minor injuries trend for VDM in the year 2012

APPENDIX 7: GRAPHICAL ANALYSIS OF ROAD TRAFFIC INJURIES AND FATALITIES ON MONTHLY BASIS FOR 2013

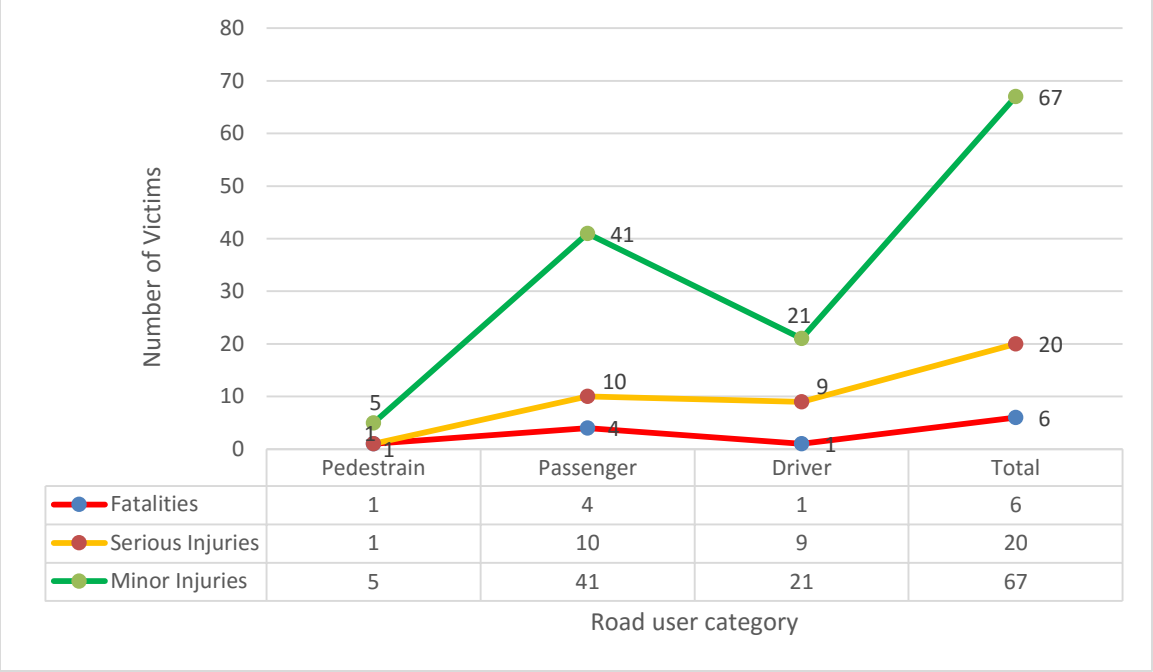


Figure 65: Composition of road traffic injuries and fatalities in VDM for Jan. 2013

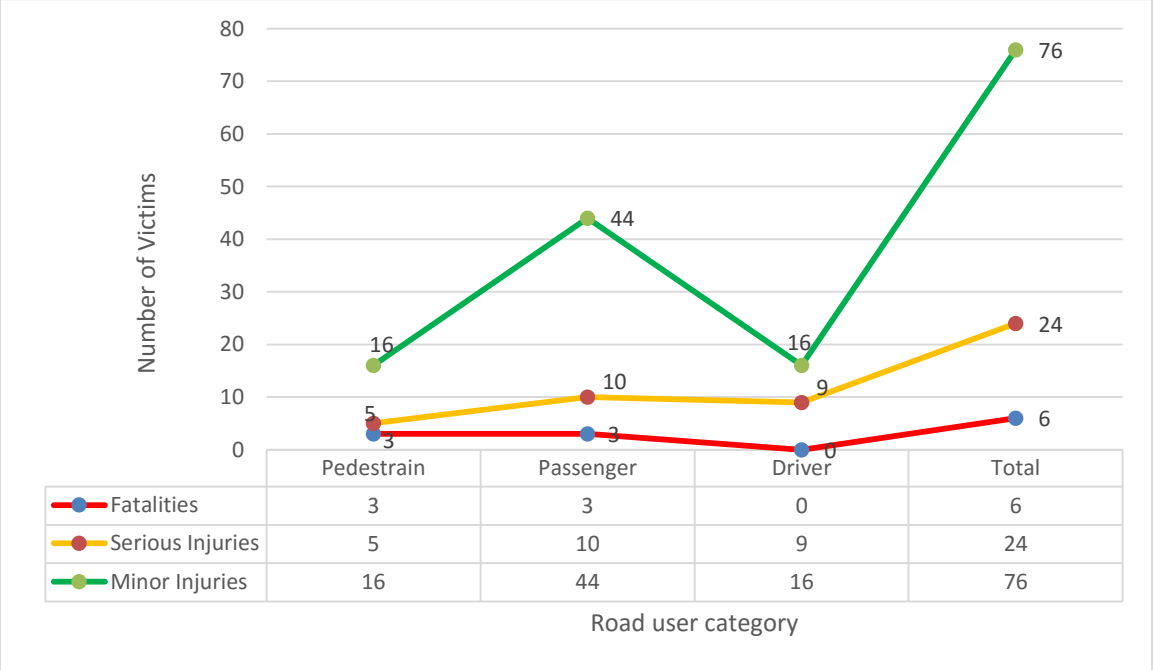


Figure 66: Composition of road traffic injuries and fatalities in VDM for Feb. 2013

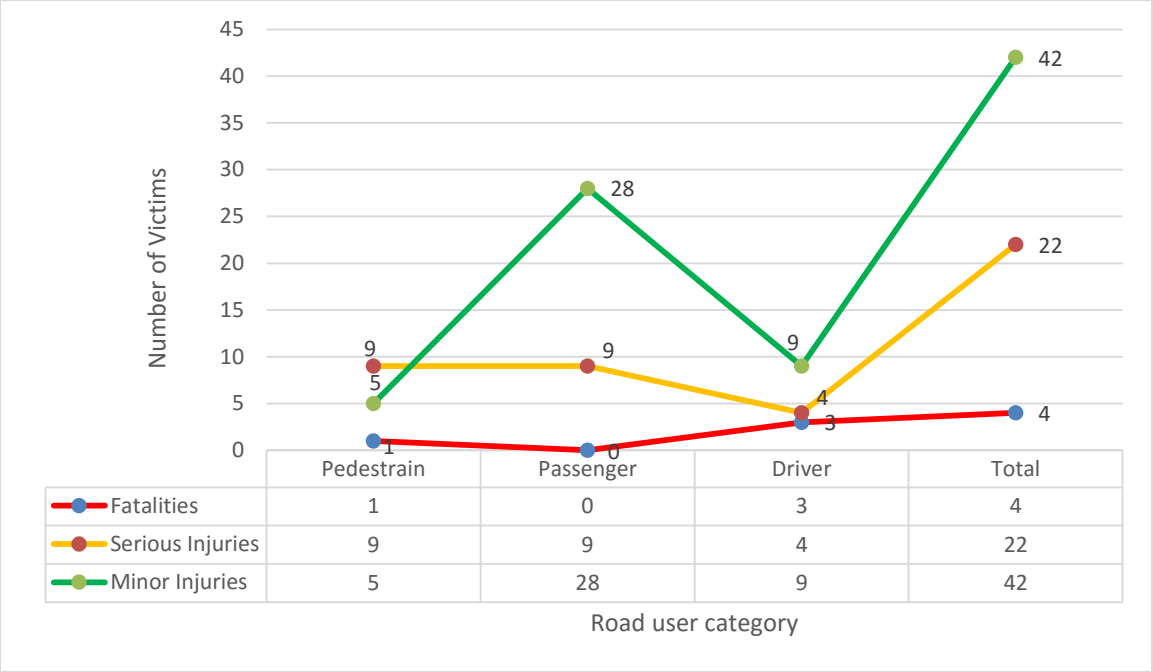


Figure 67: Composition of road traffic injuries and fatalities in VDM for Mar. 2013

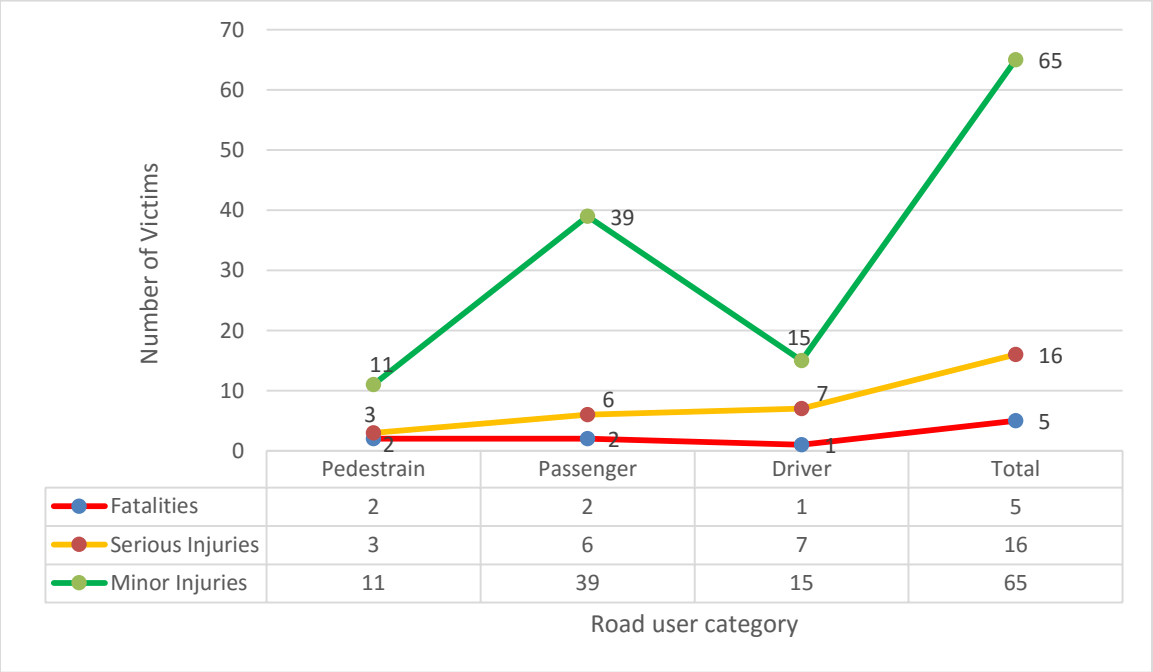


Figure 68: Composition of road traffic injuries and fatalities in VDM for Apr. 2013

Figure 69: Composition of road traffic injuries and fatalities in VDM for May 2013

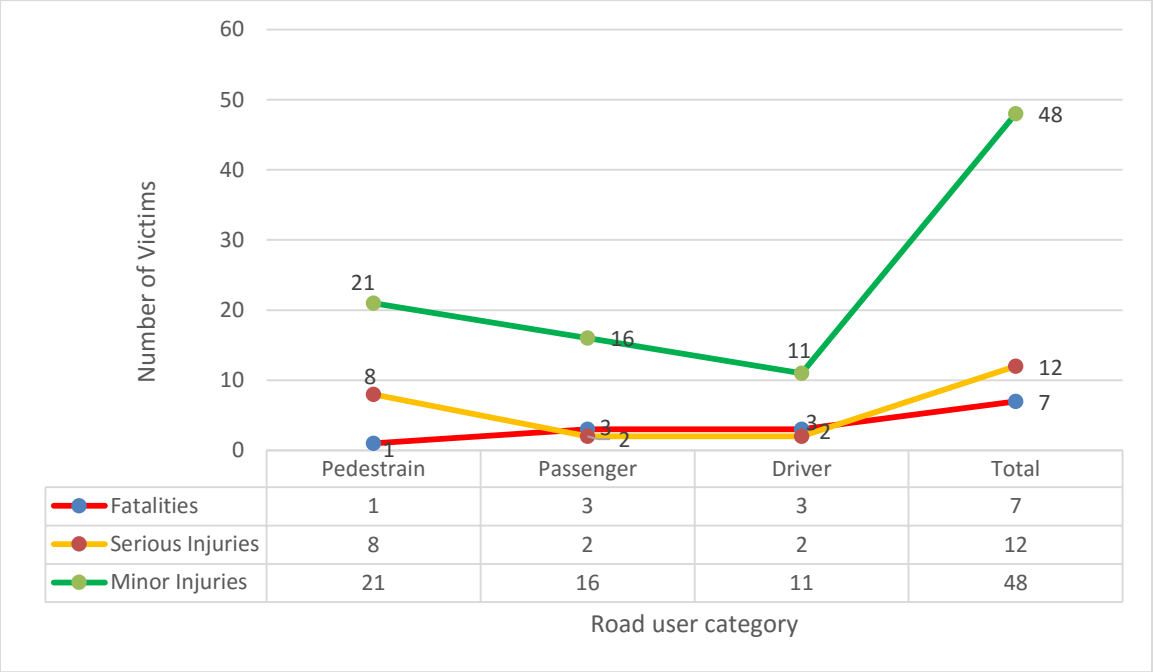


Figure 70: Composition of road traffic injuries and fatalities in VDM for Jun. 2013

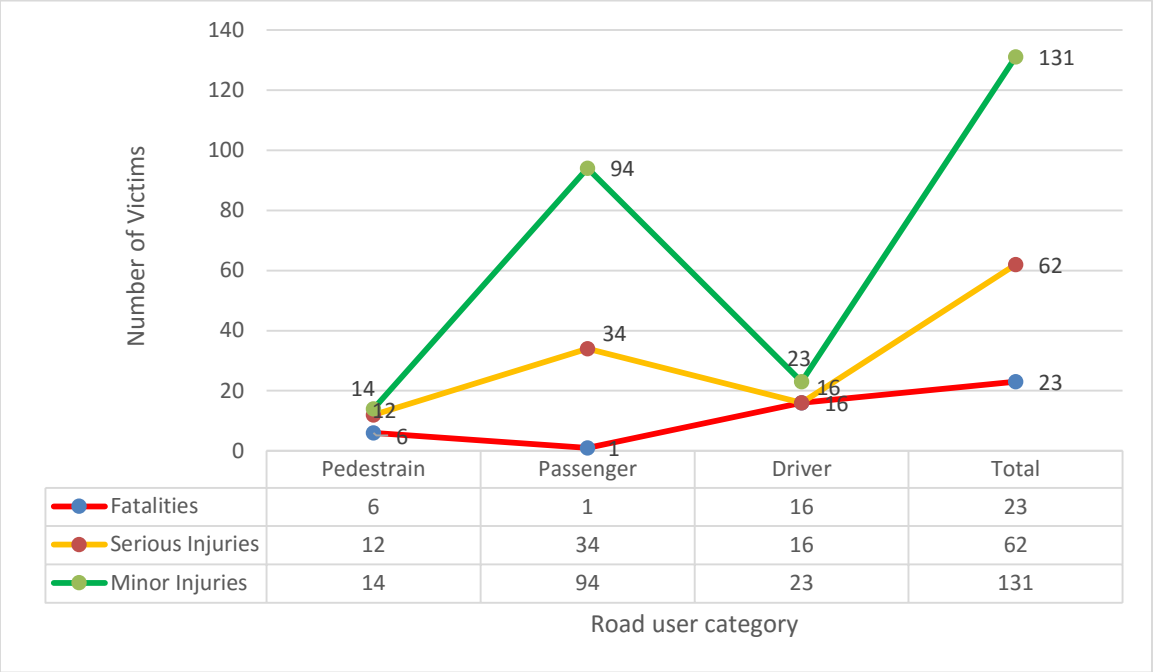


Figure 71: Composition of road traffic injuries and fatalities in VDM for Jul. 2013

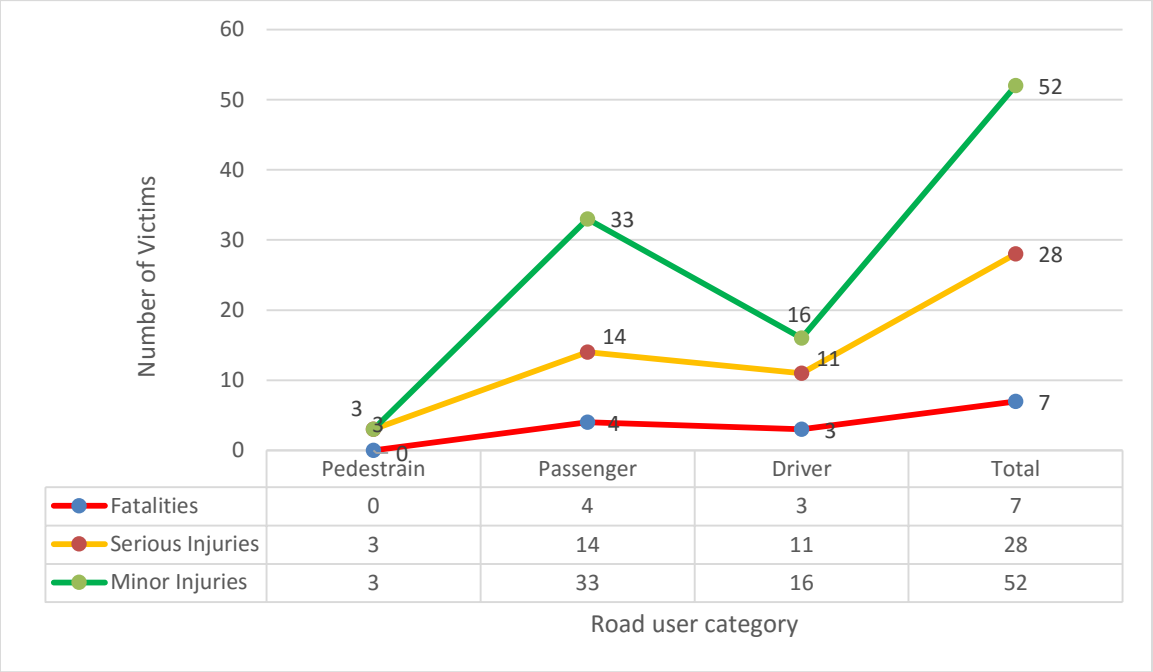


Figure 72: Composition of road traffic injuries and fatalities in VDM for Aug. 2013

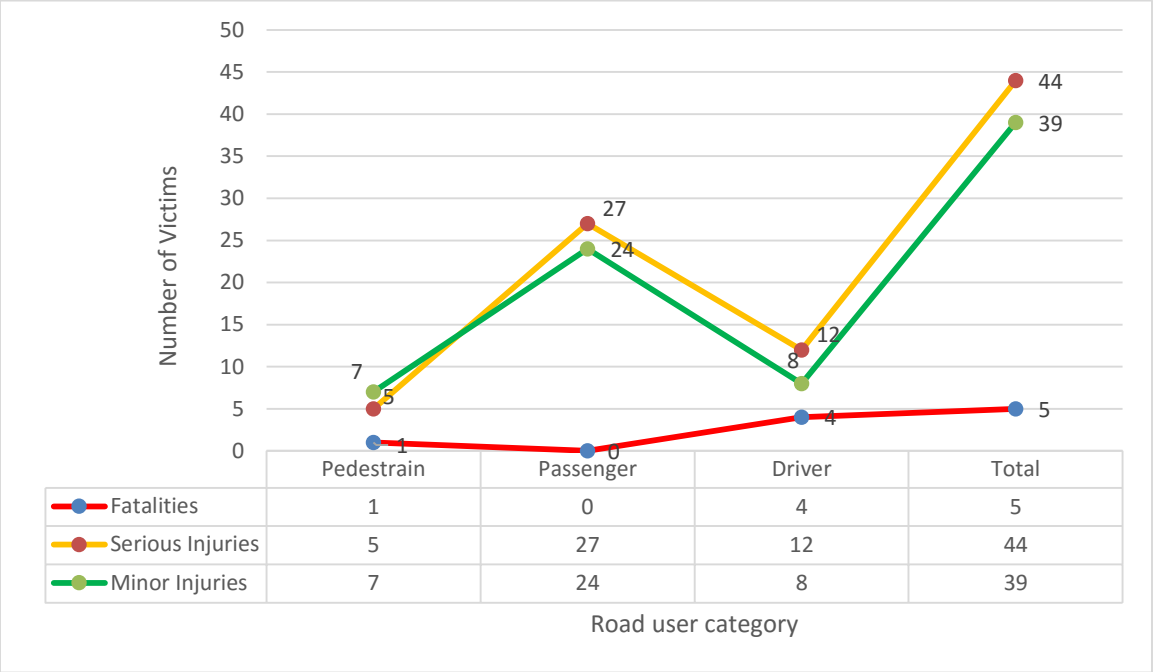


Figure 73: Composition of road traffic injuries and fatalities in VDM for Sep. 2013

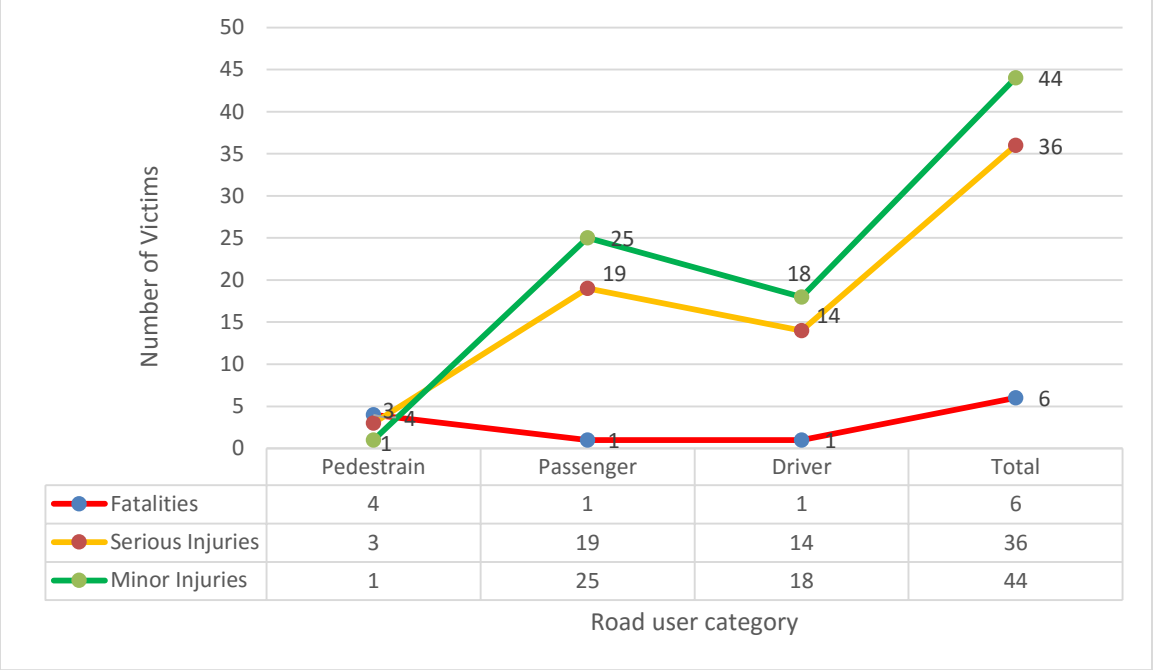


Figure 74: Composition of road traffic injuries and fatalities in VDM for Oct. 2013

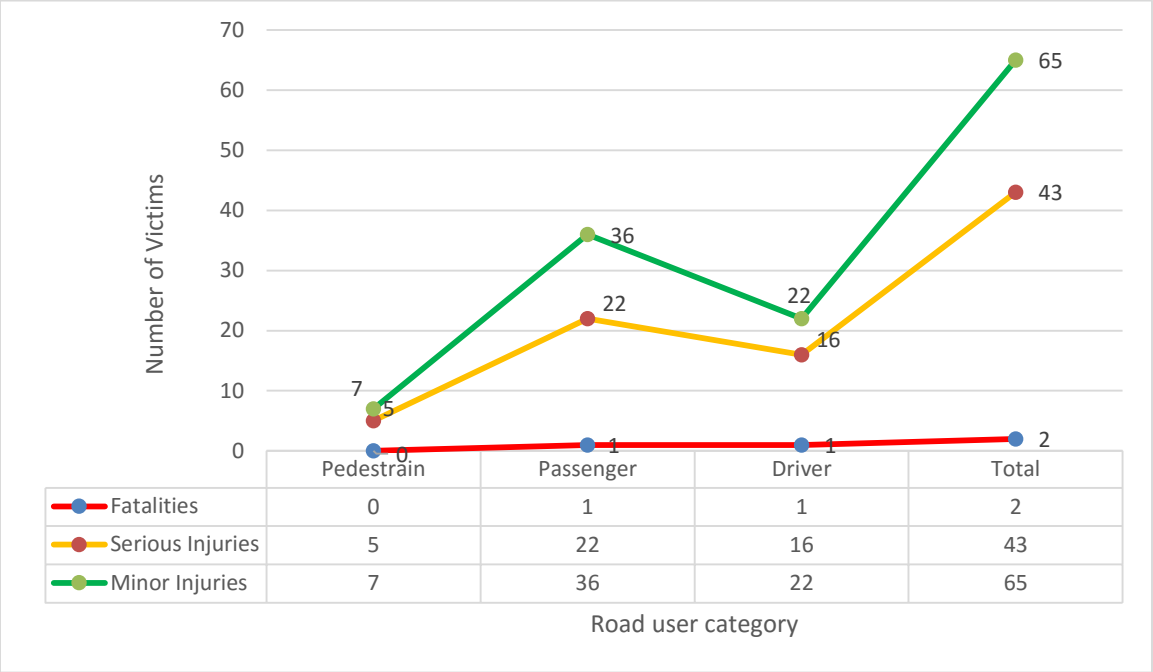


Figure 75: Composition of road traffic injuries and fatalities in VDM for Nov. 2013

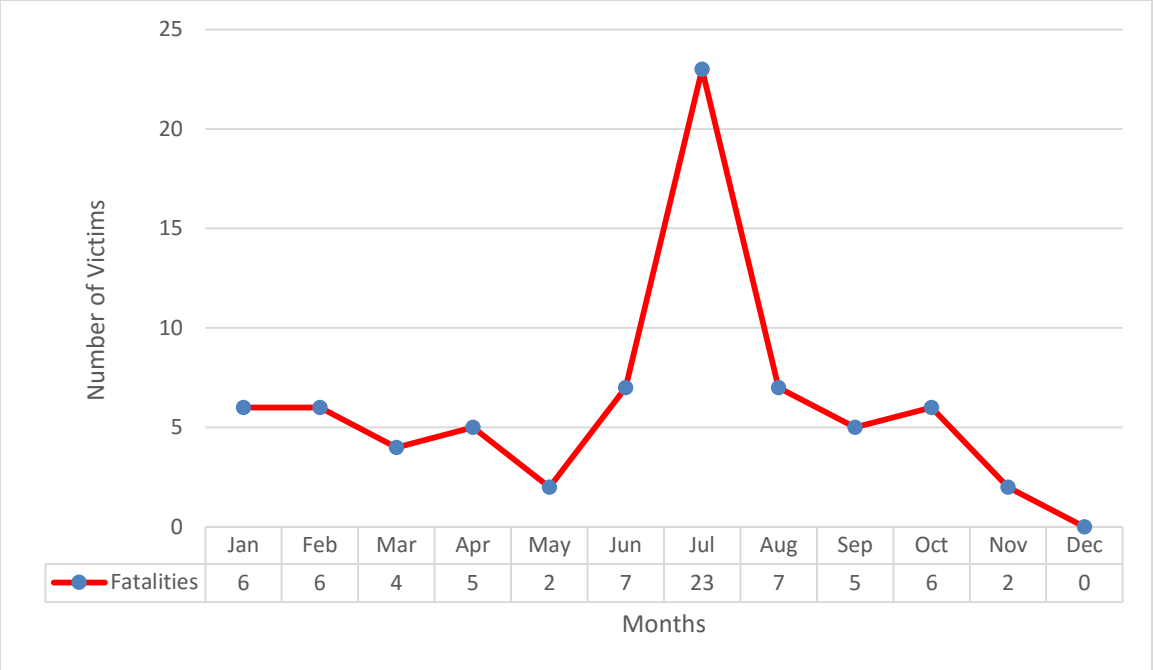


Figure 76: Road traffic fatalities trend for VDM in the year 2013

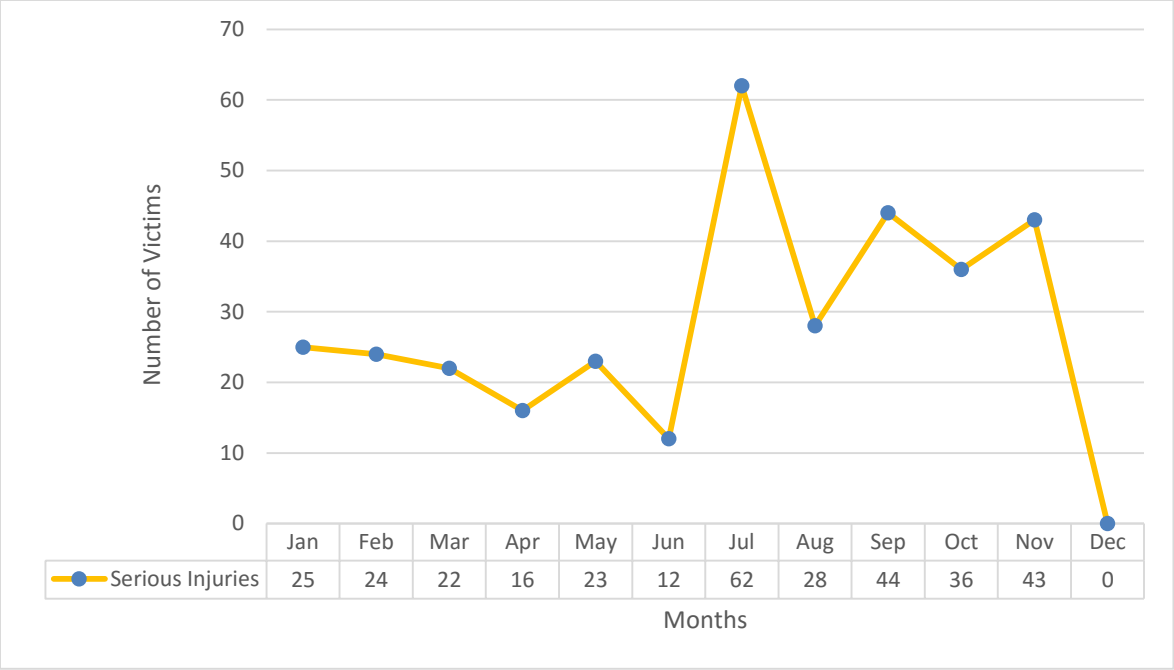


Figure 77: Road traffic serious injuries trend for VDM in the year 2013

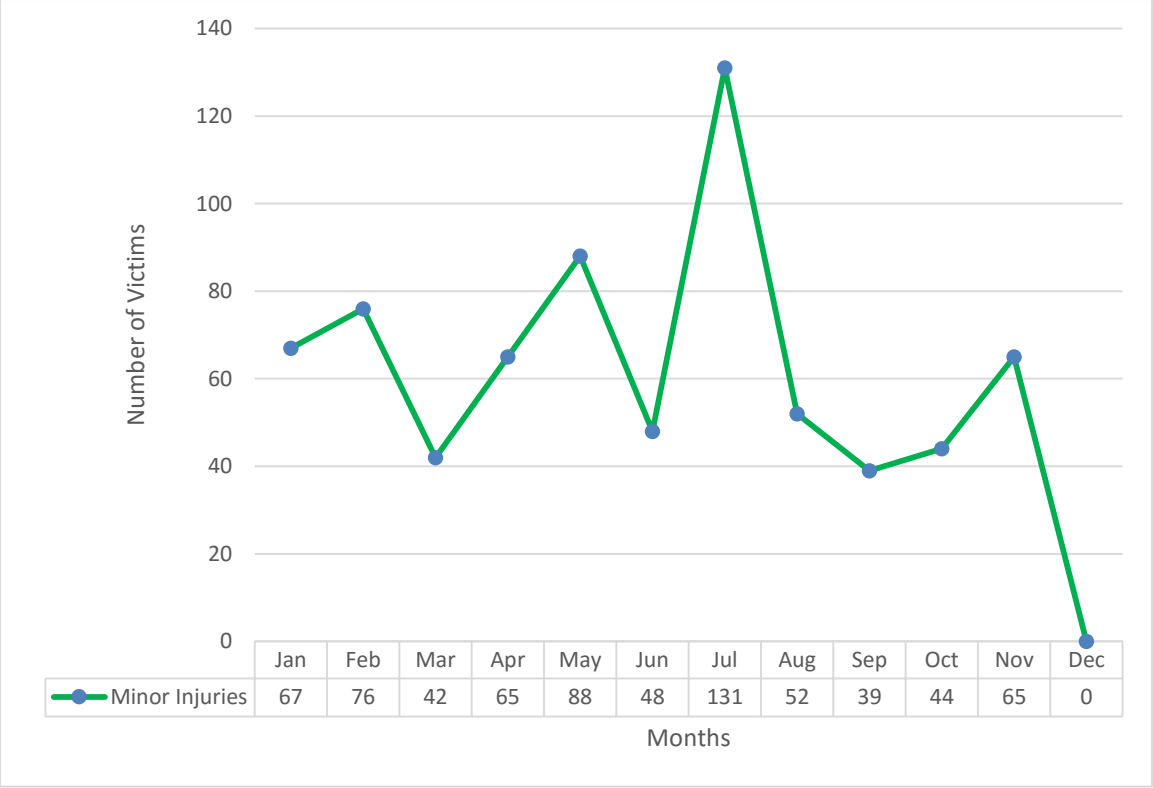


Figure 78: Road traffic minor injuries trend for VDM in the year 2013

APPENDIX 8: GRAPHICAL ANALYSIS OF ROAD TRAFFIC INJURIES AND FATALITIES ON MONTHLY BASIS FOR 2014

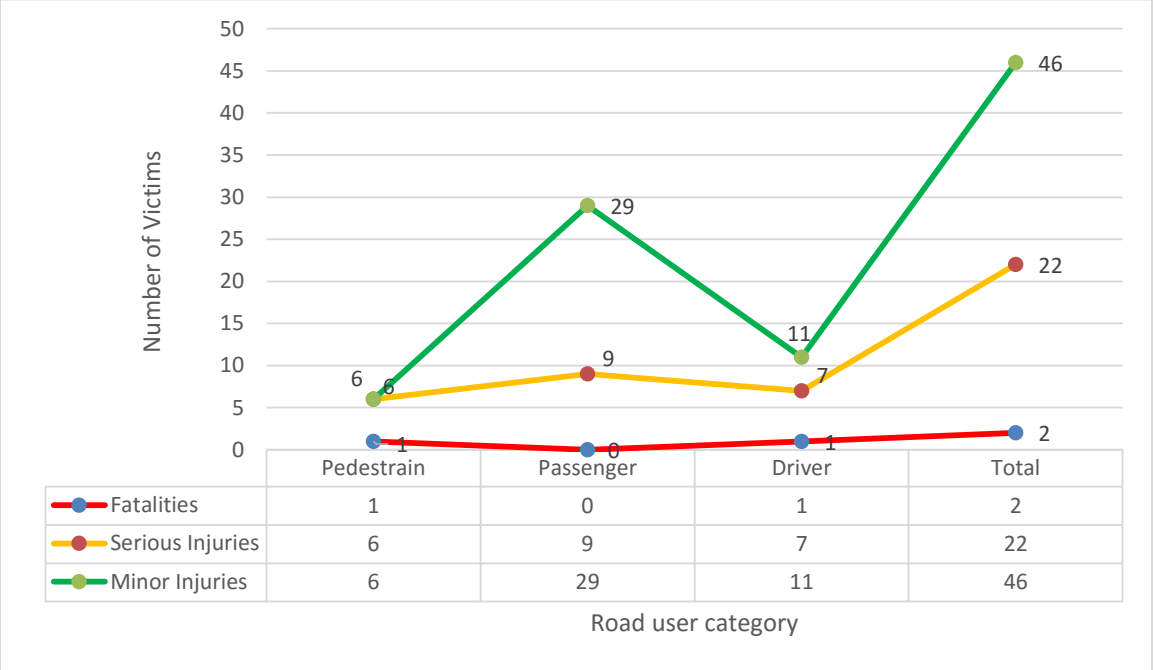


Figure 79: Composition of road traffic injuries and fatalities in VDM for Jan. 2014

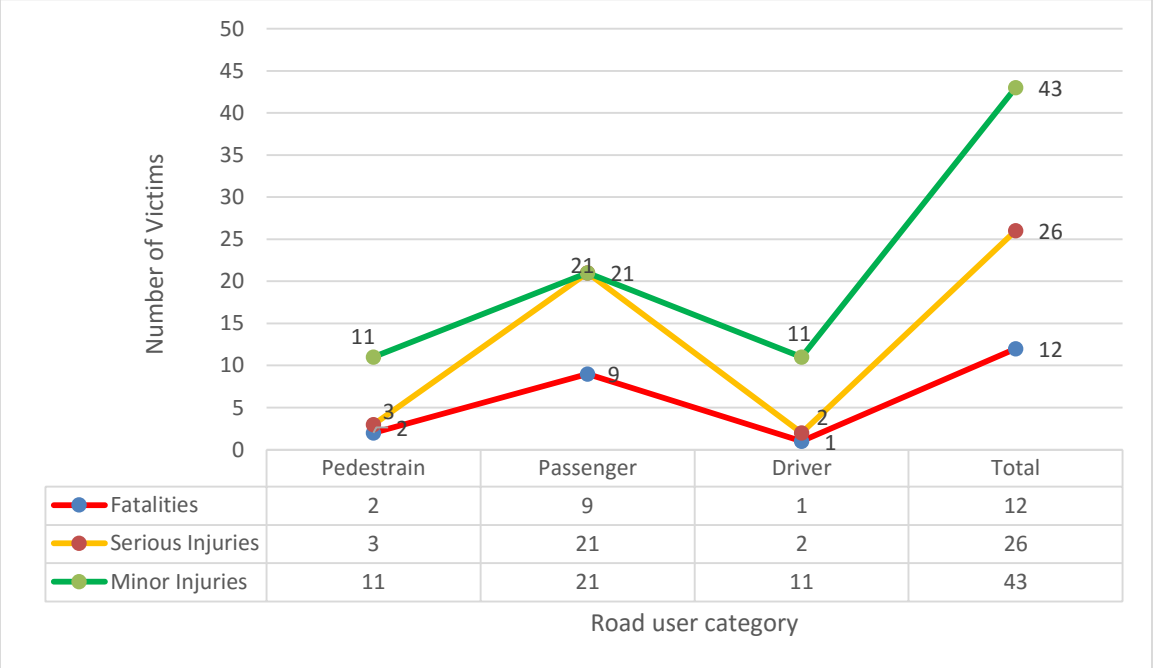


Figure 80: Composition of road traffic injuries and fatalities in VDM for Feb. 2014

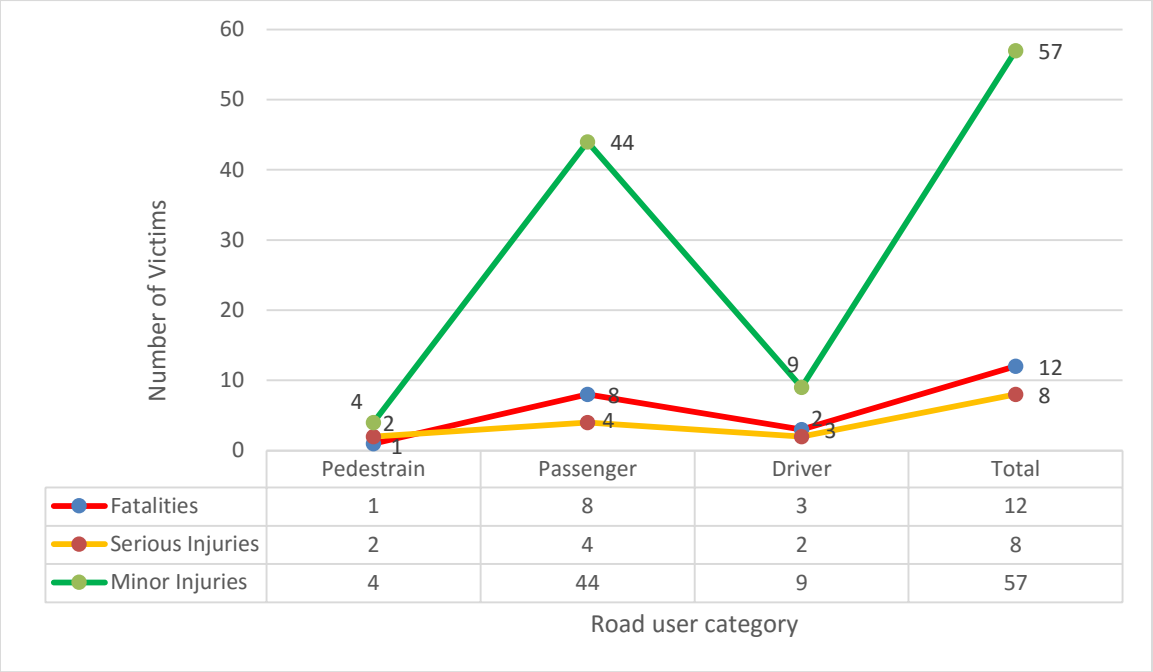


Figure 81: Composition of road traffic injuries and fatalities in VDM for Mar. 2014

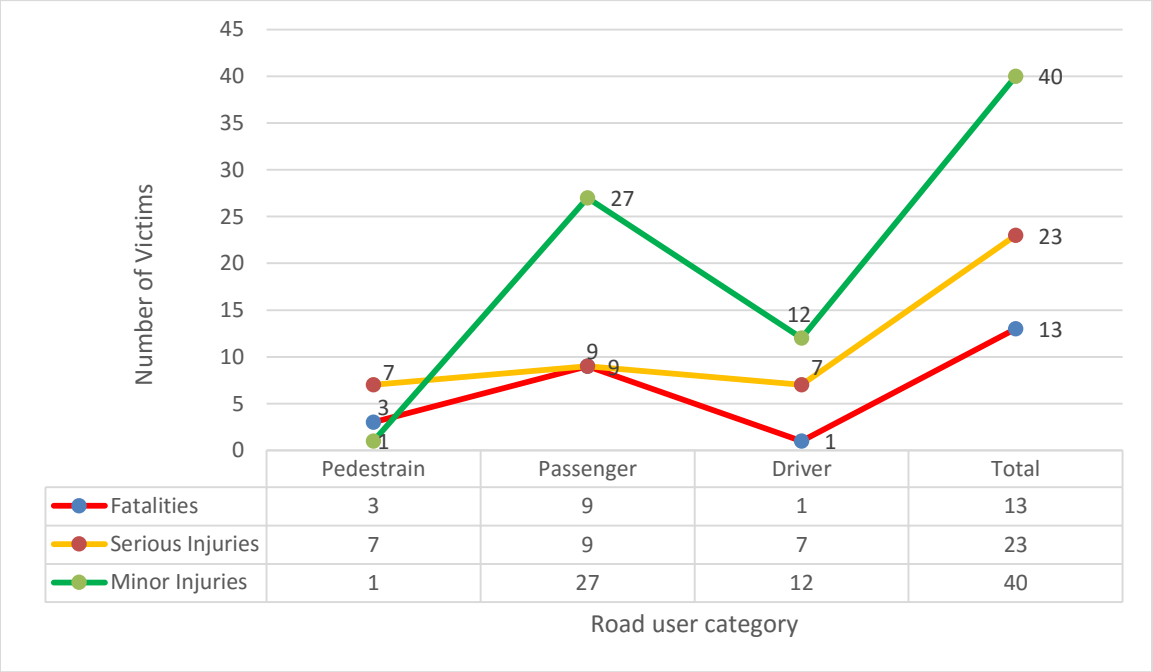


Figure 82: Composition of road traffic injuries and fatalities in VDM for Apr. 2014

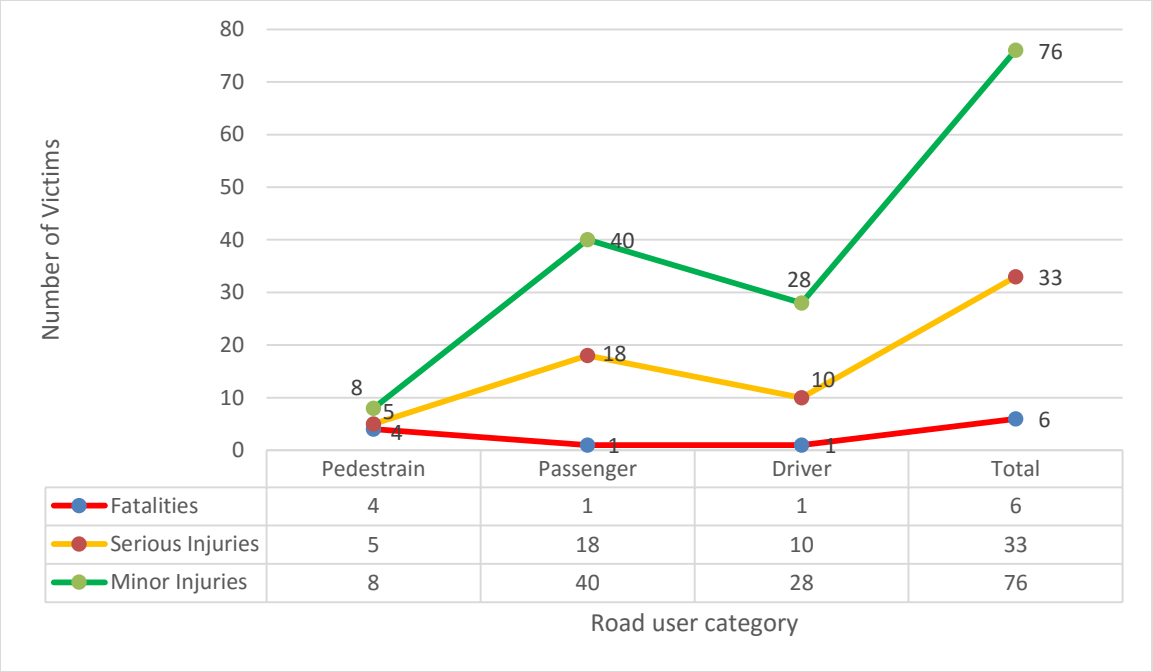


Figure 83: Composition of road traffic injuries and fatalities in VDM for May. 2014

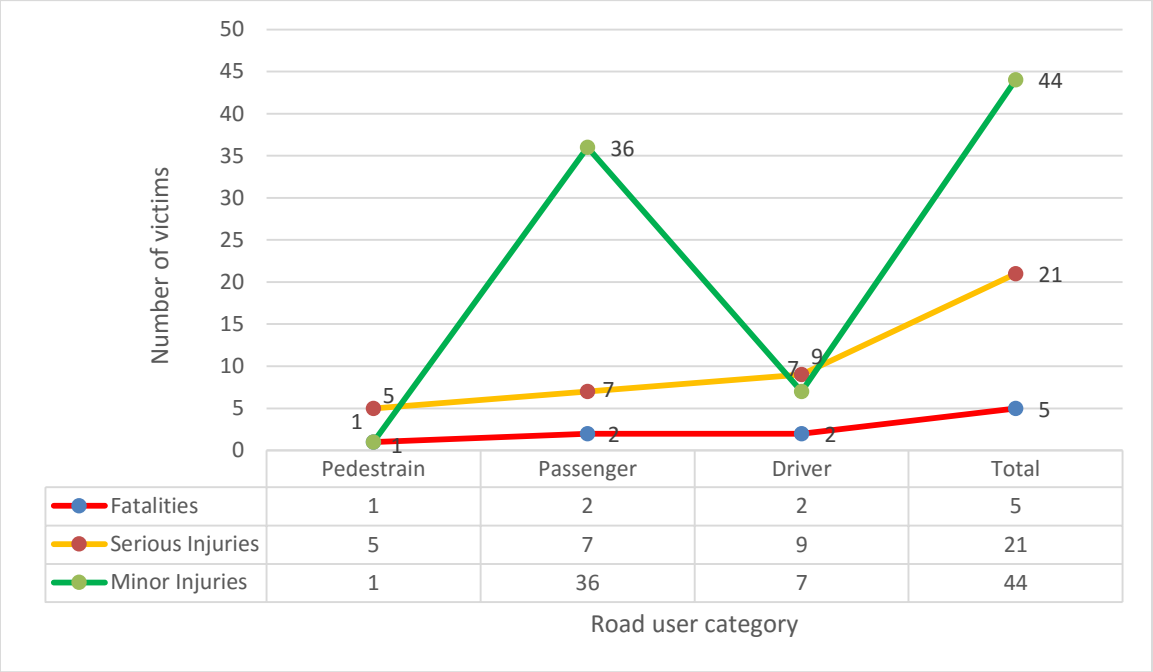


Figure 84: Composition of road traffic injuries and fatalities in VDM for Jun. 2014

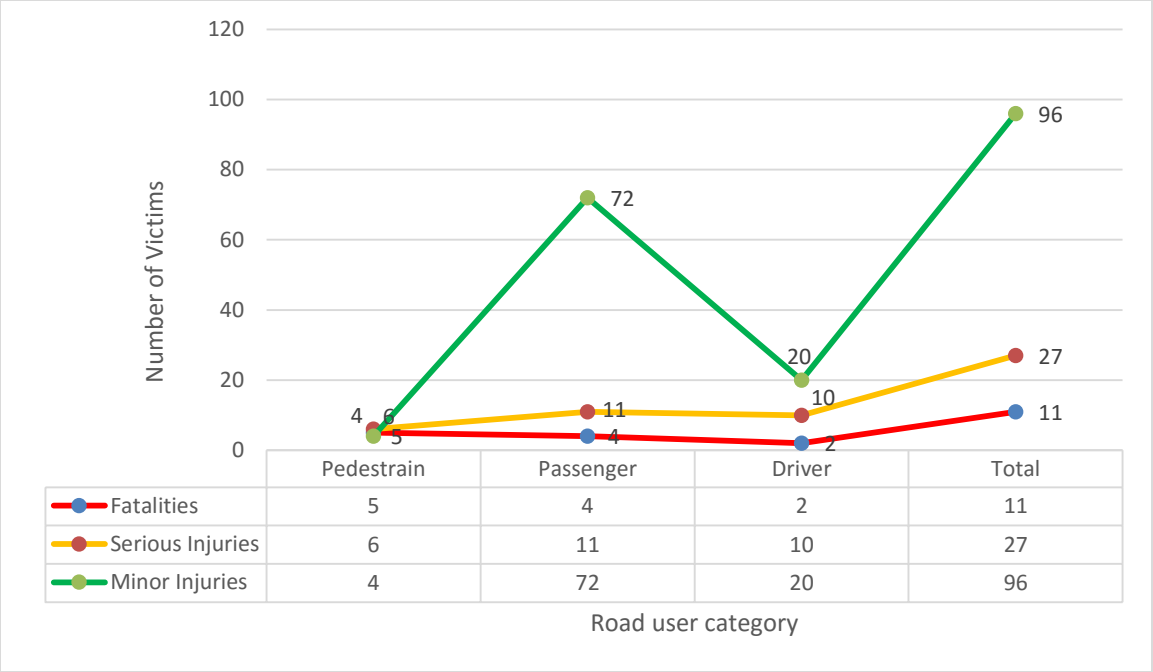


Figure 85: Composition of road traffic injuries and fatalities in VDM for Jul. 2014

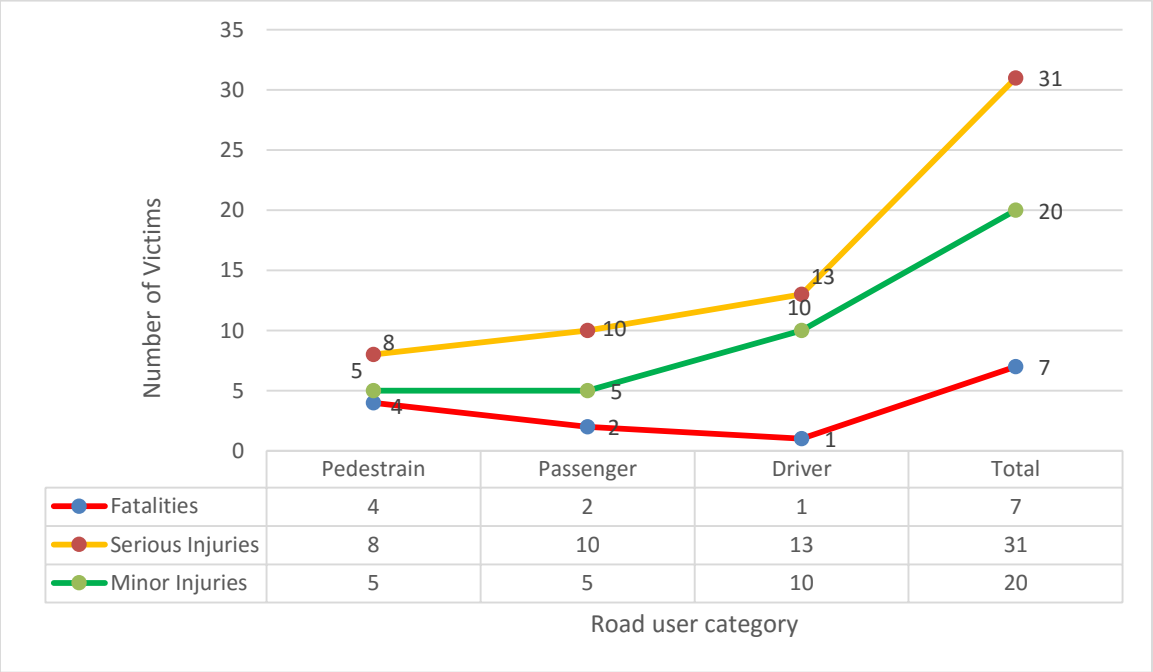


Figure 86: Composition of road traffic injuries and fatalities in VDM for Aug. 2014

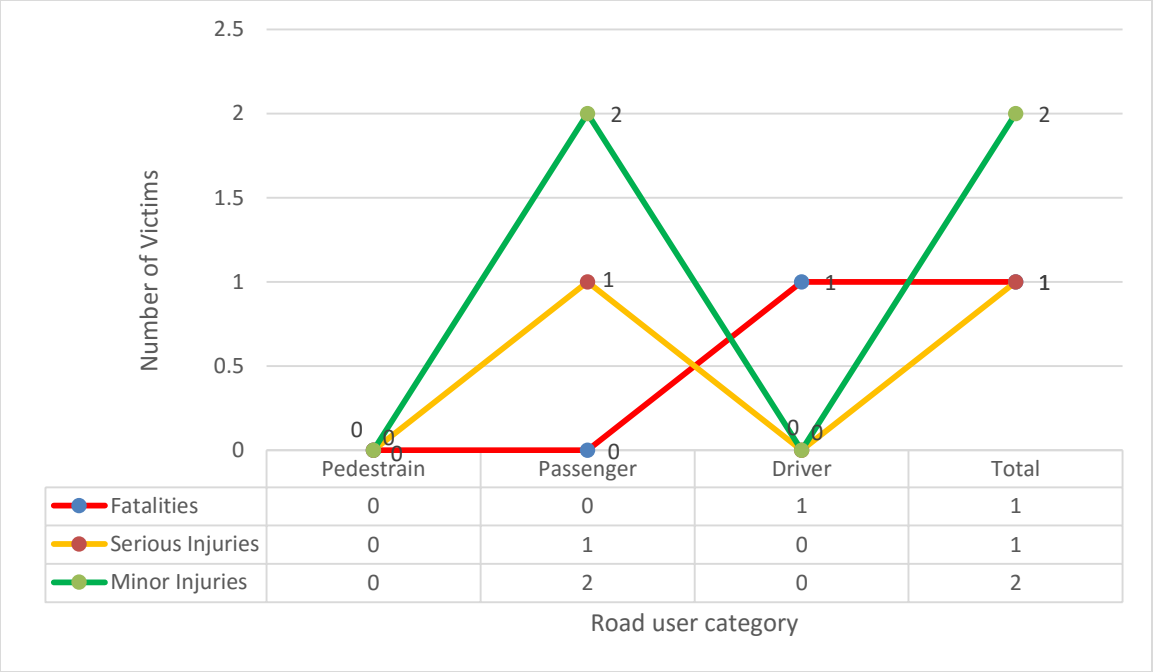


Figure 87: Composition of road traffic injuries and fatalities in VDM for Sep. 2014

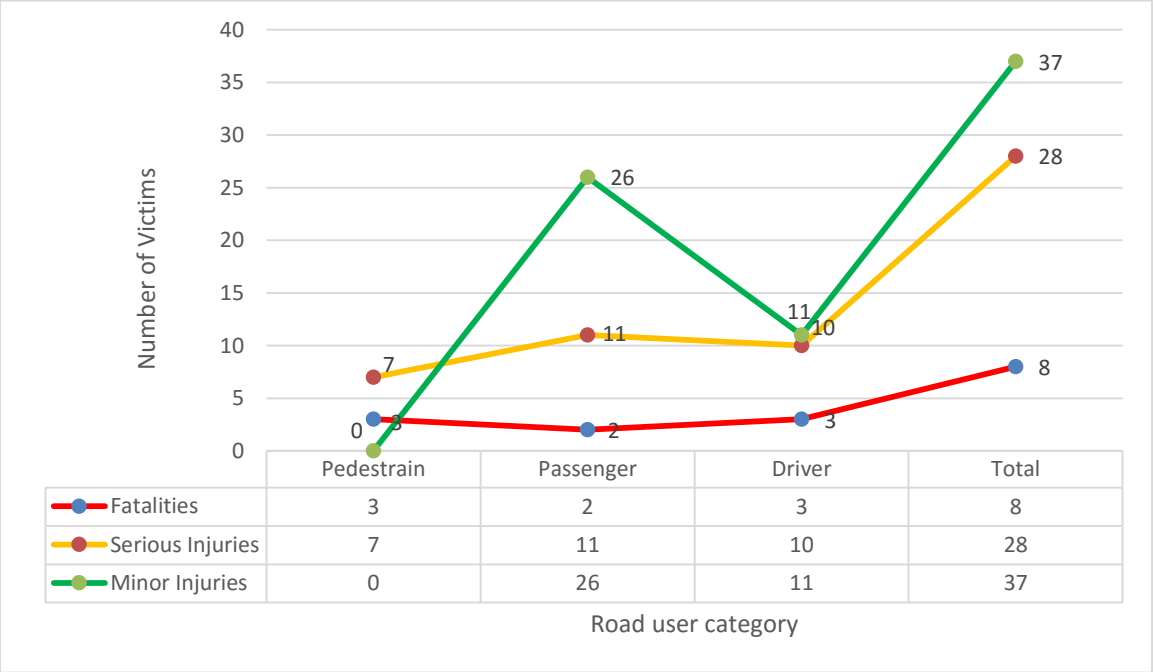


Figure 88: Composition of road traffic injuries and fatalities in VDM for Oct. 2014

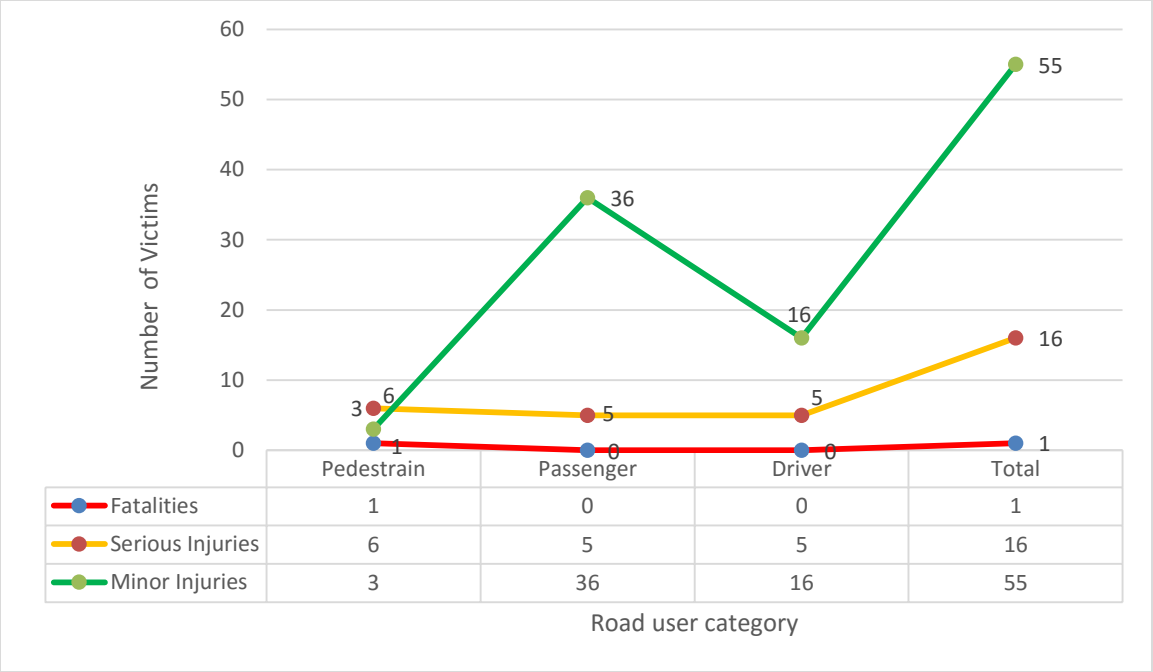


Figure 89: Composition of road traffic injuries and fatalities in VDM for Nov. 2014

Figure 90: Composition of road traffic injuries and fatalities in VDM for Dec. 2014

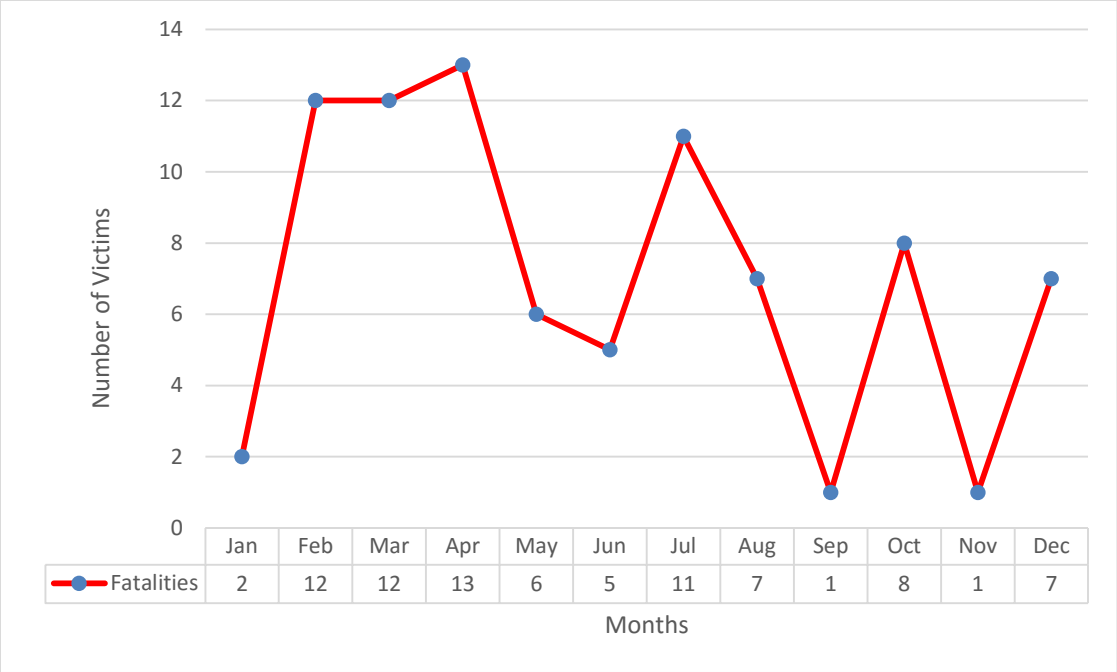


Figure 91: Road traffic fatalities trend for VDM in the year 2014

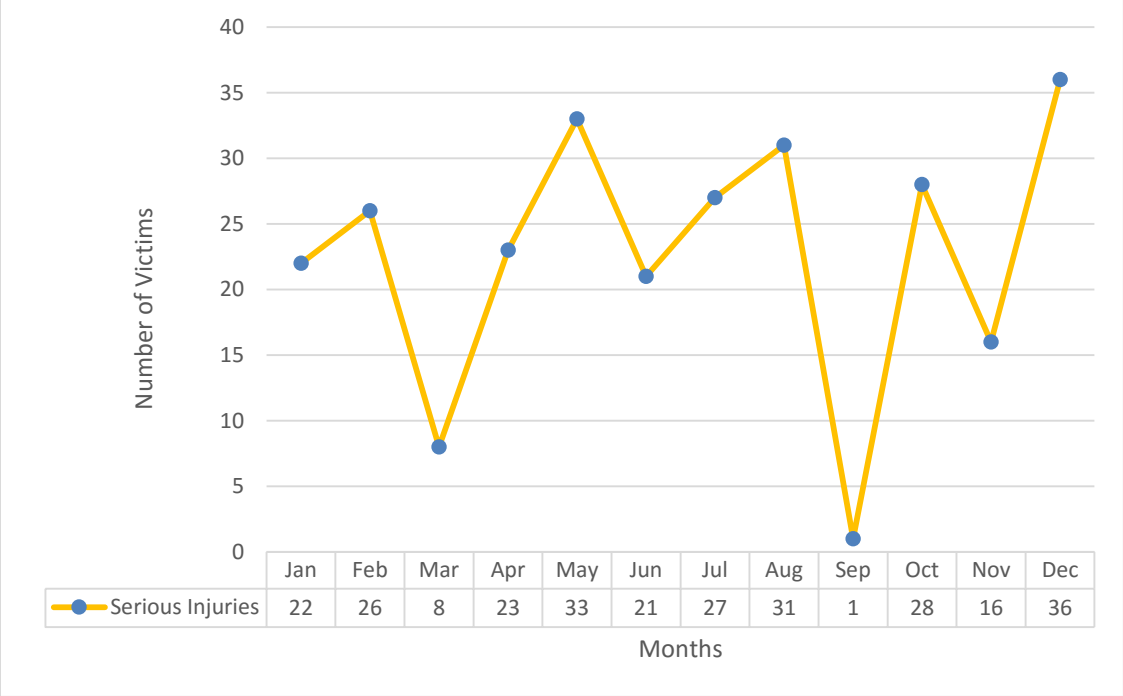


Figure 92: Road traffic serious injuries trend for VDM in the year 2014

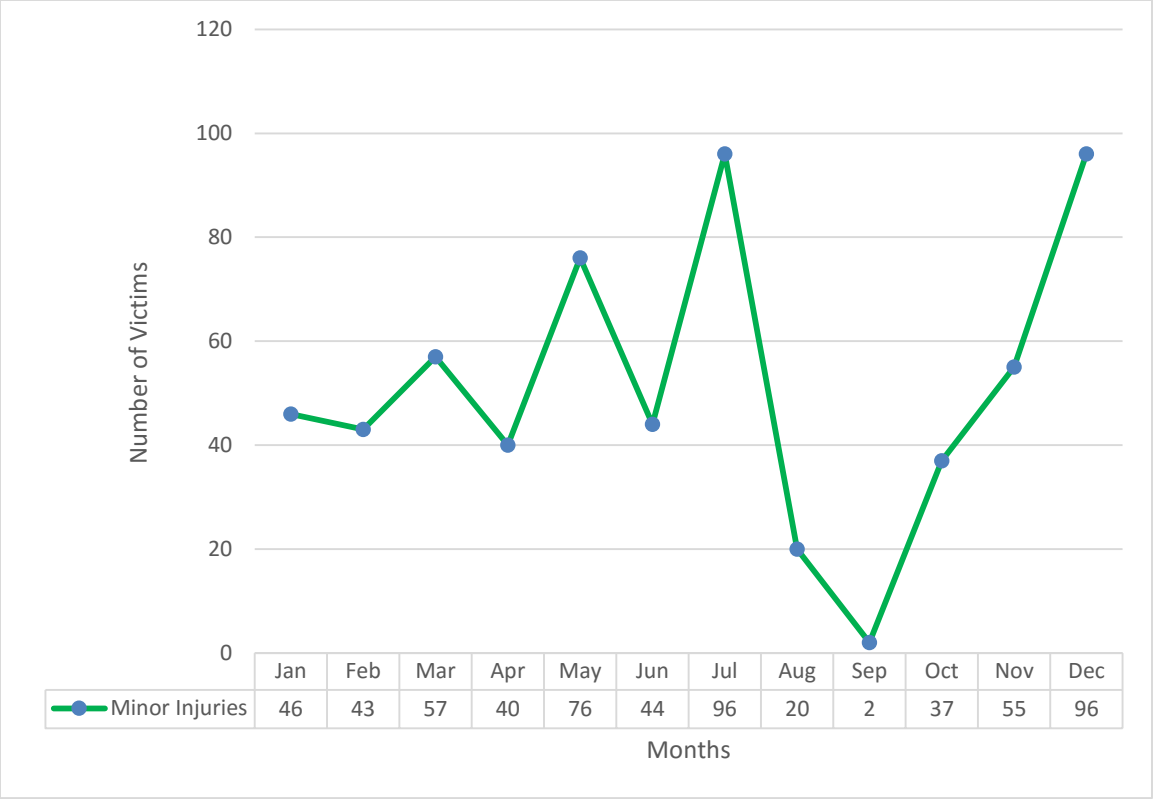


Figure 93: Road traffic minor injuries trend for VDM in the year 2014

APPENDIX 9: GRAPHICAL ANALYSIS OF ROAD TRAFFIC INJURIES AND FATALITIES ON MONTHLY BASIS FOR 2015

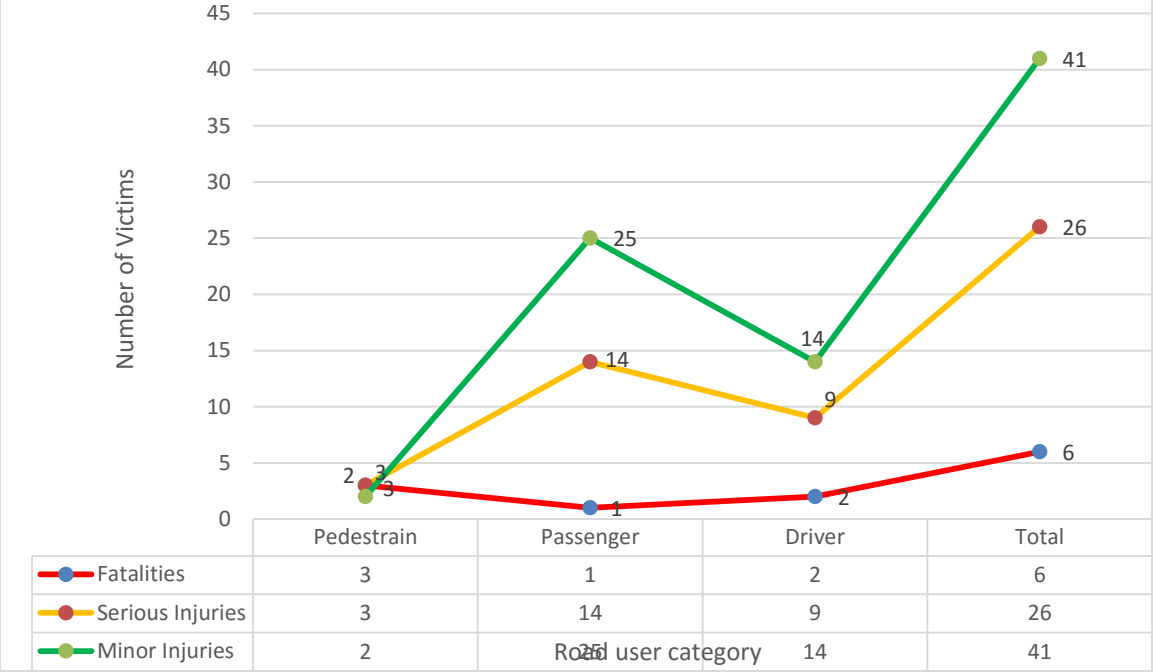


Figure 94: Composition of road traffic injuries and fatalities in VDM for Jan. 2015

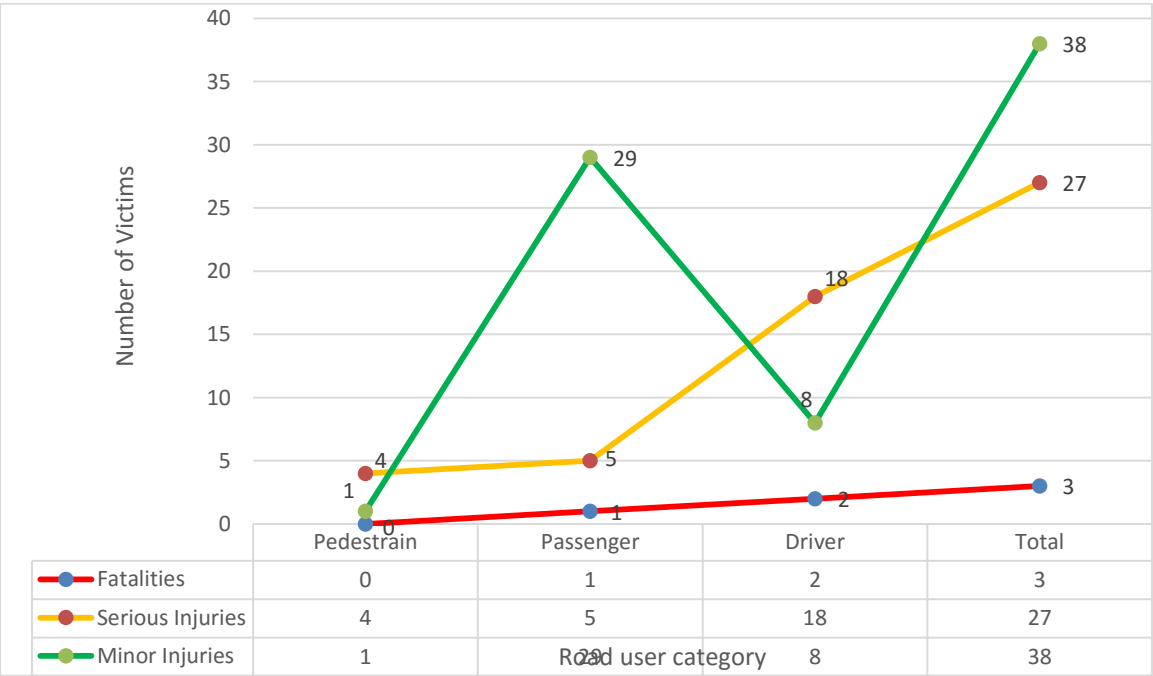


Figure 95: Composition of road traffic injuries and fatalities in VDM for Feb. 2015

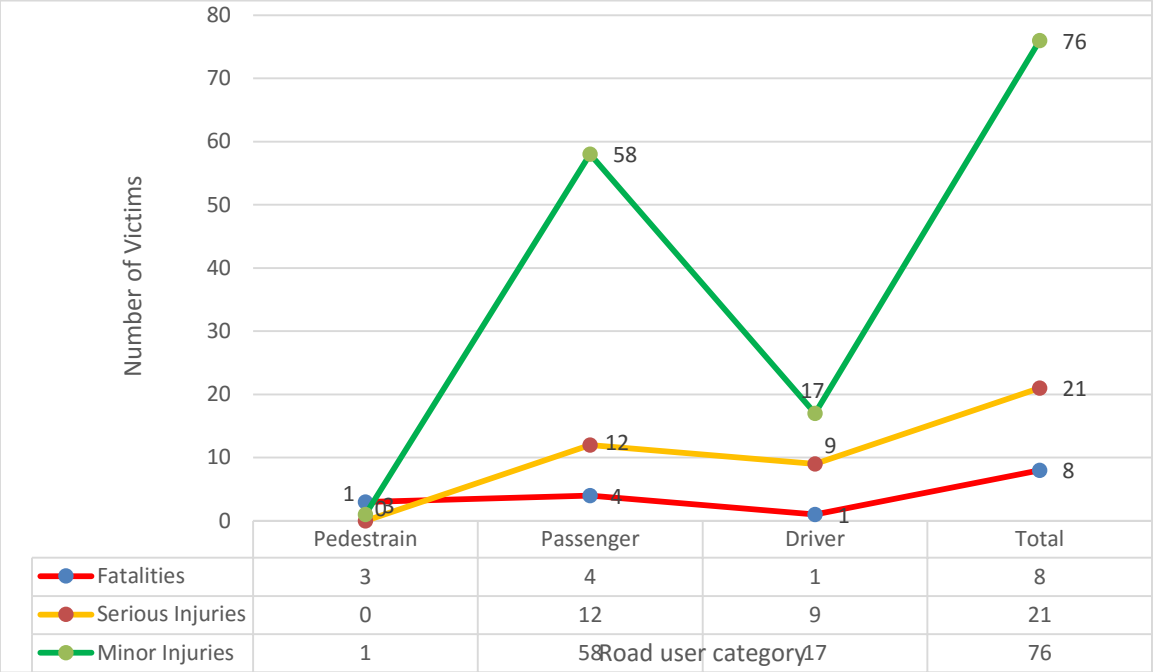


Figure 96: Composition of road traffic injuries and fatalities in VDM for Mar. 2015

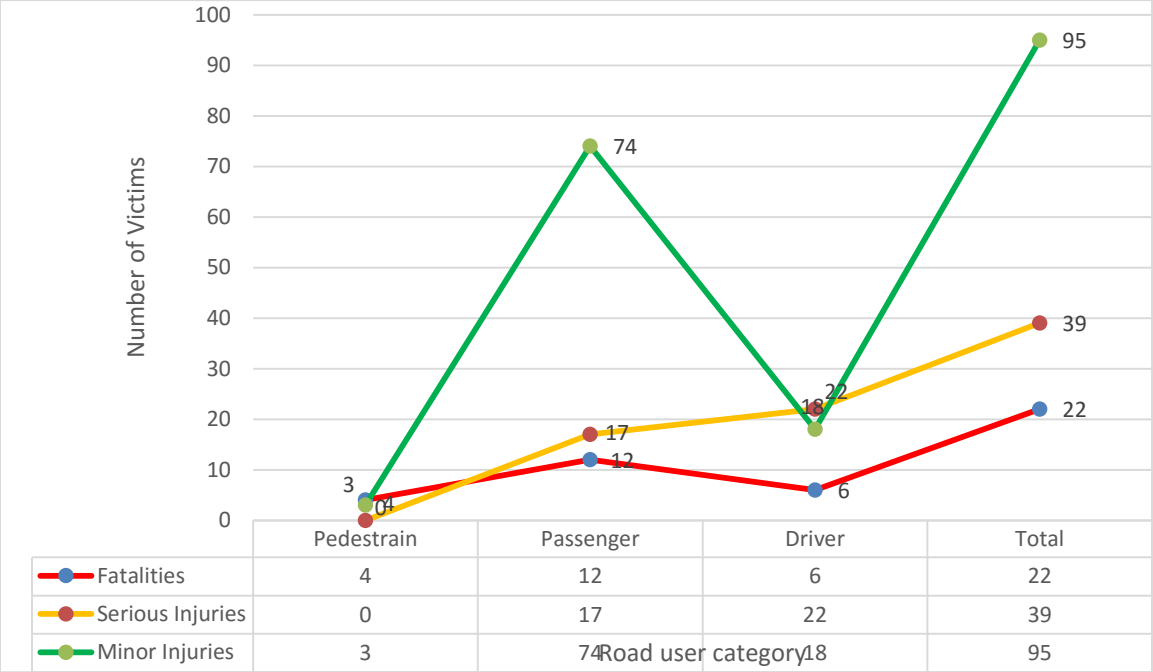


Figure 97: Composition of road traffic injuries and fatalities in VDM for Apr. 2015

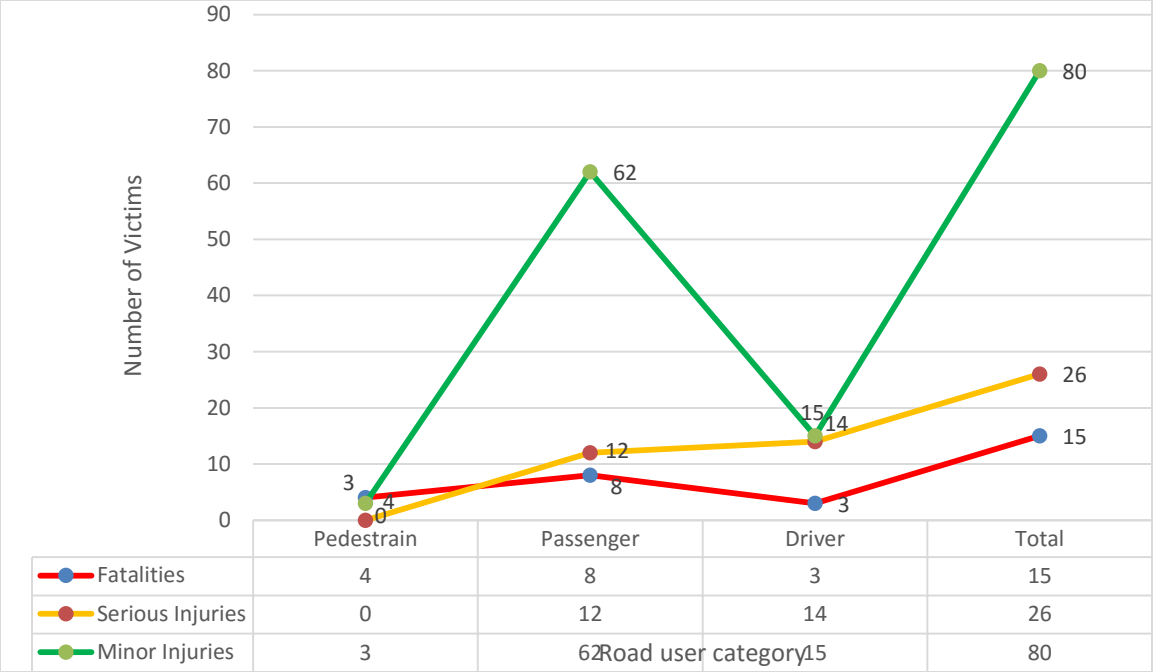


Figure 98: Composition of road traffic injuries and fatalities in VDM for May 2015

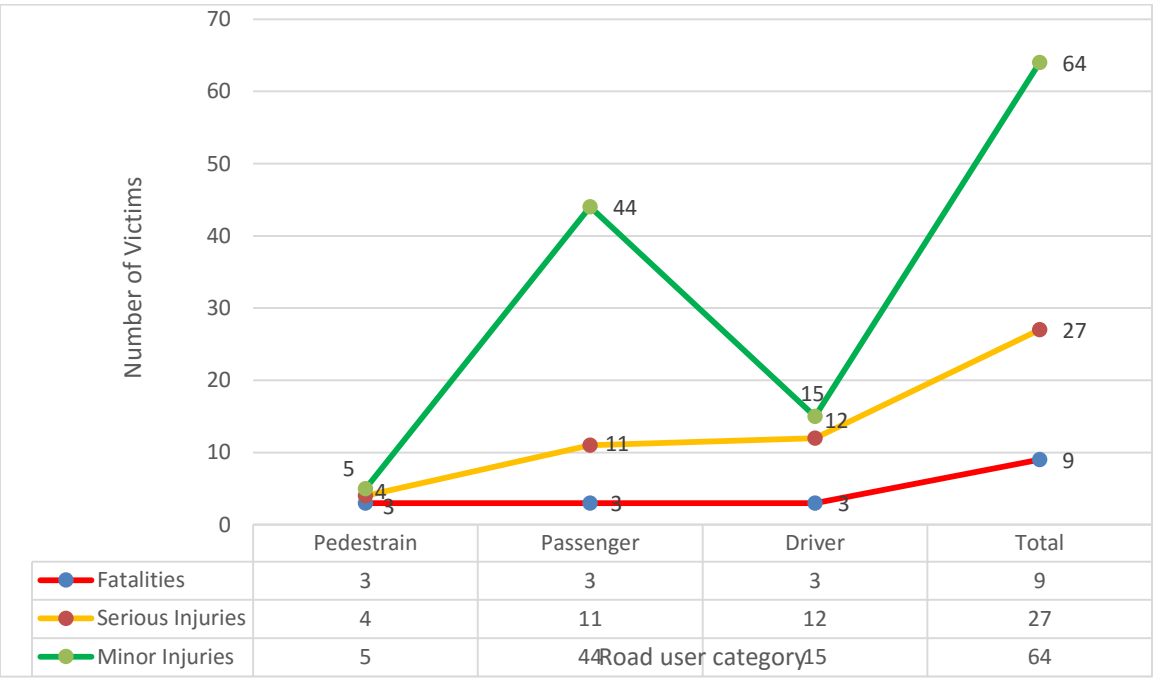


Figure 99: Composition of road traffic injuries and fatalities in VDM for Jun. 2015

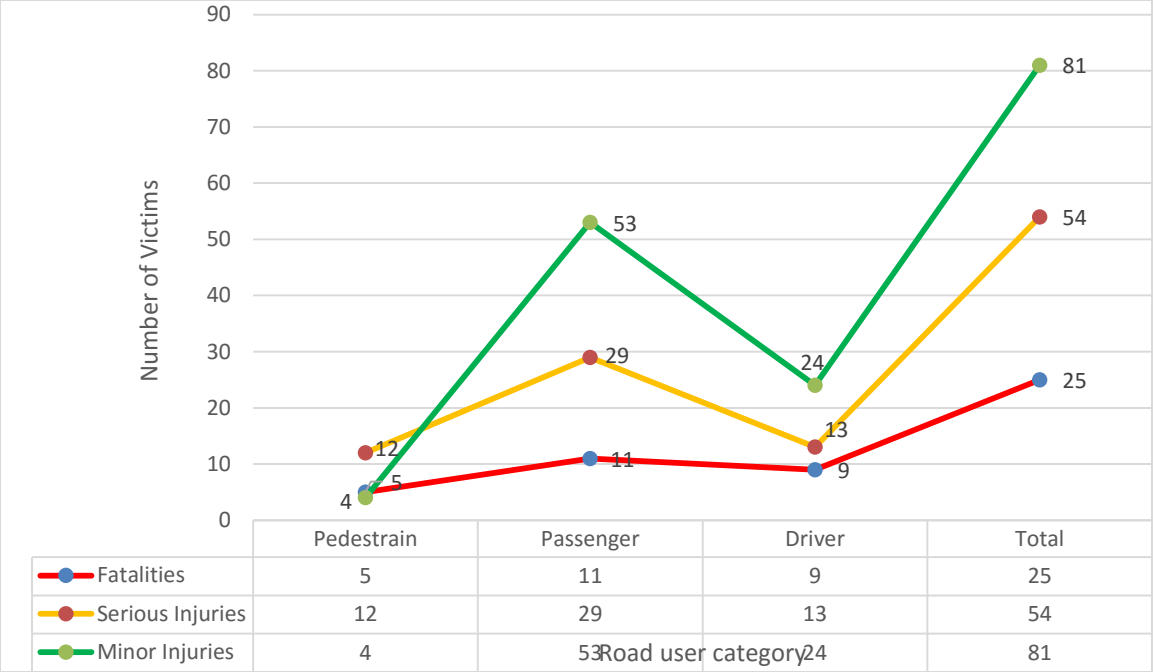


Figure 100: Composition of road traffic injuries and fatalities in VDM for Jul. 2015

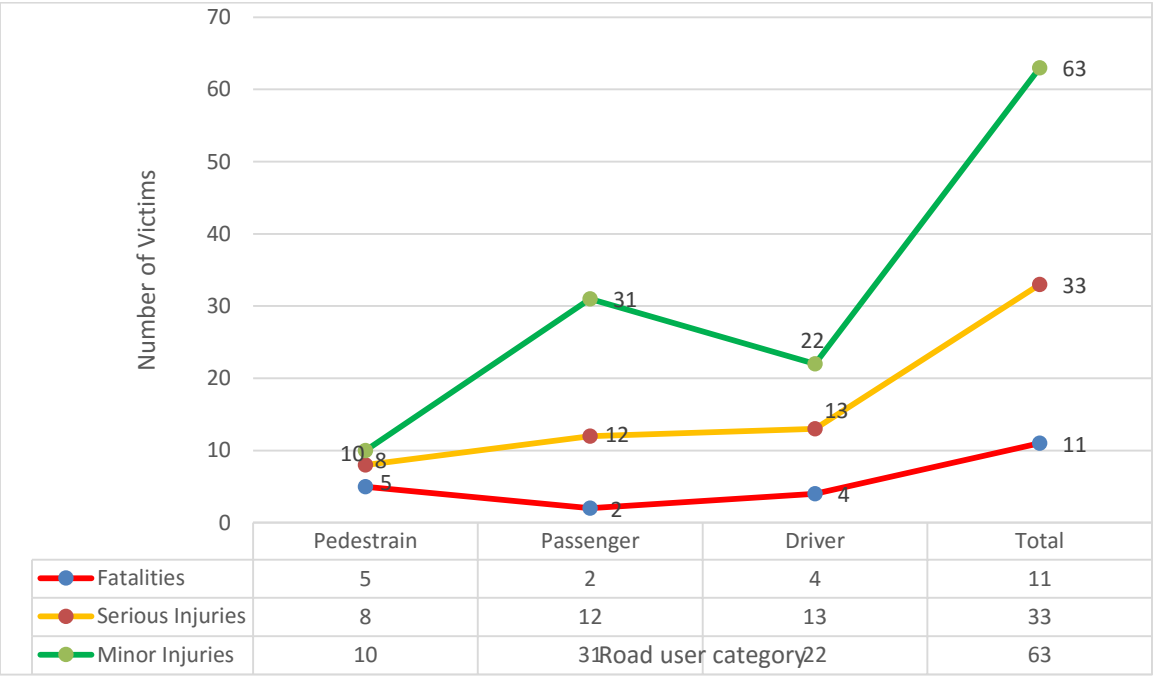


Figure 101: Composition of road traffic injuries and fatalities in VDM for Aug 2015

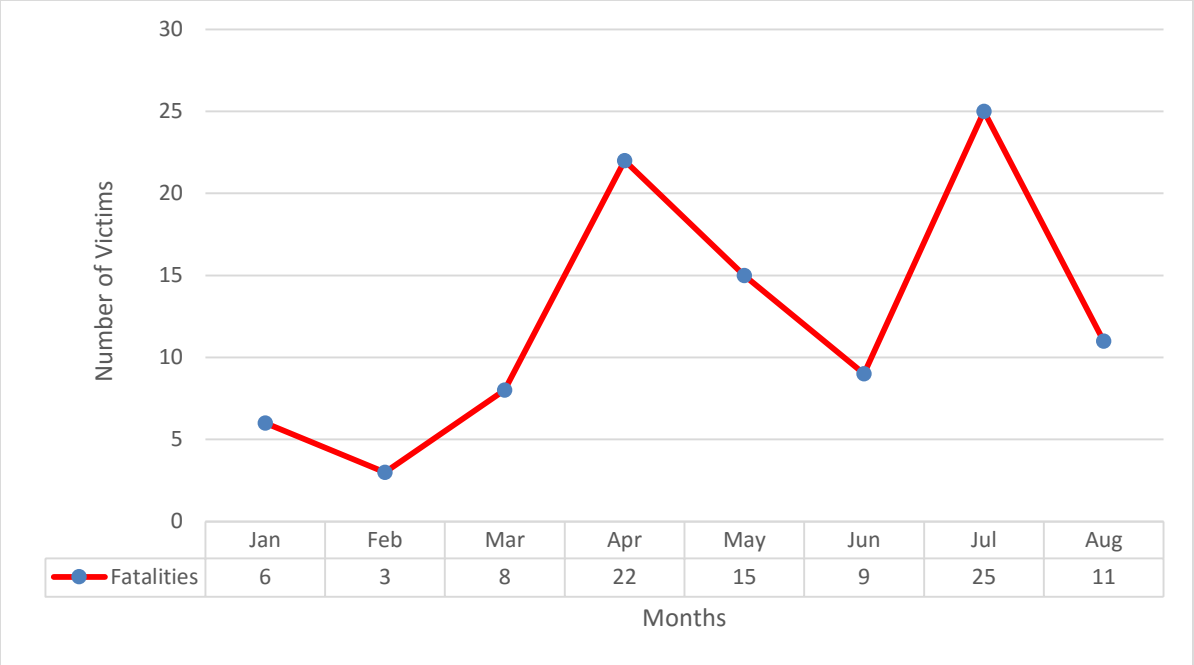


Figure 102: Road traffic fatalities trend for VDM in the year 2015

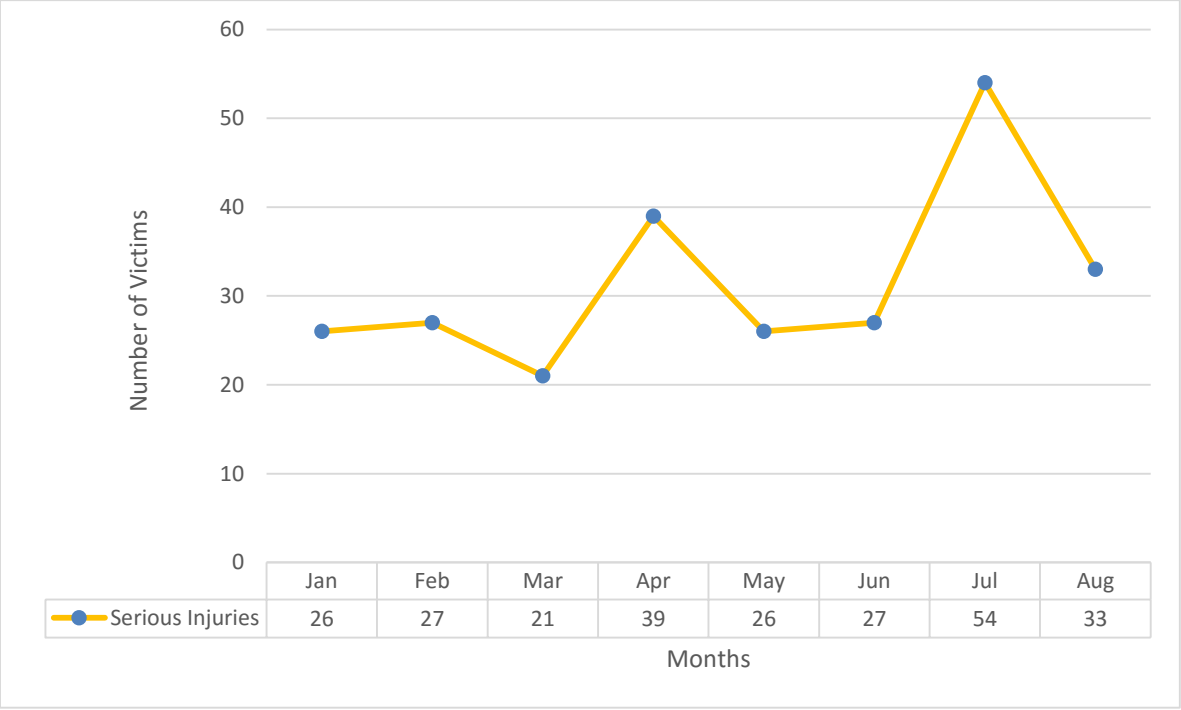


Figure103: Road traffic serious injuries trend for VDM in the year 2015

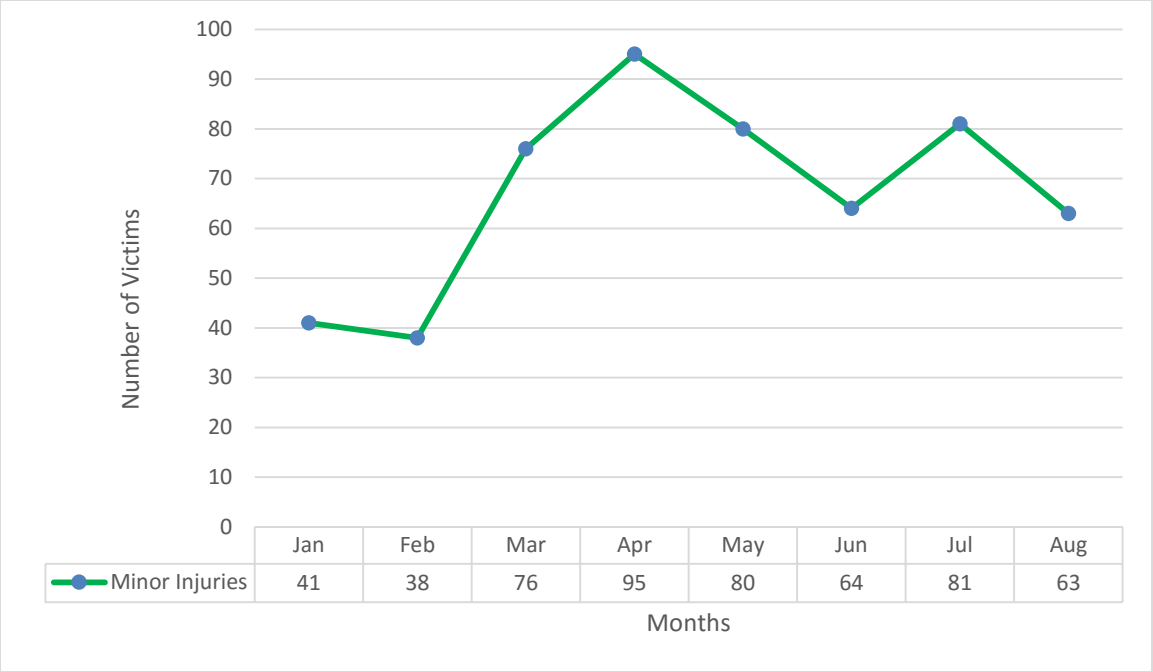


Figure 104: Road traffic minor injuries trend for VDM in the year 2015

RESEARCH AND INNOVATION
OFFICE OF THE DIRECTOR

NAME OF RESEARCHER/INVESTIGATOR:
Mr OA Osidele

Student No:
11639645

PROJECT TITLE: Using GIS to analyse the patterns and trends of road traffic injuries and fatalities in Vhembe District, Limpopo province, South Africa.

PROJECT NO: SES/15/GGIS/02/2408

SUPERVISORS/ CO-RESEARCHERS/ CO-INVESTIGATORS

NAME	INSTITUTION & DEPARTMENT	ROLE
Dr NS Nethengwe	University of Venda	Supervisor
Mr F Dondofema	University of Venda	Co-Supervisor
Mr OA Osidele	University of Venda	Investigator - Student

ISSUED BY:
UNIVERSITY OF VENDA, RESEARCH ETHICS COMMITTEE

Date Considered: August 2015
Decision by Ethical Clearance Committee Granted
Signature of Chairperson of the Committee: .....
Name of the Chairperson of the Committee: Prof. G.E. Ekosse

University of Venda
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PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
TRANSPORT

Mr. O A Osidele
Dept. of Geo Information Science
University of Venda
THOHOYANDOU
0950

Ref: RT 2/6/6/2-33/15
Enq: Mr. K P Selepe
Tel: (015) 295 1190
Fax: (015) 294 8000

Dear Mr. Osidele

RE: REQUEST FOR INFORMATION IN TERMS OF PAIA REGARDING ROAD ACCIDENTS STATISTICS IN VHEMBE DISTRICT

1. Please find attached copy of the approved memo for the Road Accidents Statistics in Vhembe District from 2011 to 2014. Statistics from 2004 to 2010 as requested could not be located due to some technicalities but we are still searching them and will be released as soon as they are found.

2. Hope the information suffices.

Warmest regards,

Ms. Hanli du Plessis
HoD: Department of Transport
Date: 8/10/15

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SCHOOL OF ENVIRONMENTAL SCIENCES
Department of Geography & Geo-Information Sciences

THE DISTRICT SENIOR MANAGER
DEPARTMENT OF ROADS AND TRANSPORT
PRIVATE BAG X 2145
SIBASA 0970

13, JULY 2015

Dear Sir/Madam,

SUBJECT: ROAD TRAFFIC INJURIES AND FATALITIES DATA REQUEST FOR RESEARCH PURPOSE AT UNIVERSITY OF VENDA

This serves to kindly request from your office road traffic injuries and fatalities data for research purpose being conducted at the department of Geography and GIS, University of Venda. The title of the research is "*Using GIS to analyse Patterns and Trends of Road Traffic Injuries and Fatalities in Vhembe District, Limpopo Province, South Africa*".

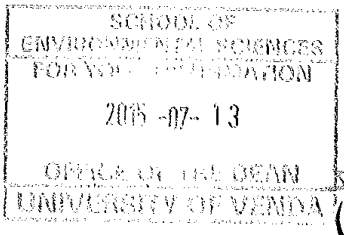
The research proposal has been approved by the University Higher Degree and the student is allowed to conduct data collection and therefore, requires permission to conduct field work in the study area.

The sets of data required for this study are:

- Statistics which comprises of all demographic composition of road traffic injuries and fatalities on all the roads in Vhembe District from 2004 to 2014;
- Scientific reports on possible factors that contribute to road traffic injuries and fatalities in Vhembe District.
- Database (manual or electronic) about locations, nature and frequencies of road traffic injuries and fatalities on all roads in Vhembe District e.g. N1, R521, R523, R524, R527. Possibly with GPS coordinates.
- Scientific reports on behavioural attitudes of road users and compliance with existing road safety measures.
- Road map network for Vhembe District identifying existing road accidents high areas.

The information collected is for academic purpose and will be analysed and presented as such. In my capacity as the supervisor, HOD and the Deputy Dean, I am hopeful that you will assist Mr. Osidele at this critical phase of accordingly with the required information.

Kind Regards,



Dr. N.S. Nethengwe (Ph.D Geography, West Virginia University, USA)
HOD: Department of Geography & Geo-Information Sciences
Deputy-Dean: School of Environmental Sciences

University of Venda

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