COMPARATIVE ANALYSIS OF ROAD TRAFFIC ACCIDENTS OF MOTORWAYS AND HIGHWAYS OF PAKISTAN. (CASE STUDY OF ROAD SECTION FROM ISLAMABAD TO LAHORE)

ASIF ZEB

(00000171063)

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THESIS ACCEPTANCE CERTIFICATE

Certified that final copy of MS thesis written by **Mr. ASIF ZEB (Registration No. 00000171063)** of **(NIT-SCEE)**, has been vetted by undersigned, found complete in all respects as per NUST Statutes / Regulations, is free of plagiarism, errors, and mistakes and is accepted as partial fulfillment for award of MS degree. It is further certified that necessary amendments as pointed out by GEC members of the scholar have also been incorporated in the said thesis.

Signature: _____

Name of Supervisor: **Dr. Muhammad jawed Iqbal**

Date: _____

Signature **(HOD)**: _____

Date: _____

Signature **(Dean/Principal)**: _____

Date: _____

DEDICATED

TO

MY PARENTS, SIBLINGS, TEACHERS, FRIENDS,

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

WHO	World Health Organization
NH&MP	National Highways and Motorways Police
NTRC	National Transportation and Research Center
RTAs	Road Traffic Accidents
RTC	Road Traffic Crashes
RTI	Road Traffic Injuries
RCF	Road Crash Fatalities
MUTCD	Manual on Uniform Traffic Control Devices

ABSTRACT

Road traffic accidents is one of the major issues in Pakistan. Like other developing countries, there are a lot of accidents occurred on every day which results in great losses of precious life, injuries as well as public and private property damage. The expected increase in road traffic and magnitude of the accidents, there will occur a great loss of social and economic losses. This research study, addresses the comparison of road traffic accidents analysis of Highways and Motorways of Pakistan. The road section from Islamabad to Lahore is selected for the study such that M-2 and N-5 North (North-II and North-III).

In this study the road traffic accidents data are analyzed in detail like time wise, sector, beat, direction, severity, casualty, severity index, weather wise etc. for both the road sections. The accidents occurring pattern, trend are find out on these sections. The vehicle that is most vulnerable to accidents on motorway is car while on highway motorcycle. The causes of accidents on motorway and highway are carelessness, dosing at wheel, brake failure, tyre burst, pedestrian crossing etc. The remedial measures are also suggested to counter these causes include proper education of traffic safety to road users. This can be done with the help of print and electronic media. Dozing alarms are used to prevent accidents due to causes of dozing. Climbing lanes must provided to prevent brake failure accidents. Pedestrian over head bridges and under passes are constructed in order to avoid pedestrian crossing accidents.

CHAPTER 01: INTRODUCTION

1.1 BACKGROUND

Mobility is the soul of our freedom. This is the basic need of our faster, modern world development. Due to rapid increase in population of the world therefore it is the major component of interaction with society. There is need of transportation facilities for survival in this world. So the world is growing faster in building road network, railway, air transportation etc. All types of road transportation and other transportation modes have a lot of advantages. In contrast there are a lot of disadvantages as well. It is also one of the biggest enemy of human beings in the modern world. People have to pay in terms of deaths, injuries and property damages as a result of traffic accidents.

Road safety is very important for all road users. In the last ten years or so the number of vehicles and on our roads has increased along with a major increase in goods transportation. Both the developed and developing countries have made heavy investments in order to improve existing roads as well as to construct new transport facilities. Despite improvement in road designs, vehicle safety standards, technical controls and laws, road accidents still remain the eight leading cause of deaths globally and the leading cause of deaths among young people aged 15 to 29 years. Every year approximately 1.25 million people die in road accidents whereas another 20 to 50 million sustain non fatal injuries. 90 % Percent of fatal accidents occur in the low and middle income countries even though they have half of the world's vehicles. These deaths and injuries result in significant social and economic costs.

Nations around the globe continue to face the challenges posed by alarming increase in number of road accidents fatalities and injuries. The Global Status Report on Road Safety – 2013, published by World Health Organization (WHO) states that about 1.24 million people die each year in road traffic crashes worldwide and approximately 20 to 50 million suffer from non-fatal injuries. The report was based on the road safety data collected from 182 countries. This accounted for almost 99% of the world`s population. Unluckily, only 28 countries, which make up 7% of world population, have sufficient laws to address key road crash risk factors (WHO, 2004; UN, 2014). There have been many efforts worldwide to quantify the economic effects of these fatalities

and injuries. But their psychological impacts on social fiber of the society and individuals still need further research.

Although, road traffic accidents have been among the major contributors of injuries in past, studies have shown that situation is getting worse. It is expected that by 2020 it will rank as high as 3rd cause of disease or injury worldwide (WHO, 2004). This trend can be partly due to ever increasing motorization of the low-income or middle-income countries together with expansion of road networks around the globe. The problem can further aggravate due to lack of preventive measures and safety legislations. Increasing economic activity is making more and more people to travel on roads. WHO data for 2002 shows that deaths caused by road traffic injuries were "20.2 per 100,000 population in low / medium income countries" which accounted for 90% of the total 1,183,492 road traffic related deaths in the world. Overall, 2.1% of all global deaths (ranking 11th leading cause of death) were caused by road traffic accidents, which were 23% of all injury deaths around the world (WHO, 2002).

Road traffic injuries put a huge burden on world economies. Road traffic injuries cost "approximately 1% of the Gross National Product (GNP) in poor countries, 1.5% in medium income countries and 2% in rich countries" (Jacobs, 2000). The data collected from poor countries is not absolutely reliable, due to the lack of comprehensive data collection and 12 incident recording procedures. Many of the injury incidents are never recorded or reported in such countries. Thus the estimates tend to present an underestimated value (Jacobs, 2000).

Pakistan has a large road network of 260,760 km of which 9,555 km are National Highways and 1,930 km are Motorways, serving approximately 11 million vehicles of all types. There has been overwhelming reliance on roads and highways in meeting transport demand with roads handling nearly 95 percent of all passenger and freight demand (NTRC, 2009). A recent study shows that in Pakistan, approximately 30,000 people die every year because of road crashes (Khan, 2013). As per WHO data, Pakistan has approximately 30,000 annual road crash fatalities (WHO, 2013). These crashes cost approximately Rs. 111.6 Billion, which amounts to be 1.5% of GNP of the country (Ahmed, 2007). Road crash fatalities (RCF) and road crash injuries (RCI) are expected to "increase by 65% in next 10 years" unless there are "new efforts" to address the prevailing state of road safety around the world (WHO, 2004).

It goes without saying that RTC are a tragedy that needs an urgent counter measure. The socio-economic cost of such injuries and fatalities cannot be ignored. They not only impact the economic prosperity of poor families by eliminating active earning members but also affect the health care institutions providing services to the RTC victims. Most of this can be prevented if the need is addressed with the utmost care and diligence it requires. The cost caused by RTC is estimated to be 1-3% of a country's gross domestic product (GDP) [WHO, 2009]. RTC must be viewed as a serious concern that has caused a significant amount of social and economic damage on societies around the world

1.2 PROBLEM STATEMENT

Injuries due to road traffic crashes can be mitigated with suitable counter measures. Reliable estimation of annual road crash injuries is a basic step in understanding the extent of the problem and focusing on remedial efforts in the right direction. However, the main issue is availability of quality data. The following three sources can be considered to analyze road traffic accidents data in Pakistan:

- **National Highways & Motorways Police (NH&MP):** National Highway and Motorway Police (NH&MP) is responsible for the gathering of data through their police stations, for road traffic crashes.
- **National Transportation and Research Center (NTRC**): National Transportation and Research Center (NTRC) is also transportation related agency and is also responsible for the gathering of road traffic accidents data.
- **Hospitals:** Hospitals records RTAs from police sources such that First Information Reports (FIRs).

In Pakistan, there is no systematic procedure for road crash data recording, reporting and storing. Useful data that is both accurate and regularly published or renewed is not yet available. For reliable estimates of road traffic accidents analysis, there is a need of appropriate data that contains the required parameters such as road infrastructure, registered vehicles and traffic laws and their enforcement. This study uses data provided by National Highways & Motorways Police (NH&MP) and NTRC to obtained comparative "Analysis of Road Traffic Accidents of Motorway and Highway of Pakistan (Road section from Islamabad to Lahore).

1.3 RESEARCH OBJECTIVE

The main of this research is to Analyze Road Traffic Accidents of Motorway and Highway of Pakistan (Road section from Islamabad to Lahore). This analysis is done to find various correlations and differences in the patterns of road traffic accidents between Highways and Motorways of Pakistan.

- Statistically analyze the accidents data of five years such that from 2013-2017. These including time wise, vehicle wise, weather wise, accidents cause wise analysis etc.
- Identify various accidents contributing factors both in Motorways and Highways of Pakistan. Also suggesting various mitigating factors of these elements.
- Identify accident blind spots on Motorway and Highway. Also provide various accidents mitigating factors which would reduced accidents in future on these locations. These include road geometric elements, law enforcement obligations etc.
- This study would help professionals to identify various hazards and pattern of road accidents in designing any road network in future for Pakistan.

1.4 SCOPE OF STUDY

Nowadays governments prioritize traffic safety. Considering, the alarming situation of fatal and non fatal road accidents around the world, identification of road accidents major causes and patterns have become the main objective in order to reduce the damage caused by traffic accidents. This study helps in discovering patterns and predict future behaviors, which enables us to take data oriented decisions and suggests measures that can reduced accidents.

1.5 OVERVIEW OF THE STUDY APPROACH

In order to gain objectives set for this research, a detailed methodology was worked out and the following tasks were identified.

- Literature review regarding relative this research was done at national, international level.
- Data was collected from National Highway and Motorway Police (NH&MP) and National Transportation and Research Center (NTRC).
- For this study road section from Islamabad to Lahore was chosen. In case of Motorway it is named as M-2 and in case of Highway it is named as N-5 North.

- Various analysis factors and strategies were finalized from previous research literature.
- Data analyzed based on selected factors, references of both Motorway and Highway and also compare these analysis.
- Results were obtained from these analysis.
- Various Conclusions are drawn from these analysis.
- Recommendations were also provided.

1.6 THESIS ORGANIZATION

This thesis is organized into five chapters.

Chapter 1 presents the background and the thesis motivation, objectives, problem statement and organization of the research study that developed the need of this research.

Chapter 2 is devoted to the literature review. In the first part, accident related terms and statistics are elaborated. In the later part of the chapter, different literature of worldwide for accidents analysis are discussed in detail to develop a concept and better understanding of accident analysis.

Chapter 3 is concerned with the research methodology proposed for this study. The process of research work, collecting the data, method to summarize accident data, method of data gathering, conducting blackspots accident analysis is presented for quantitative phase of the study. It includes indication of the tools, techniques and methods of analysis.

Chapter 4 presents detailed analysis of traffic data based on various factors like time, weather, etc for both Motorway and Highway. Also accident blind spots are identified on both the routes. These blind spots are also shown on GIS maps.

Chapter 5 indicates conclusions after detail analysis. Recommendations are also provided. Future directions are also identified.

CHAPTER 2. LITERATURE REVIEW

2.1 GENERAL

A lot of literature is available on accident data Analysis; studies have been conducted throughout the world as well as in Pakistan. As all authorities are now prioritizing accident studies to identify causes of accident in controlling accidents and reducing number of fatalities in accidents.

This chapter presents various past studies regarding Road Traffic Accidents that were either carried out internationally or within Pakistan. The first part of this chapter deals with the different methodologies practiced internationally for the analysis of Road Traffic Accidents using aggregate data. The discussion covers the importance of accurate data management, implementation of road safety laws and road safety awareness programs sponsored by the government. Enhanced traffic management are also discussed. Literature review includes national as well as international Road traffic studies, where a wide range of variables and methodologies were used.

Literature review showed that RTAs have a non-linear relationship with economic growth. Countries with high income levels utilized precautionary measures which effectively minimized RTAs. Low income countries including Pakistan are still unable to deal adequately with the problem of RTAs and continue to suffer its adverse consequences. Issues that contribute to a higher rate of RTAs include poor medical care, high non-motorized exposure and under-reporting of accidents and its relevant data. RTAs are closely linked with presence of pre-hospital care systems, governmental laws and their enforcement, road network density, increased vehicle travel, alcohol usage, high proportion of young males and high speed limits [WHO, 2013].

According to researchers, increased motorization and growth in vulnerable road users are primary causes of RTAs [WHO, 2004]. Literature review highlighting the road safety situation in Pakistan indicates that there is no approved transport policy in Pakistan. A significant drop in RTAs in the country is possible if road traffic safety expenditure is increased. The RTAs displays an increasing trend due to low traffic safety awareness, negligence in implementation of traffic rules, overloading, bad road conditions, low standards of vehicle maintenance, road safety law violations and increasing urbanization and motorization [WHO, 2004].

2.2 ROAD TRAFFIC ACCIDENTS - A REVIEW OF PAST INTERNATIONAL RESEARCH

S. Emenallo, M. Puusteli, A. Ciampii and H.P Joshie [1976] studied Road Traffic Problems in Zambia. Researchers found that the number of vehicles for 10,000 persons have increased from 170 in 1964 to 340 in 1974. Road crash fatalities increased also increased by 170%. Total number of fatalities also increased by 194%. The researchers also found that number of fatalities to injuries is double in Zambia as compared to other European countries.

Sanjay Kumar and Ashish Mishra. [2000] studied case study of Road Accident Analysis of Patna City. The RTAs data was collected from 14 local police stations. The authors incurred from the data that persons killed per 100% are 45 during the year 2000. It was concluded that people age between 18-60 contributing 80% to casualties. In the Patna city accident prone location such that New bypass road on National highway (NH-38) was also identified.

Afukaar et al. [2003] investigated the pattern for injuries of road traffic in Ghana. The accident injury data for 1994-1998 was collected from local police records. The authors inferred from the data that road crashes have increased tremendously during the observed time period (52% of these traffic injuries were observed on rural highways).

Zargar et al. [2003] studied traffic related injuries (TRI) of Tehran. Data were collected for the period 1999 - 2000 from six trauma centers located in Tehran. The study analyzed patients up to 19 years of age. Results indicated that 29% of injury cases were 19 years or less than that). The major causes of injury were traffic related injuries (TRI) and falling (39% and 46%, respectively). The number of boys was 3.5 times more than girls in Traffic related Injuries (TRI's). Authors found discovered that very few motorcyclists and drivers make use of safety devices (helmets, seat belt etc.).

Hyder et al. [2006] studied traffic injuries among children in order to measure disease burden associated with road traffic accidents. Data from 1505 already published articles was inducted into the study. Data was used to estimate characteristics and proportions of child and adolescent RTI. This research concluded that most of injuries occurred in males in the age of 0 - 9 years, constitute 40% of the total number of cases.

Caliendo et al. [2007] estimated different count data models for Italian motorways using data from 1999 to 2003. The explained fraction of systematic variation and total variation was measured using the Goodness of fit test. Model suitability was ascertained using cumulative residuals methods for the range of each variable. The model parameters included: curvature, AADT, sight distance, side friction factor, and the presence of intersection for both curves and tangents. The variables that were found significant are length, curvature and AADT for curves. For tangents, AADT, length, and junctions are significant variables. The study concluded that the methodology adopted in this study would be helpful in reducing accidents caused by infrastructure deficiencies. The research also concluded that wet pavements significantly increase the number of accidents.

Savolainen and Mannering. et al [2007]. This research highlighted the severity of motorcyclist accident injuries in Indiana State. The authors used probabilistic models to determine severity of crash injuries. Injury severity probabilities were influenced by various estimated factors determined using nested logit and standard multinomial logit model. Researchers concluded that the severity of injuries was related to age of the motorcyclist and various other factors like collision type, level of alcohol consumption, roadway characteristics, helmet use and unsafe speeding.

Anastasopoulos et al. [2008] studied crash rates on Indiana interstate highways using Tobit analysis. o. The study used 5-year data of vehicular accidents on Indiana interstates and concluded that factors like pavement conditions, traffic characteristics and roadway geometrics significantly affect accident rates.

Rasouli et al. [2008] compared data on road crashes (involving injuries and fatalities) of Iran with other countries. The data were collected from the National health department of Iran for the years 1997 to 2006. Results of that study revealed that RCI and RCF rates increased till 2005 but decreased in 2006. The study concluded that despite the reduction in road traffic crashes in the year 2006.

Anastasopoulos et al. [2009] modeled vehicle crash frequencies using random parameters count models. The study used data from the Anastasopoulos et al. [2008] study. The study concluded that various factors such as international roughness index (IRI), Pavement condition rating (PCR) pavement rutting, pavement friction, length of segment under consideration, type of

median, vertical and horizontal curves and shoulder width affect accidents rates. Traffic factors like Average annual Daily Traffic (AADT) and percentage of truck in mix traffic streams were found to be significant in explaining the variation in accident rates.

Sayed and El-Basyouny. [2009] used random parameter models to explore factors responsible for road crashes in different corridors. The study used data from 392 urban arterial segments (58 corridors) from Vancouver, British Columbia. Various factors emerged as significant forces in affecting accident frequencies. A poisson-lognormal (PLN) model was developed which provided the best fit for random parameters like roadway geometric design, traffic, environmental factors and driver behavior. The study approach also helped in capturing the heterogeneity related to road geometrics, traffic characteristics.

Burgut et al. [2010] determined the risk factors involved in road traffic accidents in Qatar. That study utilized cross sectional data collected from health care centers in Qatar. It was found that about 26% of drivers were involved in road traffic crashes, out of which 69% were males. Furthermore, about 23% of drivers involved in crashes did not use seatbelts while close to 38% of the drivers were either drinking or eating while driving. About 42% of these drivers were using mobile phones while driving.

Moore et al. [2011] investigated injury severity of bicyclists using mixed logit analysis and data from 10,209 bicyclists accidents from state of Ohio The study pointed out various distinct factors responsible for bicyclist injuries at non-intersection and intersection locations but also suggested that the results themselves may be biased or inconsistent.

Chen & Chen [2011] using mixed logit model and data from Highway Safety Information System (HSIS) for year 1991 to 2000 investigated the injury severity of single and multi-vehicle accidents on rural highways. The study concluded that snow covered road surfaces and indicator variable for light traffic were randomly distributed.

Schmucker et al. [2011] determined the accident patterns involving motorized rickshaws in India. About 18% of recruited participants were found to be injured in motorized rickshaw accidents of which about 54% were injured in single vehicle rather multi-vehicle collisions. The trauma load was found substantial as indicated by mean injury severity score (5.8).

Abay [2013], examined the injury severity of pedestrians using alternative disaggregate models. The aim of this research was to investigate injury severities utilizing Danish road accident data involving detailed road user characteristics models with alternative specifications. Results indicated that road user activates and characteristics can be helpful in injury severity analysis. However, the model employed for injury prediction could underestimate important accident behavioral attributes. Table 2.1 summarizes the past international studies on RTAs.

Study	Data/Time of study	Modeling/ Analysis Technique	Factors related to RTAs
S. Emenalo, (1976)	Zambia (1964-1974)	Smeed`s Law	Crash rate, Fatality rate, Vehicles increase rate
Sanjay Kumar Ashish Mishra. [2000]	Patna, India (1998-2000)	Statistical analysis	Accidents fatalities, Vehicle type, crash location, age, vehicle involvement
Afukaar et al. (2003)	Ghana (1994-1998)	Standard surveillance method	Road type, vehicle type, crash location, age ,gender, vehicle speed
Zargar et al. (2003)	Tehran (1999- 2000)	Linear regression	Pedestrians, age group, gender, safety devices (helmet and seat belt)
Hyder et al. (2006)	South Asia	Review of published articles	Age, gender, population, pedestrians, vehicle occupants, injury location
Caliendo et al. (2007)	Italy (1999-2003)	Poisson, negative binomial and negative multinomial	AADT, road length, road geometry and characteristics
Savolainen and Mannering (2007)	Indiana state (2003- 2005)	Nested and standard multinomial logit model	Roadway characteristics, helmet use, vehicle speed, motorcyclist age and alcohol consumption
Anastasopoulos et al. (2008)	Indiana state (1995-1999)	Tobit regression	Pavement conditions, traffic characteristics and roadway geometry
Rasouli et al. (2008)	Iran (1997-2006)	Retrospective analysis	Population and registered vehicles

Anastasopoulos et al. (2009)	Indiana state (1995-1999)	Negative binomial regression	AADT, pavement conditions, roadway geometry and traffic characteristics
El-Basyouny and Sayed (2009)	Vancouver, British Columbia (1994-1996)	Poisson-lognormal model (PLN)	Road geometrics, traffic characteristics, driver behavior and environmental factors
Burgut et al. (2010)	Qatar (2009)	Cross-sectional study	Excessive speed, traffic violation, driver behavior, age, gender and environmental factors
Moore et al. (2011)	Ohio state (2002-2008)	Multinomial and mixed logit model	Driver, vehicle, road geometry and environment
Cheen and Cheen (2011)	Illinois (1991-2000)	Mixed logit model. (MXL)	Snow road surface, light traffic indicators, driver, vehicular and environmental characteristics.
Schmucker et al. (2011)	India (2005-2006)	Bivariat analysis	Pedestrians, vehicle type, vehicle occupants, type of collision
Abay (2013)	Denmark (1998-2009)	Alternative disaggregate models	Pedestrians, motor vehicle, driver's crime history and marital status and driving license

Table 2. 1 Summary of past international research

2.3 ROAD TRAFFIC ACCIDENTS - A REVIEW OF PAST NATIONAL RESEARCH

Razzak and Luby [1998] used capture and re-capture method to estimate road traffic injuries and fatalities for Karachi city. Police record data was used as first capture source and non-governmental ambulance service data was used as re-capture data source for 10 months and 20 days of the year 1994. The study concluded that as per police data, 544 death and 793 injured were reported for the year 1994 whereas ambulance services recorded 343 deaths and 2048 injuries for the same year. The capture and re-capture analysis yielded at least 972 deaths and 18936 injuries for the same year due to RTA.

Hyder et al. [2000] investigated the impact and magnitude of motor vehicle crashes in Pakistan. The published governmental data from 1956 were utilized for detailed analysis. The authors found significant increase in motor vehicle crashes, injuries and fatalities. Motor vehicle injuries were largely caused by commercial vehicles.

Razzak et al. [2011] analyzed the cost of road traffic injuries for Karachi. This study analyzed data from 2007 to 2008 and found that majority of road injury victims were two wheelers and breadwinners for their families. The study revealed that total healthcare cost on traffic patients was about 4.7 million US dollars. There were, however, a few limitations to the study; (1) no alternative method was applied to counter check the reported costs (2) data obtained on treatment costs from hospitals might be inaccurate.

Farooq et al. [2011] studied road traffic injuries for Rawalpindi city using standard surveillance methods. One years' worth of data was analyzed and results indicated that about 32% of injuries could be attributed to road traffic injuries.

Razzak et al. [2004] studied the epidemiology of injuries among children in Karachi city using 1993 to 1996 data for children under the age of 15 years from emergency medical departments. The authors studied 1320 cases of injuries for children in this age group. Factors responsible for injuries included motor vehicle crashes, burns, drowning and falls. Fifty-four% of traffic injuries were attributed to large vehicles.

Ghaffar et al. [2004] studied factors affecting road traffic injuries in Pakistan using household interview surveys. The study concluded that males, vendors, children under age of 5 years, the urban population and vehicle occupants were major victims of road traffic 14 injuries. The study had two major limitations: (1) inaccurate information (2) underreporting of accidents.

Bhatti et al. [2008] studied road traffic injuries using cross sectional (survey) data from Rawalpindi General Hospital for the year 2005. Results indicated that 24% of traffic injury cases were admitted to the emergency department while majority 64% of the cases were referred for further treatment (concerned specialty). A total of 6.8% of injury cases were due to road traffic injuries, 71% of which were males. The study discovered that road traffic injuries were very low

in proportion to the total number of patients admitted, indicating a poorly maintained hospital records and information system.

In order to quantify the understanding of traffic rules and attitudes, Hussain et al. [2011] carried out a random observational study using standard questionnaire surveys. Drivers, pedestrians and passengers were randomly selected for face-to-face interviews. Major shortcomings in road safety mechanisms were observed, including lack of road-safety awareness, incorrect/nonexistent use of seatbelts/helmets, under-age driving, vehicle fitness and legislative shortfalls. The study concluded that road traffic crashes can be avoided by treatment of black-spots, systematic road-safety education, and enforcement of laws and policies.

Shamim et al. [2011] studied road traffic injury patterns for Karachi city using data from the Road Traffic Investigation Program (3 years data from 2006-2009). The study compared traffic injuries of Karachi city with low/middle income countries. It concluded that road traffic injuries in Karachi were lower as compared to central cities in other countries. A high proportion of road traffic crashes involved males, motorcycle users and pedestrians.

Bhatti et al. [2011] studied discrepancies in data on road traffic injuries collected from police, hospital emergency services and Edhi ambulance services for Karachi city in the year 2008. The study concluded that road traffic injuries reporting systems of police departments need significant improvements.

Khan and Tehreem [2012] found: (1) lack of driver training, (2) lack of driving experience (3) bad condition of roads, (4) cell phone usage while driving, (5) use of intoxicants, (6) vehicular over loading and (7) governmental mismanagement were major factors responsible for road traffic crashes in Pakistan.

Mirza et al. [2013] studied the demographic distribution of road traffic accident victims in Karachi using one year cross sectional data from various hospitals. The authors carried out detailed analyses of autopsy reports (examination of dead bodies) of victims from police cases still under investigation. The study concluded that out of all autopsies, 27.8% cases were victims of road traffic accidents of which 55.8% were between the ages of 19-40 years. The ratio of males to females was 7:1. Furthermore, majority of RTA victims were pedestrians while the second highest

number was of motorcyclists. The authors concluded that males ranging between 0-14 years are more vulnerable to road traffic accidents.

Shah and Khattak [2013] carried out a similar study i.e. "Road Traffic Accident Analysis of Motorways in Pakistan ". The authors conducted a detailed analysis of Accident data for M2, from 2009 to 2011. His study found that a majority of accidents occurs due to careless driving and a bulk of accidents on M2 occurs in the alpha direction.

A summary of past studies on RCI carried out in Pakistan is presented in Table 2.2.

Study	Data/Time of study	Modeling/ Analysis Technique	Factors related to RTAs
Razzak and Luby (1998)	Karachi city (1994)	Capture and recapture method	Motor vehicle collision, time and location of crash, pedestrians, motorcyclists, vehicle type
Hyder et al. (2000)	Pakistan (1956)	Registry-based data	Increased motor vehicle crashes, commercial vehicles
Razzak et al. (2004)	Karachi city (1993-1996	Standard surveillance method	Age, gender and crash type
Ghaffar et al. (2004)	Pakistan (1997)	Standard surveillance method	Age, gender, urban population, vehicle occupants
Bhatti et al. (2008)	Rawalpindi city (2005)	Cross-sectional survey	Age, gender
Razzak et al. (2011)	Karachi city (2007-2008)	Stratified sampling	Age, gender, household income.
Farooq et al. (2011)	Rawalpindi city (2007-2008)	Standard surveillance method	Age, gender, site, activity, alcohol use
Hussain et al. (2011)	Islamabad (2009-2010)	Standard surveillance method	Road safety awareness, seatbelt/helmet use, under-age driving, vehicle fitness, legislative aspects
Shamim et al. (2011)	Karachi city (2006-2009)	Registry-based data	Age, gender, pedestrians, road user group
Bhatti et al. (2011)	Karachi (2008)	Comparative analysis of different data reporting system	Age, gender, road user group

Khan and Tehreem (2012)	Pakistan	Standard surveillance method	Lack of training, inexperienced drivers, road condition, cell phone usage, intoxicants use, overloading, mismanagement
Mirza et al. (2013)	Karachi (2008-2009)	Registry-based data	Age, gender, injury type
Shah and Khattak (2013)	Motorway M-2 (2009-2011)	Registry-based data	Lack of driving skill, lack of education, geometric design, careless driving, dozing at wheel, tire burst, brake failure

Table 2. 2: Summary of Past National Research on RTAs

2.3 CHAPTER SUMMARY AND CONCLUSIONS

RTAs are a crucial public health problem around the world. Various studies indicate that millions of people every year are injured while traveling and the figures are expected to keep rising unless innovative and determined efforts are directed to free society from this menace. The situation is improving in the developed world but continues to deteriorate in poor countries. According to international studies, major contributing factors associated with RTAs include road density, number of registered vehicles, population density, level of healthcare services, vehicle kilometers driven, traffic regulations, corruption levels, level of alcohol consumption and employment rates. Research findings show that augmented medical services, good quality of public transport, proper application of road safety regulations, stern enforcement of traffic laws/polices, higher level of road safety awareness, improved road design, strong multi-sectoral involvement in road safety and efficient accident reporting systems contribute towards lower road fatality rates. No real efforts have has been made at the national level to estimate annual road crash injuries in Pakistan. However, multiple studies have investigated factors linked with RCI and RCF. National studies indicate that factors related to road crash injuries include over speeding, dosing at wheel, brake failure, pedestrian crossing, animal crossing, mechanical fault, tire burst, under-age driving, driver fatigue, violation of seatbelt laws, weather conditions, cell phone use while driving and poor road maintenance. National research findings show that better traffic law enforcement, effective road markings, proper seatbelt usage, improved vehicle maintenance standards, enhanced traffic safety education, improved driver licensing systems, modern accidents reporting systems, traffic safety awareness programs and better healthcare systems are likely to result in lower RCI rates.

CHAPTER 3. RESEARCH METHODOLOGY

3.1 INTRODUCTION TO RESEARCH METHODOLOGY

This chapter presents the procedure of achieving goals that are set for this study. After selection of road section such that from Islamabad to Lahore both M-2 and N-5 North, data is collected from various sources. For this study data is collected from National Highways and Motorways Police (NH&MP) and National Transportation and Research Center (NTRC). Site Visits is also performed of black spots on both the road sections. Detailed accident analysis is done of both road sections and then also compared these two road section is discussed in this chapter.

Road Traffic Accidents (RTAs) are analyzed from broad perspective in this study. It helps in identification of variables that are the basic causes of different loses like people lives, property damaged etc. After performing analysis for the roads separately a comparative analysis is also done in this study which clearly determines changing trends of accident patterns on Highways and Motorways. Also accidents blind spots are analyzed comparing the accidents severity on different locations. Following is the strategy that are adopted in this thesis is as under:

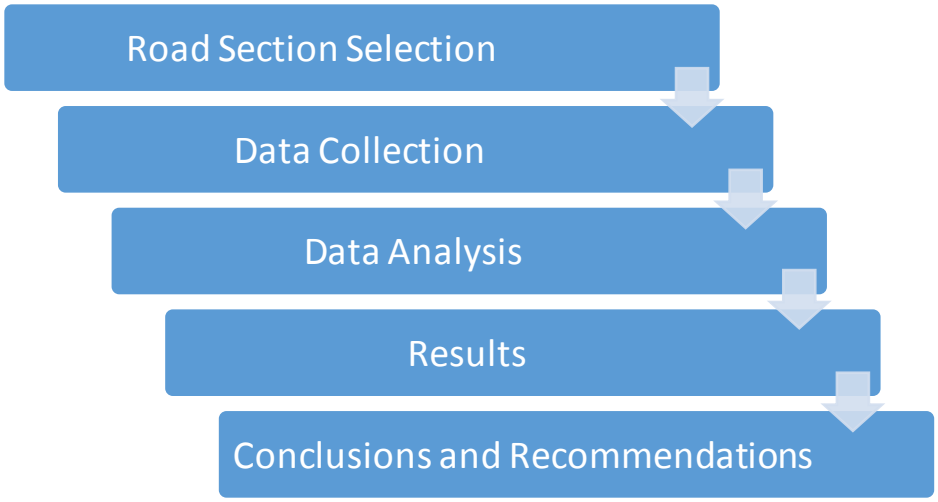

Figure 3. 1: Frame work for Accidents Analysis

So according to this procedure first selected road section from Islamabad to Lahore both M-2 and N-5 North, Then data is collected from the from National Highways and Motorways Police (NH&MP) and National Transportation and Research Center (NTRC). Data analysis is done

on SPSS and MS Excel software. Find results from these analysis. Finally conclusions are drawn from these results and recommendations are suggested to overcome road crashes.

3.2 DATA COLLECTION AND RECORD SYSTEMS

Investigation of accidents is quite different the methods used to monitor the transit parameters. Because accidents are rare and unpredictable time and place, cannot be directly observe and recorded in the field. All accidents data comes from other sources, mainly police and other research and recording agencies like NTRC etc. All information and data comes from these reports and systems for store and retrieve this information in a convenient and effective is an absolute necessary (Rosés et al., 2010). Information necessary for a number of reasons, including:

- Identification of blind spots on road section.

- Evaluate the causes of accidents that are occurred on various locations and should provide remedial measures for it.

- Develop statistical model of accidents happening and to take take data oriented decisions in future

- Developments of strategies that helps in the pointing of hazards before huge amount of accidents occurred.

3.2.1 ACCIDENTS REPORTING

Accident data for both Motorway (M-2) and Highway (N-5 North) was obtained from the National Highways and Motorways Police (NH&MP) and NTRC, both are responsible for the administration and collection of crash data of these road sections. The accident data base upgradation of these roads is upgraded which clearly shows the importance of accidents reporting data. A reliable accidents report form is designed in which there is present from very minor to larger information. Accident data collection form contains various details like time, date, location, beat, direction, etc.

3.2.2 MANUAL FILING SYSTEM

State and National computerized registry systems are highly valuable in the development of statistical Analysis and a common consideration of the site requires a detailed that exist in the written report of the accident. Thus, it still used to keep file records and written in accident reports from police in a particular location can be restored and these reports are usually sent and reviewed. Central file reports of accidents, usually written by the most valuable source of information for traffic management for detailed 32 study of the most frequent accident location, while the government computer Registration system useful for the production and Analysis of statistical data. In NH&MP these forms are collected and stored in store room on monthly basis.

3.2.3 COMPUTER RECORDING SYSTEM

Computer recording accident reports have the advantage of maintaining a large number of accidents. Computer systems also can be correlated with the records of the accident other data and information. Certain details of the crash Chart with add-on explanations often lost, and the information is limited to materials that can easily be stated as a series of alphanumeric characters. Motorway police has systematic approach that it converts information provided on form to the computer system and an excel sheet data is developed. Computer recording systems have two main functions: (1) to produce regular statistical reports required regularly (usually once a year), the choice of the accident data to provide an overview of the accident patterns and issues, and (2) Provide (on request) huge amount of data on accidents at certain spot or other specific locations. In addition, most of the computer Registration system to create a file of other accidents information systems throughout the state, including highway Network system code, files on the volume of regular traffic Programs and files are improving the project. They may be linked to calculate statistics, performance and various statistics related analyses. Accidents statistical reports that are available from state computer include:

- Total Numbers of accidents by location, fatal/non fatal accidents accident, vehicle type, driver, pedestrian characteristics, date and time of day, weather and other environmental conditions, and other detailed information.

- Accident intensities based on highway location, segment length, driver and pedestrian features, road class, and other info.

- Correlating different elements which cause accidents.

- Correlating improvement projects with accident Involvement.

Most states also handle requests outstanding professional experience Special records and statistical correlations, although take a little longer to arrive because the polls must be specially planned. Regular statistical records, in most countries, however, provide a broad range of beneficial information to the technical person, who must always know the specific functions of National and local systems are available.

3.2.4 PROBLEMS IN DATA COLLECTION

After the accident, the patrol officer radio transmits a high-ranking police officer, fax, and paper within one day such that 24 hours. Accident proforma which is called Microcomputer Accident Analysis Package (MAAP) officials gathered in one place for four days, and the reports are published twice a year. The shortcomings of the reports were to identify the stakeholders to use the data, and the limited opportunities for change in the process of recording and monitoring. Furthermore, the definition of accidents and injuries that are not compatible with international standards practiced in other countries. NH&MP accident reports should be simplified and standardized, and should take steps to improve its use for prevention or mitigation of accidents. Mostly there are two problems in accident data collection procedure, first process is very slow that it takes four days to cover whole documentation procedure due to typical police structure and secondly under reporting is a common phenomenon which makes data unreliable because other sources on matching the events show different statistics.

3.3 ANALYSIS OF ACCIDENT DATA

According to Garber accident data is used to know about the accident at a site, find the causes of the accidents and then suggests possible mitigation measures to minimize accidents. After collecting accidents data from NH&MP and NTRC, data analysis is done in detail. The data which are obtained are summarized. As this is very this is very large data and consist of many and long routes and these routes are also dispersed. Analysis are done in order to find out the causes of the accidents and also find the remedial measures for it. The only aim is to enhance safety and

reduce accidents on the said routes. Following are some of the areas on which the analysis is done for this study:

3.3.1 TIME WISE ANALYSIS

- Year wise Analysis
- Month wise Analysis
- Day wise Analysis
- Hour wise Analysis
- Day/night Analysis

Firstly accident is summarized based on time such that yearly, monthly, daily, hourly, and according to day/night. In case of Yearly Analysis five years data of 2013-2017 are used. Accidents frequency are calculated and shown on graph in excel.

Accidents are also summarized based on month wise. Total number of accidents are fined in each month for the total five years such that in case of January, total number of accidents for the year 2013, 2014, 2015, 2016 and 2017 are obtained and shown on graph similarly the whole procedure is repeated for all twelve months of the year.

In case of day wise analysis. Total accidents are found for all seven days thought the five years. Such that on Monday total number of accidents are observed for all five years and then sum up all the values. After that percentage of each day are calculated based on the total frequency of accidents throughout the five years duration.

For hour wise analysis, analysis is done on the basis of each two hours duration like from 0000 to 0200 Hours, 0200 to 0400 Hours etc. the same procedure is repeated like in case of day wise analysis. Finally peak hour volume is calculated for both the Highway and Motorway.

Analysis also done according to day and night. Day is observed from 0600 hours (morning) to 1800 (evening) and night from 1800 to 0600. Both day/night analysis are carried out for Motorway and Highway throughout five years.

3.3.2 SECTOR WISE ANALYSIS

Motorway have two sectors such that M-2 North and M-2 South. M-2 North is that half of road which is towards Islamabad while M-2 South is that portion which is towards Lahore.

Similarly in case of Highway the route from Islamabad to Lahore is called N-5 North which consists of N-5 North-2 and North-3. North-2 starts from SOS Swan to Karrian Cantt and North-3 starts from Karrian Cantt to Kala Shah Kaku. Frequency of accidents are found for these routes and then shown on graph.

3.3.3. BEAT WISE ANALYSIS

M-2 is composed of 14 beats while N-5 from Islamabad to Lahore consist of 11 beats. Both road sections is analyzed according to beats. Frequency of accidents are find for all beats and the compare the beats in order to know which beats causes more number of accidents. From Beat wise Analysis accident blind spots on the routes are also determined.

3.3.4. DIRECTION WISE ANALYSIS

- Alpha
- Bravo

The direction of Motorway is represented by two ways such that Alpha and Bravo. Alpha represents the direction from Islamabad to Lahore while Bravo represents the direction from Lahore to Islamabad.

3.3.5 SEVERITY WISE ANALYSIS

- Fatal
- Non Fatal
- Property Damage Only

Severity wise analysis include fatal, non fatal and property damaged only. Fatal are those accidents in which at least one people died, non fatal are those accidents in which people are not dead but they are injured. Property damaged accidents are those accidents in which there is neither people dead nor injured but only loss occurs in form of property like public or private property. Public property contains damage of Traffic Control Devices, Traffic Lights, road construction etc. private property include vehicles etc. In this study composition of fatal, non fatal and property damaged are found for five years of both the sections and then compared.

3.3.6 CASUALTY WISE ANALYSIS

- No of People Dead
- No of People Injured

Casualty wise analysis means analysis based on number of people dead and injured throughout the study duration (2013-2017). Frequency of all the people dead and injured are calculated and then determined that how many people dead and injured in case of both the sections. Also found out the year in which more number of people dead and injuries occurred.

3.3.7 SEVERITY INDEX WISE ANALYSIS

Severity index= No of people dead /Total accidents

The severity index for all the five years are determined for both Motorway and Highway. These values are then compared to know the intensity of occurrence of fatalities in each year.

3.3.8 COLLISION TYPE WISE ANALYSIS

- Head on
- Nose to Tail
- Animals
- Pedestrian

Collision type analysis means the pattern of happening of accidents. Head on collision are those accidents in which front ends of both vehicles are hit. Nose to tail means collision occurs between one end of face vehicle and other end of back vehicles. It is also called rare end collision. Collision also occurs between vehicles and animal or pedestrian crossing. In this literature analysis is done based on collision type of both the selected sections.

3.3.9 WEATHER WISE ANALYSIS

- Fog
- Rain
- Dry

Most of the accidents are happening in bad weather like fog, smoke and rain. Accidents frequency is determined among fog, rain and dry weather for the five years duration for the selected routes.

3.3.10 ACCIDENT CAUSING WISE ANALYSIS

- Dosing at wheel
- Brake Failure
- Carelessness
- Pedestrian Crossing
- Dense Fog
- Tire Burst
- Slippery Road
- Mechanical Fault
- Others
- Animal Crossing
- Dense Smoke
- Over Speeding
- Short Circuit

Accidents are happened due to many reasons which are discussed above. In this study accidents are analyzed based on the following reasons and then compared on Motorway and Highway that which cause is the more frequent on Motorway and Highway.

3.3.11 VEHICLES INVOLVEMENT WISE ANALYSIS

- Bus
- Truck
- Pickup
- Car
- Jeep
- Van
- Trailer

- Unknown
- Hiace
- Mazda
- Coaster
- Carry Van
- Container
- Milk Container
- Oil Tanker
- Shehzore
- Water Tanker
- Cycle
- Motorcycle
- Rickshaw
- Tractor

Accidents are also analyzed in order to know about that which vehicle is more vulnerable to accidents on both the routes. Accidents frequencies for all the said vehicles are obtained for all five years. These values are then compared in order to find out which vehicle causes more accidents.

3.4 BLACK SPOTS IDENTIFICATION AND ACCIDENT ANALYSIS

After accidents analysis black spots or blind spots on the routes are also find out. It is also a large public interest and demand to provide safety measures on accident blind spots so as to minimize life loses as well as public or private property. So this is the requirement of government to attain safety at these locations in a minimum cost. Due to huge importance of the identification of blind spot at the road sections, there are present a large number of techniques to find these spots. In this study these techniques are discussed chronologically which will help the readers to familiarize with black spots study importance.

The simplest way to identify black spots are placing the accidents frequencies in descending orders of all sites on a roadway section. The one with more accidents occurring site is termed as accident blind spot. This method is very straightforward, however the efficiency of this

method is not 100%, and it leaves ways for more improvement. Now to overcome the deficiencies of this simple method there are various methods which are explained ahead.

3.4.1 IDENTIFICATION OF TOP RANKED HAZARDOUS LOCATIONS

Blackspots are identified numerically by counting the reoccurrences of accidents within patch of 1 km. Following is the formula to evaluate reoccurrence of accidents at same location on Motorway M-2 Lahore to Islamabad. By using the Accident Point Weightage (APW) formula of Mustakim at el. (2011) and Sohadi et al.(1994) as this method is centered on the value that is been give by The Transport Research Laboratory (TRL) from Interim Guide on detecting, Prioritizing and Considering Hazardous Locations on Roads, accidents can be classified into four main categories. For fatalities it will be multiplied with 6.0, for serious injuries it will be multiplied with 3.0, for slight injuries it will be multiplied with 0.8 and for property damage only it will be multiplied with 0.2.

$$APW = 6(X1) + 3(X2) + 0.8(X3) + 0.2(X3)$$

Where,

X1 = Fatal accidents

X2 = Serious injury accidents

X3 = Slight injury accidents

X4 = Damage only accidents

Depending upon the value of accident point weightage, accident blackspots are ranked and are dealt accordingly for safety treatments. Top ranked blackspots are identified from the ranked list on the basis of analysis and causes are observed involved in accidents.

3.4.2 ACCIDENTS SITE INVESTIGATION

Investigate the site and consider the accidents data of that site and find out the causes of accidents on that specific site. According to Roess (2010) one of the most accidents data analysis and safety investigation help in identifying the causes of the accidents that happened on that site. It also helps in provision of remedial measures that helps in leading to greater safety. When specific

site is identified as most frequent accident site such as that site is termed as blind spot, then more information is required in the following areas.

- Happening of accidents in under consideration area.
- Existing physical and environmental conditions of that place.

Advantage of finding these information's help in identifying whether the accidents are happening due to bad weather or some other physical conditions. Weather conditions include fog, smoke and rain causes more accidents while physical conditions like bad geometry conditions of roads also caused most of the accidents. Investigation of site mostly done by Engineers by using cameras to record all the relevant information. But a more detailed analysis is also obtained from police data and other investigation agencies. The Engineers after site investigation and accident data can drawn the counter measures to minimize accidents on that places.

3.4.3 EVALUATION OF SAFETY AT BLIND SPOTS

First of all it is necessary to find the causes of accidents. Find out the contributing factors that help in occurring of accidents. All the existing measures and previous studies are analyzed. Then in view of all these intervention factors, suggested suitable to counter these interventions and enhance safety at these sites. Graphical representation of data shows all the physical and environmental contributing elements of the site:

1. What are the actions of drivers that that lead to the accident occurrence?
2. What are the existing conditions of the site that compel the drivers to take such actions?
3. What are the remedial steps to prevent the drivers from taking such actions?

A map of the accident blind spots shown all the features of the locations like geometric design, location, traffic control devices like signals, markings, signs etc. It also tells about all the relevant info about the section including land use etc. Road Safety is not a remote problem for the study of transport Engineers. But they have everything to do with one of the aim of consolidation traffic safety for all traffic patterns, and control measures working plans of the roads.

3.4.4 PROVISION OF EFFECTIVE REMEDIAL MEASURES

Roes (2010) determined accidents minimizing countermeasures and these are already adopted in the world to reduce accidents and to counter same type of safety flaws. His remedial measures are economically and socially suitable for adopting. Analysis is basically the development of strategies to avoid these accidents. However to adopt any strategy accidents data must be reviewed and analyzed in detail. In order to inform about safety of roads, public seminars, advertisement must be done. These safety measures include evaluation of drivers, monitoring of vehicles and health of drivers road physical features. Those manuals which are related to safety must be used and get advantage from it. Strict rules and laws should followed by monitoring health of drivers. It must restricts from driving when he is drug addict or visually impaired such that his eye sight is week. There can be used an electronic devices which applies brakes when obstruction came to it. The main thing is first to identify hazards regarding accidents provide suitable measures for its reduction. This can be in terms of following strict rules, improving road designs and invention and installing of electronic devices in order to save precious lives, prevent people from disability and protect public and private property.

3.5 SUMMARY OF THE CHAPTER

This chapter contains procedure of road traffic accidents of Motorways and Highways of Pakistan. For both Motorway and Highway a road section from Islamabad to Lahore is selected, such that M-2 and N-5 North. After analysis of accidents data, accident black spots are also identified for both road sections. It also answers those questions which disturb safety on the roads. Accident analysis is actually a complex procedure and composed of many procedures. All the persons involved with traffic like Traffic Engineers, monitoring and control, planning and design relates to safety of vehicles. Understanding accident contributing factors needs high level of research. The method that are used for identification of blind spots is very simple. while the detail data of accidents provided the causes of the accidents. After know about the causes the safety measures become easier to provide and to reduce the accidents.

CHAPTER 4: DATA ANALYSIS AND RESULTS

4.1 INTRODUCTION OF THE DATA ANALYSIS AND RESULTS

This chapter describes collection of data, process of data summarizing and analysis of data. On roads different types of accidents are caused due to multiple flaws in driving skills of drivers, mechanical fault of vehicles and roadway design etc. It is not feasible that only number of accidents are counted on some spot but the root causes of the accidents as well its environmental characteristics, physical characteristics and the driver involved in the accidents are known. Accidents by itself do not occurs but there are some factors involved that become the cause of the accidents.

By analyzing the accidents data it is possible to find out the root cause of the accident. For example the rare end accidents mostly occurs due to slippery roads in the rain. It is very difficult for the drivers to stop the vehicle in rain. Accidents which occurs at night time shows that it occurs due to low visibility of the drivers. Accidents which occurs in fog is due to low visionary by the drivers. Peak hour accidents occurs due to congestion. Similarly there are a lot of accidents occurs due to various reasons. The main objective of this study is to find the trend and pattern of accidents on Motorways and Highways and also find out the causes of the accidents and provide suitable measures for its reduction or mitigation.

4.2 METHOD OF ACCIDENTS ANALYSIS

Accidents not always happening due to ignorance but due to carelessness and overconfidence of the drivers. Other factors like roadway design, human, environmental and vehicular characteristics play important role before, during and after accidents. In this study accidents are studied in detail like time, date, place, directions, vehicle involved beat and weather conditions of every accidents. The sequence which are followed for this study is as under:

1. Condition of road (which include length, lanes, median, interchanges, intersection etc.)
2. Accident data (which include time, date, place , beat etc. of accidents)
3. Analysis of accident data (summarize according to time wise, beat wise, weather wise etc.)
4. Analysis of black spots on Motorway and Highway

4.3 DESCRIPTION OF MOTORWAY SECTION

The Motorway section that are selected for this study is from Islamabad to Lahore which is commonly called M-2. Its total length is 358 km. In 2001 National Highway authority handed over its administration to National Highways and Motorways Police (NH&MP).

This road section was constructed in the year in 1997. Due to rapid increase in population the density on M-2 is increasing day by day. But since now this road does not get improved or overlaid. This road passes through various cities like Sheikhpura, Pindi Bhattian, Bhalwal, Kallar Kahar, Chakwal etc. Its alignment is straight. Sharp horizontal curves are also present like at Kallar Kahar. Speed limit for light traffic is 120 km/hr. and 90-110 km/hr. for heavy vehicles.

4.3.1 CONDITION OF SELECTED MOTORWAY SECTION

This road section consists of both flexible and rigid pavement. It is dual carriageway. It composed of total 6 lanes. Each lane is 3.5 meters wide and has outer shoulder of 2 to 3 meters. Inner shoulder is 1.7 meters with a median barrier of 0.6 meter. These all comprises of total width of 33 meters. It has divider with urban areas. Total length of Motorway (Islamabad-Lahore Section (M-2) is 358 km. Total 10 service areas, 11 interchanges, 43 flyovers, 158 under passes, 26 bridges, 42 nallas, 28 police stations and touches 7 districts. on M-2 are as under: -

4.3.2 AREA JURISDICTION OF MOTORWAY SECTION

Breakdown of Sectors (Beats):

1. Beat No. 5	315 Km – 353 Km	Islamabad Trunal to Chakri Interchange	38 km
2. Beat No. 6	267 Km – 314 Km	Chakri Interchange to Balksar	47 km
3. Beat No. 7	214 Km – 266 Km	Balksar to Lilla Interchange	52 km
4. Beat No. 8	213 Km – 163 Km	Lilla Interchange to Sial Chowk	50 km
5. Beat No. 9	162 Km – 120 Km	Sial Chowk to Pindi Bhattioan	42 km
6. Beat No. 10	119 Km – 082 Km	Pindi Bhattion to Khankadogara	37 km
7. Beat No. 11	082 Km – 047 Km	Khankadogara to Sheikhupura	35 km
8. Beat No. 12	047 Km – 001 Km	Sheikhupura to Shahpure Interchange	47 km

Here is the map attached showing the territory of Motorway(M-2), best available map to show motorway linking Lahore to Islamabad. These beats are also shown in Fig 4.1. Each beat is administrated by a DSP rank officer named as chief patrolling officer.

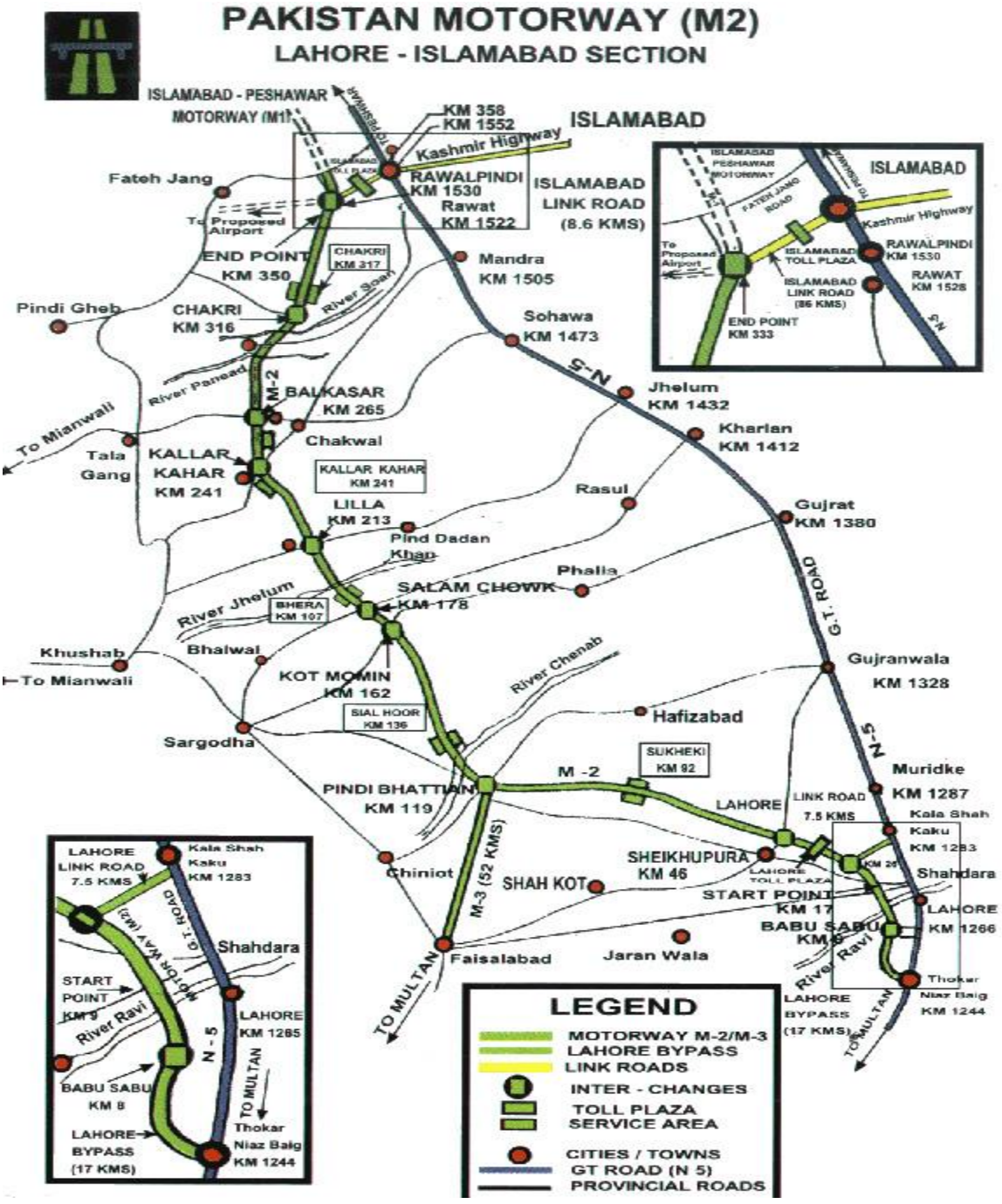

Figure 4. 1: Motorway (M-2) Map (Source NTTFC 2010)

4.3.3 OPERATION AND MAINTENANCE STATISTICS

It is necessary to observe the expenses of facilities provided on the Motorway .National Highway Authority are the major agency to handle the highways of Pakistan. At the time of construction of motorway, there were many concepts related to design and execution but finance was the core issue of construction of such mega projects. Daewoo Company of Korea was the major construction firm involved in execution process. Now there are many for operation and maintenance. National Highway and Motorway Police is for law enforcement, Frontier Works Organization is for repair and maintenance of structures, Special Communication Organization deals with the emergency telephones, Pakistan Revenue Automation Limited is working for weigh Stations, Daewoo is still maintain the service area of Motorways and National Highway Authority is supervising and financing all the working process. Here is some detail of the operation and maintenance detail for Motorway (M-2) in Table 4.1. A reasonable amount is invested on some facilities, contributing in safety and maintenance.

Sr No.	**Items**	**Agency**	**Yearly Expenditure (Millions)**
1	O& M of M-2	NH & MP	195
2	Maintenance of M-2	FWO	110
3	Emergency Phones	SCO	11
4	Weigh Stations	PRAL	14
5	Mobile workshops	Services Group	12
6	Service Areas (BOT)	Daewoo	Nil
7	Procurement of Toll Tickets	NHA	5
8	O/M of Camp	NHA	7
9	Utility Bills	NHA	40
10	NHA Establishment	NHA	5
11	O/M. of Toll Automation	PRAL	37
Total			**436**

Table 4. 1: List of Operations & Management of M-2 (source, NH&MP)

4.4 DESCRIPTION OF HIGHWAY SECTION

4.4.1 CONDITION OF HIGHWAY SECTION

The section that is selected for the study is from Islamabad to Lahore which is called N-5 North Zone. It is total 275 km. There are more traffic present on the Highway as compare to Motorway because Motorway connects interprovincial big cities while highways connects small cities. Also the length of Motorway is more than that of Highway from Islamabad to Lahore.

4.4.2 AREA JURISDICTION OF HIGHWAY SECTION

N-5 North is actually the distance from Peshawar to Lahore. While the distance from Islamabad to Lahore is called N-5 North (2 & 3) which is selected for the study. Table 4.2 represent the area jurisdiction of N-5 North.

NORTH-I (04 Beats) (Chamkani, Peshawar to Motorway Chowk, Islamabad)	135 Km
NORTH-II (03 Beats) (SOS Swan to Kharian Cantt)	123.5 Km
NORTH-III (04 Beats) (Kharian Cantt to Kala Shah Kaku)	134.5 Km
Total Length	393 km

Table 4. 2: Area jurisdiction of N-5 North.

The total length of N-5 North is 393 km km. it has 11 beats which are named as Beat 01-11 which starts from Chamkani (Peshawar) comprises to Kala Shah Kaku of total length of 393 km. North-1 starts from Peshawar to Islamabad (4 beats). North-2 from Islamabad to Kharian Cantt (3 Beats) and North-3 starts from Kharian Cantt to Lahore (4 beats). The area jurisdiction of N-5, number of beats and its length is represented in the table 4.3.

Below Figure 4.2 shows jurisdiction Map of N-5 North.

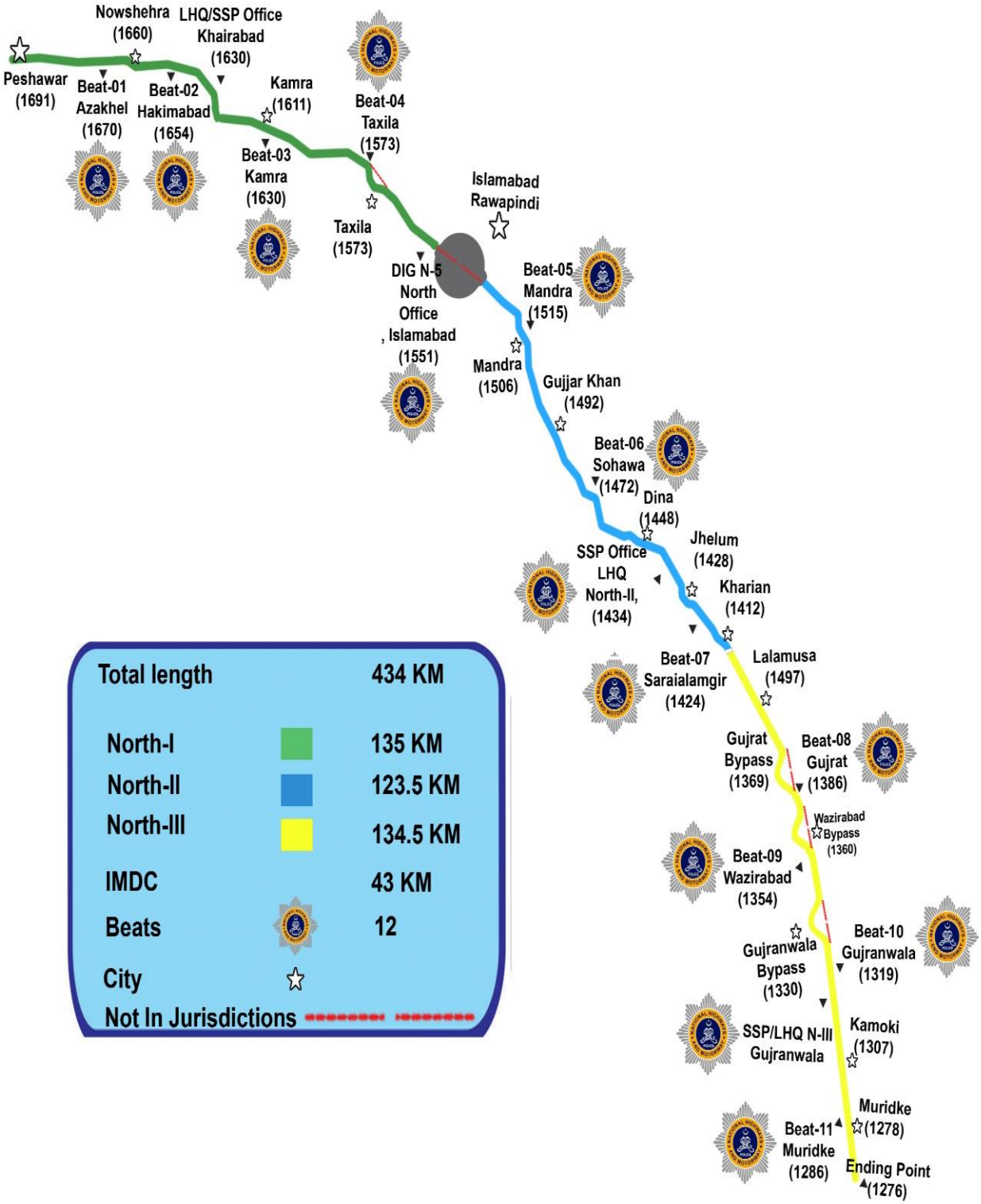

Figure 4. 2: Jurisdiction Map of N-5 North (source, NH&MP)

Beats	Area of Jurisdiction	Length
Beat-05 Mandra	SOS Swan, (km 1533) to Gulyana, Gujjar Khan (km 1490) Beat Camp Near PS Rawat, (South), Km-1515	43 km
Beat 06 Sohawa	Gulyana, Gujjar Khan (km 1490) to Bora Jungle (km 1446) Beat Camp Opposite PS Sohawa, (South), Km-1472	44 km
Beat 07 Sarai Alamgir	Bora Jungle (km 1446) to Kharian Cantt (km 1409.5) Beat Camp Adjacent PS Sarai Alamgir, Near Canal (North), Km-1424	36.5 km
Total		123.5 km

Table 4. 3 Area jurisdiction of North-2.

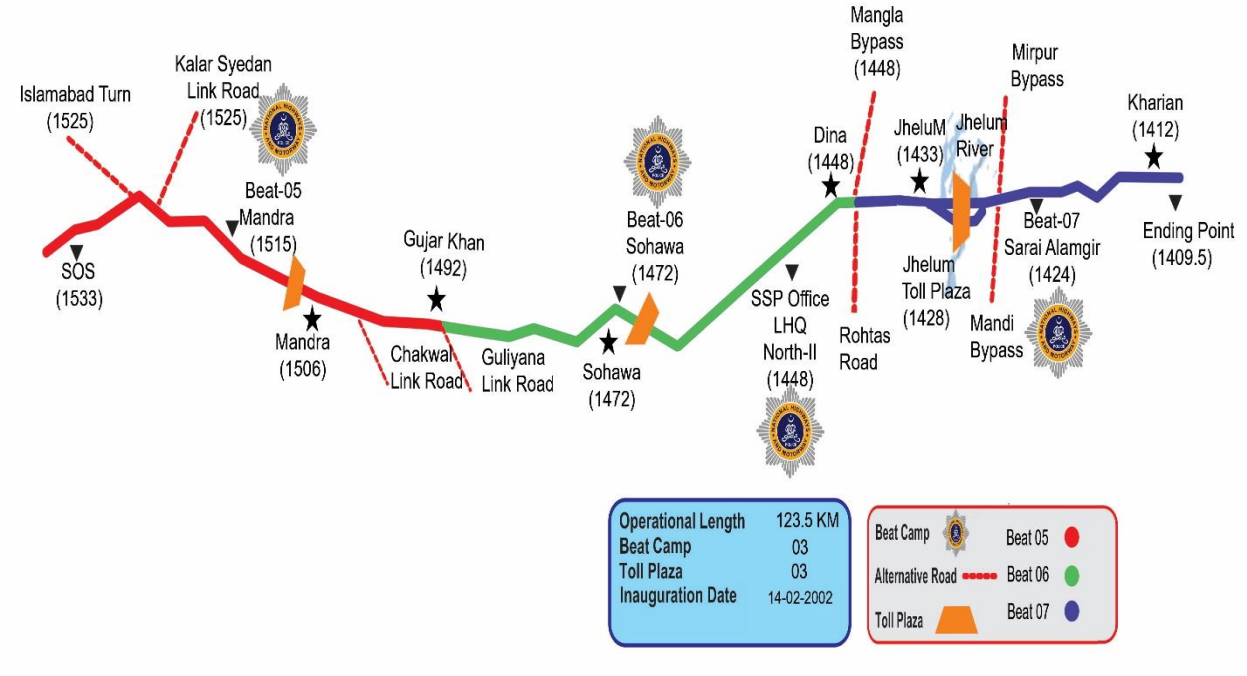

Figure 4. 3: Jurisdiction Map of North-2 (source, NH&MP)

Table 4.4 gives the jurisdiction area of North-3

Beats	Area of Jurisdiction	Length
Beat-08 Jalyani	Kharian Cantt (km 1409.5) to Chenab Bridge, Gujrat (km 1369) Beat Camp Near Chana Chowk, Jalyani, (South) Km-1387	40.5 km
Beat-09 Jandiala	Chenab Bridge, Gujrat (km 1369) to Lohianwala Chowk, Gujranwala (km 1335) Beat Camp Jandiala Dhabwala, (North), Km-1354	34 km
Beat-10 Chan-da-qila	Lohianwala Chowk, Gujranwala (km 1335) to Kamonke (1305) Beat Camp Chan-da-qila, Jalil Town, (North), Km-1320	30 km
Beat-11 Muridke	Kamonke (km 1305) to Motorway Chowk Kala Shah Kaku (km 1275) Beat Camp Kala Shah Kaku (South), Km-1283	30 km
Total		134.5 km

Table 4. 4: Jurisdiction area of North-3

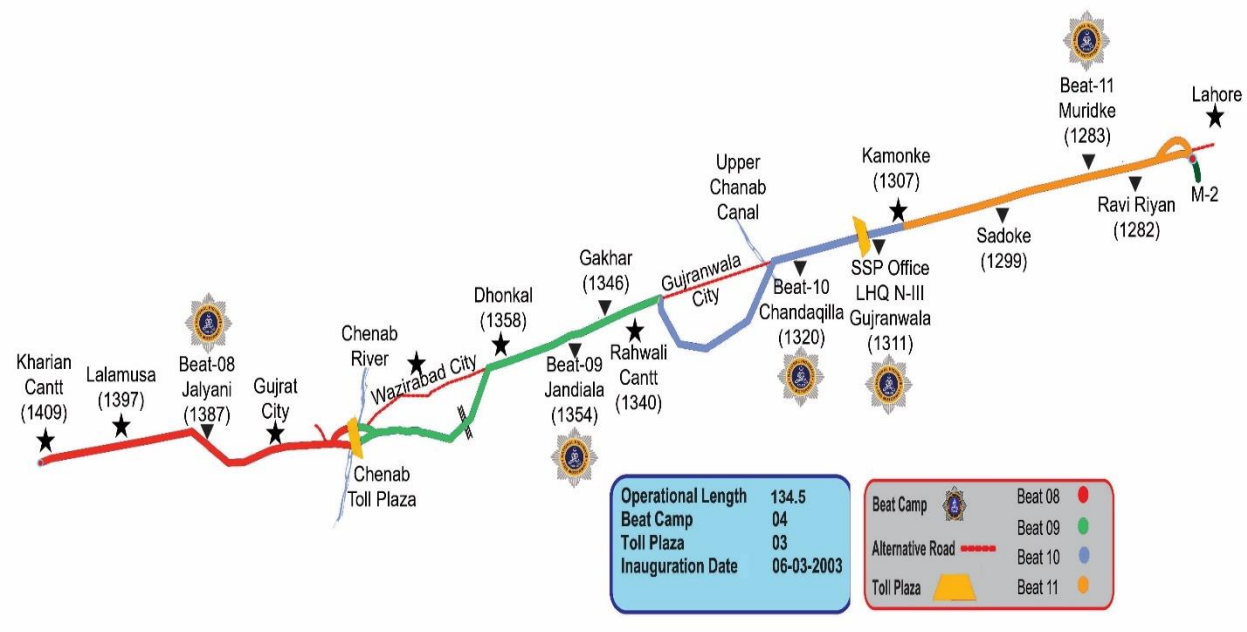

Figure 4. 4: Jurisdiction Map of North-3

4.5 ANALYSIS OF ACCIDENT DATA

The accident data for two road sections such that for Motorway and Highway from Islamabad to Lahore is is selected for analysis. Motorway from Islamabad to Lahore is called M-2 while Highway is called N-5 North. The comparative analysis is done for both Motorway and Highway. This analysis helps in finding the trends and patterns of accidents of Motorway and Highway. After analysis the causes of the accidents are determined. Then remedial measures are suggested to overcome these accidents causes. Accidents blind spots on both the routes are also determined. To overcome or reduce accidents at a given location the accident data of this location must be study in detail to find the causes of accidents. For example if accidents occur due to peak hour then it is due to cause of congestion. If the accidents mostly occur at night time then it is due to poor vision due to bad lightening. So in this case there are a lot of accidents causes. The main job of accident summarizing is to help out the causes of the accidents.

4.5.1 TIME WISE ANALYSIS

After collecting the data firstly the data is summarized according to time. It gives the time, date, place and location of the accidents. It also gives the effect of light, peak hour volume of vehicles and tells about the most frequent accident occurring season of the year. Four different time periods can be used:

- Year wise Analysis
- Month wise Analysis
- Day wise Analysis
- Hour wise Analysis
- Day/night Analysis

4.5.1.1. YEAR WISE ANALYSIS

In case of Yearly Analysis five years data from 2013-2017 are used. Accidents frequency are calculated and shown on graph in excel. The overall trends are inspected on the basis of the years. Table 4.5 gives the year wise accidents analysis.

Year	Motorway	Highway
2013	106	92
2014	89	81
2015	308	209
2016	264	110
2017	108	95

Table 4. 5: Year wise accidents.

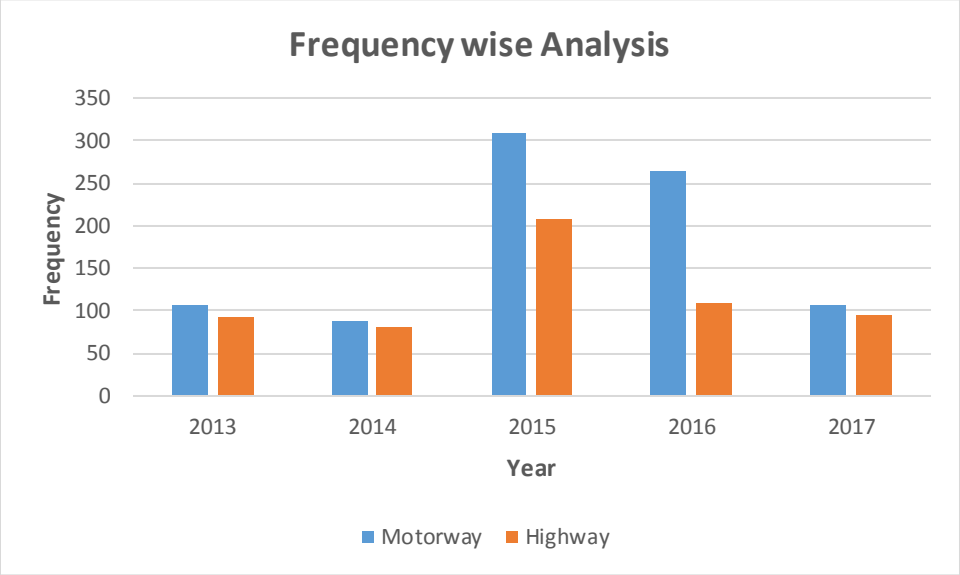

Figure 4. 5**:** Year wise accidents.

The overall trends are inspected on the basis of the years. Yearly data analysis shows in case of Motorway accidents that are recorded in the year 2013-2017 are 106, 89, 308, 264 and 108 respectively while for highway these are 92, 81, 209, 110 and 95 respectively. During this study period greater number of accidents occurred in 2015 on both Motorway and Highway.

4.5.1.2 MONTH WISE ANALYSIS

Accidents are also summarized based on month wise. Total number of accidents are fined in each month for the total five years such that in case of January, total number of accidents for the year 2013, 2014, 2015, 2016 and 2017 are obtained and shown on graph similarly the whole

procedure is repeated for all twelve months of the year. Table 4.6 gives the month wise accidents analysis.

Month	Motorway	Percentage	Highway	Percentage
January	54	6.17%	36	6.1%
February	63	7.20%	43	7.3%
March	87	9.94%	55	9.4%
April	85	9.71%	50	8.5%
May	86	9.83%	35	6.0%
June	78	8.91%	47	8.0%
July	76	8.69%	62	10.6%
August	79	9.03%	54	9.2%
September	69	7.89%	57	9.7%
October	66	7.54%	52	8.9%
November	61	6.97%	50	8.5%
December	71	8.11%	46	7.8%

Table 4. 6: Month wise accidents analysis of Motorways and Highways.

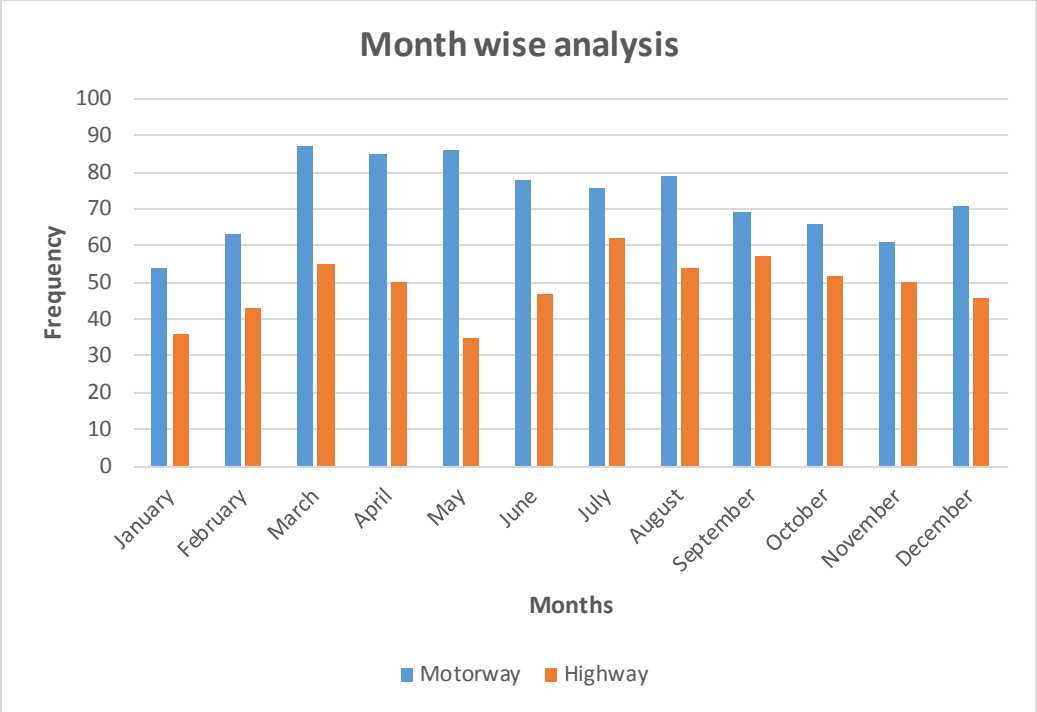

Figure 4. 6: Month wise accidents analysis of Motorways and Highways.

From the above graph it is clear that on Motorway mostly accidents occurred in March are 87 (10%) while on Highway most of the accidents occurred in July 62 (11%).

4.5.1.3 DAY WISE ANALYSIS

In case of day wise analysis. Total accidents are found for all seven days thought the five years. Such that on Monday total number of accidents are observed for all five years and then sum up all the values. After that percentage of each day are calculated based on the total frequency of accidents throughout the five years duration. Table 4.7 gives the day wise accidents analysis.

Day	**Motorway**	**Percentage**	**Highway**	**Percentage**
Sunday	143	16.3%	89	15.2%
Monday	110	12.6%	76	12.9%
Tuesday	141	16.1%	64	10.9%
Wednesday	110	12.6%	85	14.5%
Thursday	115	13.1%	83	14.1%
Friday	113	12.9%	92	15.7%
Saturday	143	16.3%	98	16.7%

Table 4. 7: Day wise accidents analysis of Motorways and Highways.

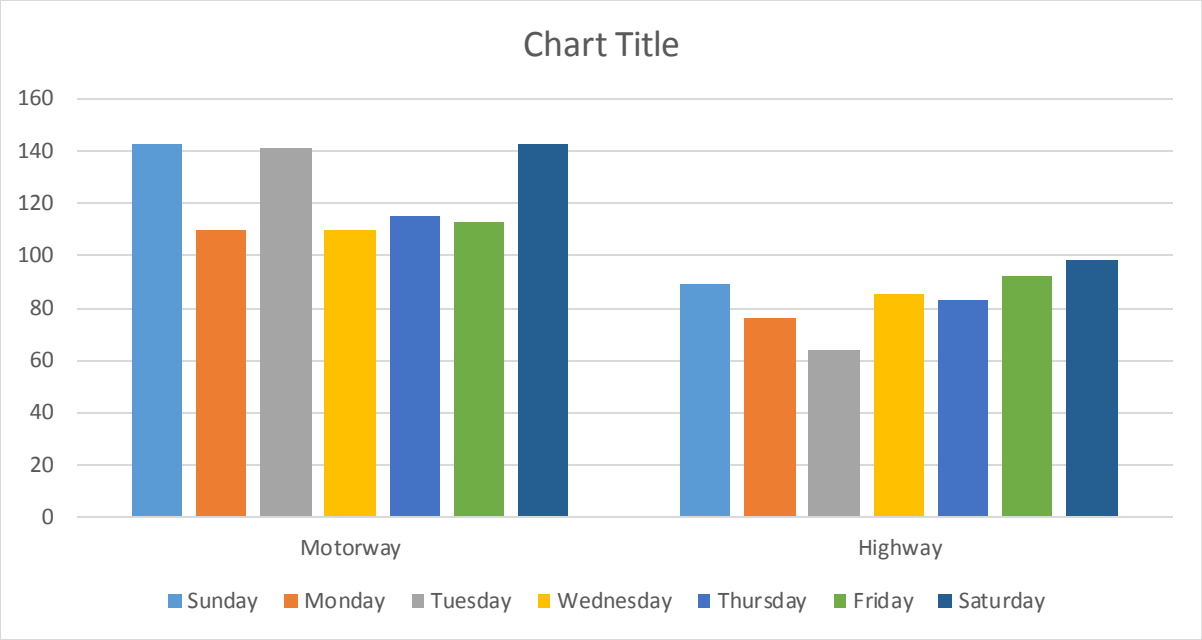

Figure 4. 7: Day wise accidents analysis of Motorways and Highways.

After analysis it is concluded that most frequent day for accidents on motorway are Sunday and Saturday (143 or 16.3%) while on Highway it is Friday (92 or 15.7%).

4.5.1.4 HOUR WISE ANALYSIS

Time (Hours)	Motorway	Percentage	Highway	Percentage
0000 to 0200	90	10.3%	33	5.6%
0200 to 0400	95	10.9%	28	4.8%
0400 to 0600	116	13.3%	34	5.8%
0600 to 0800	68	7.8%	58	9.9%
0800 to 1000	55	6.3%	55	9.4%
1000 to 1200	36	4.1%	68	11.6%
1200 to 1400	54	6.2%	74	12.6%
1400 to 1600	61	7.0%	62	10.6%
1600 to 1800	80	9.1%	62	10.6%
1800 to 2000	70	8.0%	50	8.5%
2000 to 2200	80	9.1%	40	6.8%
2200 to 2400	70	8.0%	23	3.9%

Table 4. 8: Hour wise accidents analysis of Motorways and Highways.

For hour wise analysis, analysis is done on the basis of each two hours duration like from 0000 to 0200 Hours, 0200 to 0400 Hours etc. the same procedure is repeated like in case of day

wise analysis. Finally peak hour volume is calculated for both the Highway and Motorway. Table 4.7 gives the day wise accidents analysis. Table 4.8 gives the day wise accidents analysis.

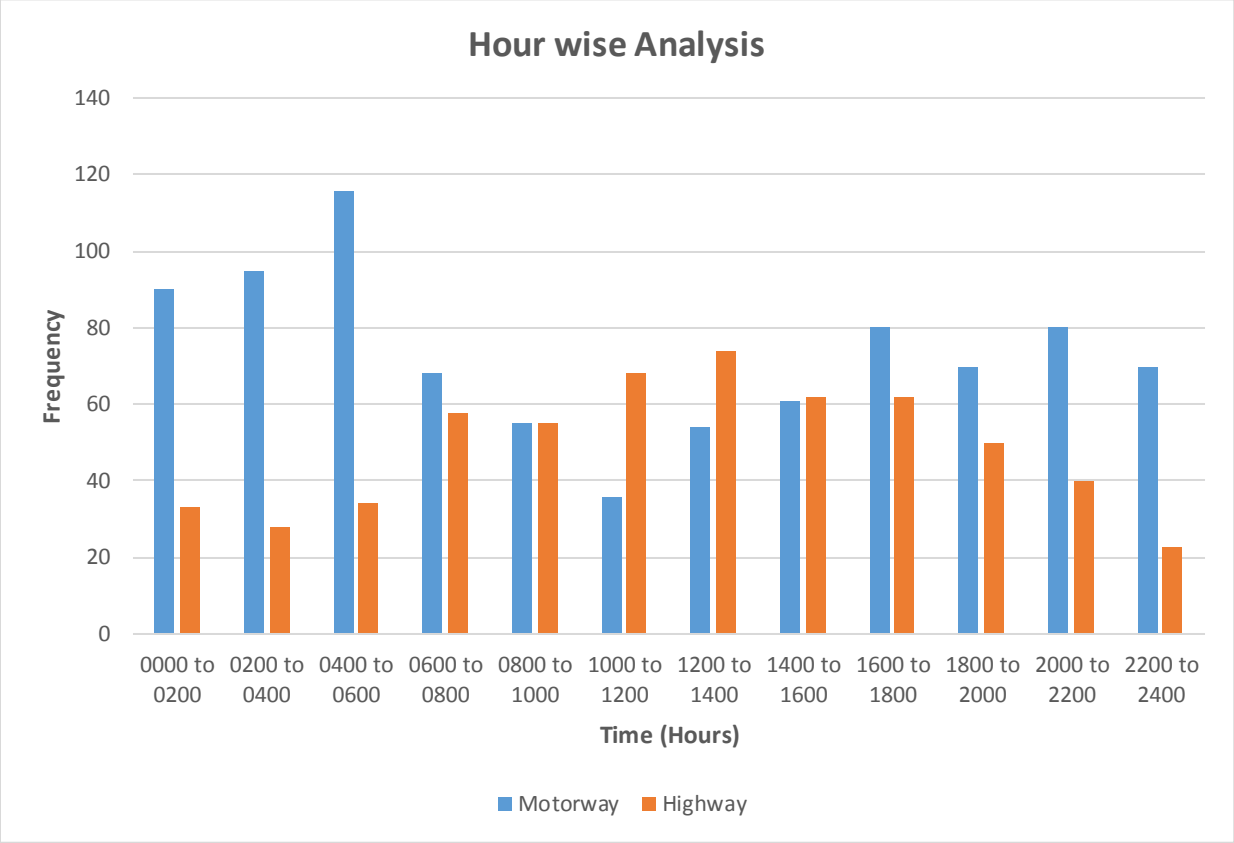

Figure 4. 8: Hour wise accidents analysis of Motorways and Highways.

From the results it is cleared that on Motorway maximum accidents occurred between 0400 0600 hours. The accidents are 116 (13.3%) and on Highway it is between 1200 to 1400 hours. The accidents at highway are 74 (12.6%) because this is the time of offices and schools.

4.5.1.5. DAY/NIGHT ANALYSIS

Analysis also done according to day and night. Day is observed from 0600 hours (morning) to 1800 hours (evening) and night from 1800 hours to 0600 hours morning. Both day/night analysis are carried out for Motorway and Highway throughout five years. Table 4.8 gives the hour wise accidents analysis.

Section	Day	Percent	Night	percentage
Motorway	361	41%	514	59%
Highway	391	67%	196	33%

Table 4. 9: Day/Night wise accidents analysis of Motorways and Highways.

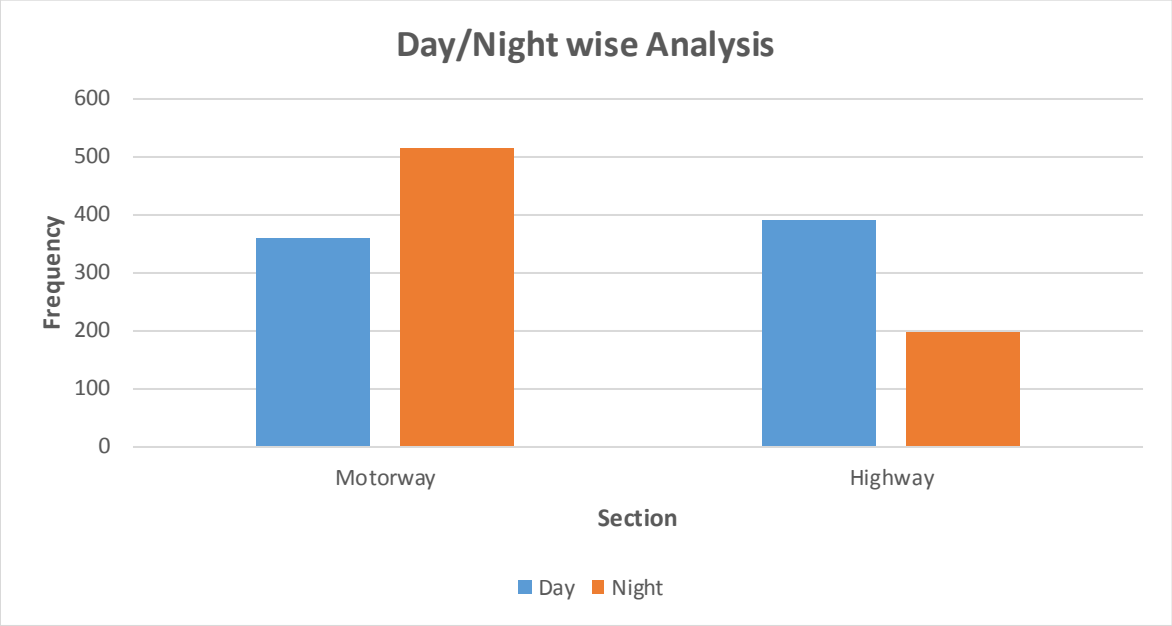

Figure 4. 9: Day/Night wise accidents analysis of Motorways and Highways.

From graph it is concluded that on motorway (59%) most of the accidents occurs at night time while on Highway mostly accidents occurred at day time (67%).

4.5.2 SECTOR WISE ANALYSIS

Motorway have two sectors such that M-2 North and M-2 South. M-2 North is that half of road which is towards Islamabad while M-2 South is that portion which is towards Lahore. From the results it is clear that North portion has higher number of accidents of 56% while south portion has lower number of accidents 44%.

Similarly in case of Highway the route from Islamabad to Lahore is called N-5 North which consists of N-5 North-2 and North-3. North-2 starts from SOS Swan to Karrian Cantt and North-3 starts from Karrian Cantt to Kala Shah Kaku. Frequency of accidents are found for these routes

which shows that 66% of accidents are occurred on North-2 and 34% of accidents occurred on North-3. Table 4.9 shows Motorway sector wise accidents analysis.

Year	North	South
2013	42	64
2014	49	40
2015	192	116
2016	138	126
2017	71	37
Percent	56%	44%

Table 4. 10: Shows Motorway sector wise accidents analysis.

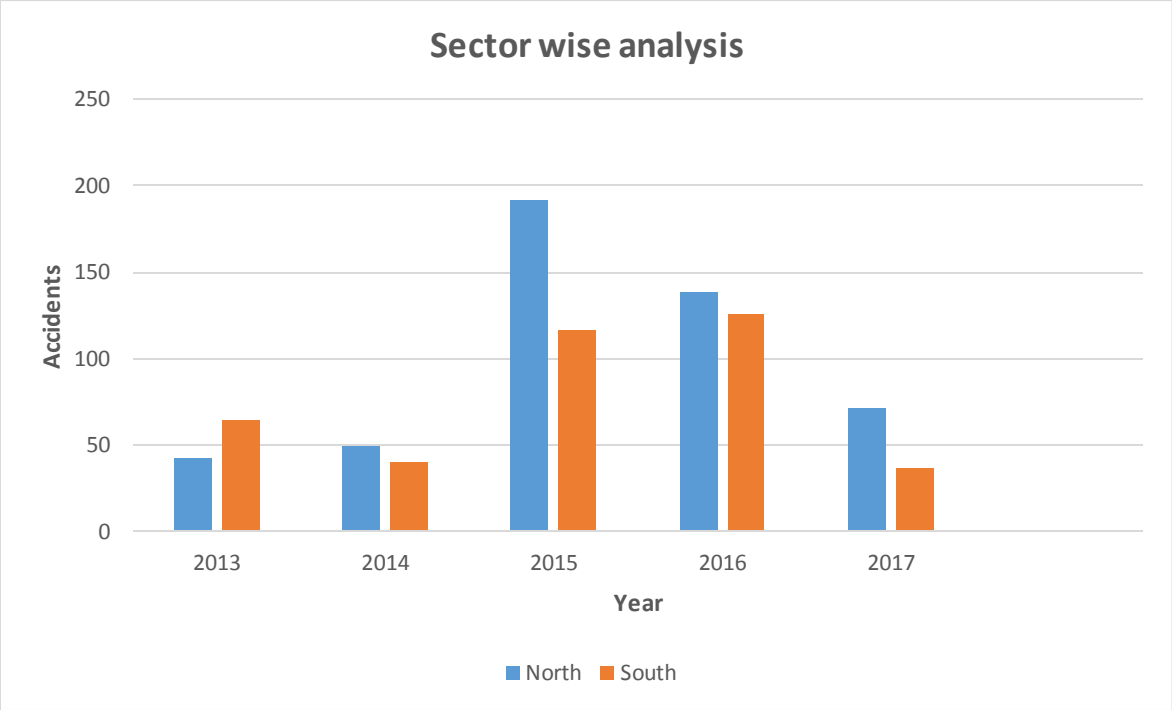

Figure 4. 10: Shows Motorway sector wise accidents analysis

Year	North-2	North-3
2013	61	31
2014	52	29
2015	142	67
2016	74	36
2017	60	35
Percent	66%	34%

Table 4. 11: Shows Highway sector wise accidents analysis.

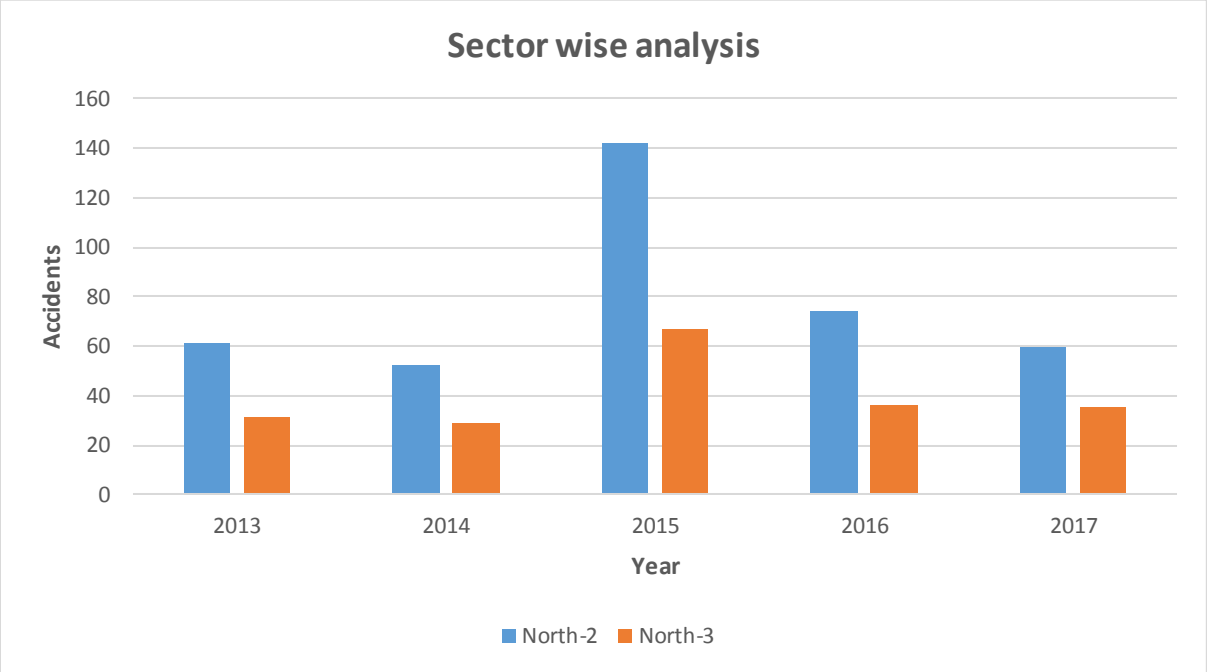

Figure 4. 11: Shows Highway sector wise accidents analysis

4.5.3 BEAT WISE ANALYSIS

M-2 is composed of 14 beats while N-5 from Islamabad to Lahore consist of 11 beats. Both road sections is analyzed according to beats. Frequency of accidents are find for all beats and the compare the beats in order to know which beats causes more number of accidents. From Beat wise Analysis accident blind spots on the routes are also determined. On Motorway most frequent accident occurring beat is 07 which starts from Balkasar to Lillah and it has a total length of 52

km. This area consist of salt range so mostly accidents are higher in this beat. Table 4.11 shows the distribution of accidents on Motorway beats.

On Highway mostly the accidents occurred on Beat 05 which starts from SOS Swan, (km 1533) to Gulyana, Gujjar Khan (km 1490) which is total length of 43 km. The accidents occurred on Beat 05 are 162 (28%). After beat 05 secondly the accidents occurred on beat 06 which starts from Gulyana, Gujjar Khan (km 1490) to Bora Jungle (km 1446). The total accidents during five years on this beat are 147 (25%). Table 4.12 shows the distribution of accidents on Motorway beats.

Beat	2013	2014	2015	2016	2017	Total	Percent
5	11	11	45	27	13	107	12%
6	10	8	64	43	18	143	16%
7	18	20	54	51	23	166	19%
8	3	9	29	17	17	75	9%
9	11	8	22	19	10	70	8%
10	16	13	31	43	6	109	12%
11	14	11	17	23	11	76	9%
12	14	7	14	10	3	48	5%
13	9	1	24	23	6	63	7%
14	0	1	8	8	1	18	2%

Table 4. 12: Shows Motorway beat wise accidents analysis.

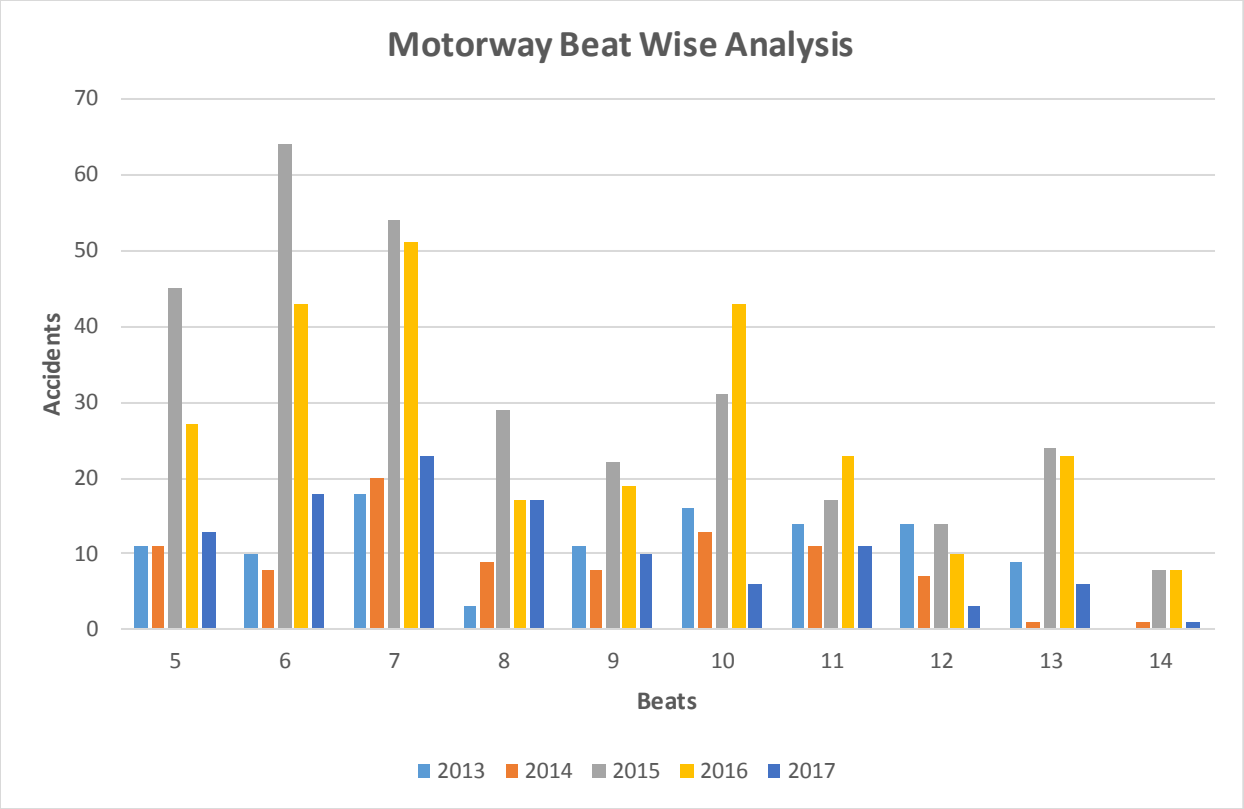

Figure 4. 12: Shows Motorway beat wise accidents analysis.

Beat	**2013**	**2014**	**2015**	**2016**	**2017**	**Total**	Percent
5	20	20	65	34	23	**162**	28%
6	24	17	47	27	32	**147**	25%
7	17	15	30	13	5	**80**	14%
8	3	3	16	1	6	**29**	5%
9	2	3	6	8	6	**26**	4%
10	8	10	10	12	15	**55**	9%
11	17	13	35	15	8	**88**	15%

Table 4. 13: Highway beat wise accidents analysis.

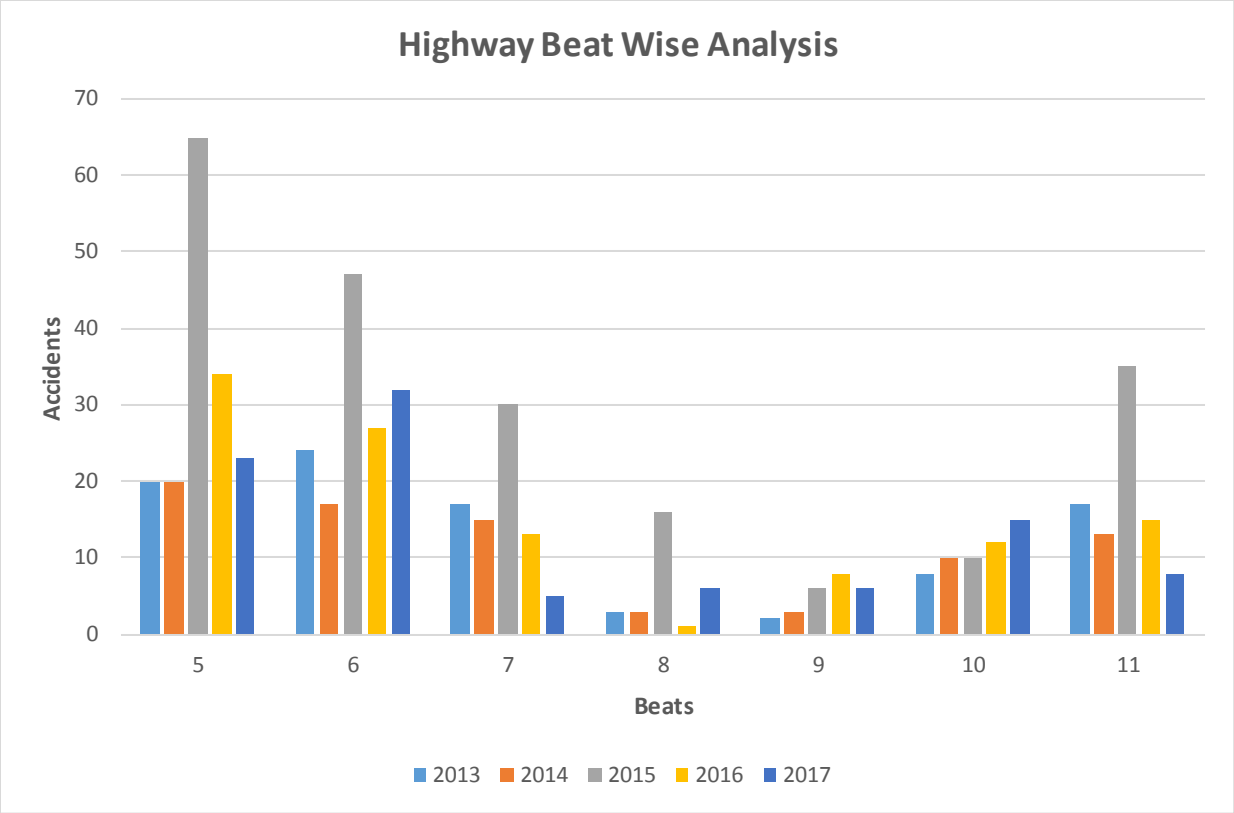

Figure 4. 13: Shows Highway beat wise accidents analysis.

4.5.4 DIRECTION WISE ANALYSIS

The direction of Motorway is represented by two ways such that Alpha and Bravo. Alpha represents the direction from Islamabad to Lahore while Bravo represents the direction from Lahore to Islamabad. On Motorway the accidents occurred on Alpha direction are 51% and on Bravo direction these are 49%. The accidents on Alpha direction is greater as compared to Bravo direction. Because while moving from Islamabad to Lahore there are many sections having problems of slopes. 280 km to 286 km area has sharp downward slope, Salt range has also a slope of 7% which not according to standard but also contribute accident when vehicles remain in condition of testing. Mechanically there is certain limit up to which vehicle can sustain pressure and temperature, after that brakes fail. Certain critical lengths are also followed that a slope can have a certain length after those vehicles cannot keep control. South bound lane has more accidents only because of slope like phenomenon while North bound lane has problems of climbing that heavy vehicles find difficult to climb such a sharp slopes and adopted alternative routes.

On Highway the accidents on Alpha direction is low as compared to Bravo direction. The accidents on Alpha direction are 44% and on Bravo direction these are 56%. Table 4.13 shows the distribution of accidents on Alpha and Bravo direction of Motorway and Highway.

Section	**Alpha**	**Bravo**
Motorway	51%	49%
Highway	44%	56%

Table 4. 14: Direction wise accidents of Motorway and Highway.

Figure 4.13 shows the distribution of accidents on Alpha and Bravo direction of Motorway and Highway. It is concluded from he graph that on Motorway the accidents occurred on Alpha direction are 51% and on Bravo direction these are 49%. While on Highway the accidents on Alpha direction is low as compared to Bravo direction. The accidents on Alpha direction are 44% and on Bravo direction these are 56%.

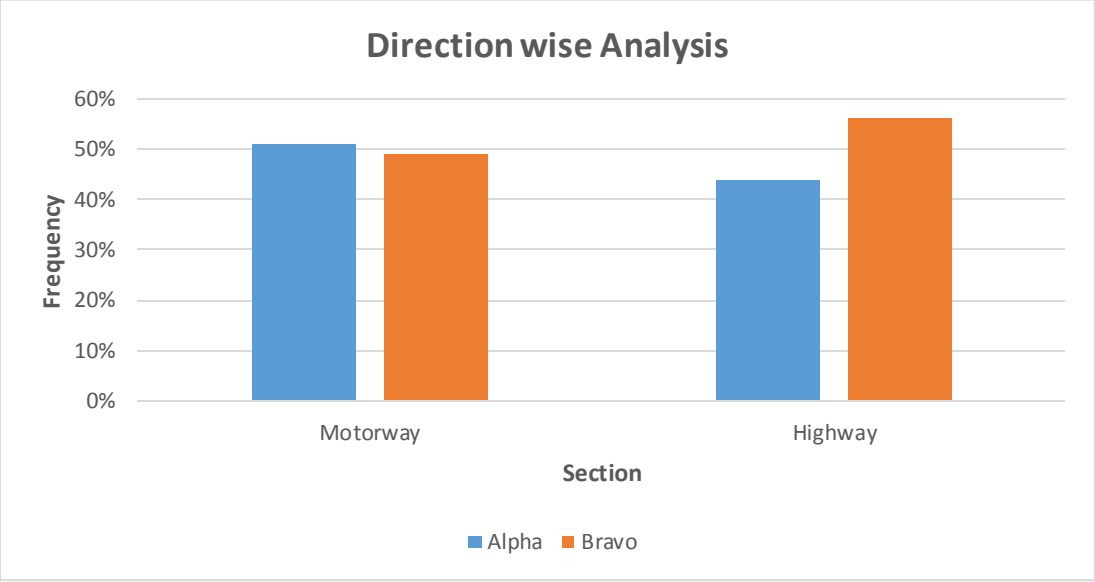

Figure 4. 14: Shows direction wise accidents on Motorway and Highway.

4.5.5. SEVERITY WISE ANALYSIS

Severity wise analysis include fatal, non fatal and property damaged only. Fatal are those accidents in which at least one people died, non fatal are those accidents in which people are not dead but they are injured. Property damaged accidents are those accidents in which there is neither people dead nor injured but only loss occurs in form of property like public or private property. Public property contains damage of Traffic Control Devices, Traffic Lights, road construction etc. private property include vehicles etc. Composition of fatal, non fatal and property damaged are found for five years of both the sections and then compared .On Motorway the composition of accidents are fatal 34%, non fatal 48% and Property damaged are 18%. While on Highway it is fatal 56%, non fatal 43% and property damaged are 1%. Table 4.14 shows the composition of severity of accidents on Motorway and Highway.

Severity	**Motorway**	**Highway**
Fatal accidents	34%	56%
Non Fatal accidents	48%	43%
Property Damage only	18%	1%

Table 4. 15: Composition of severity of accidents on Motorway and Highway

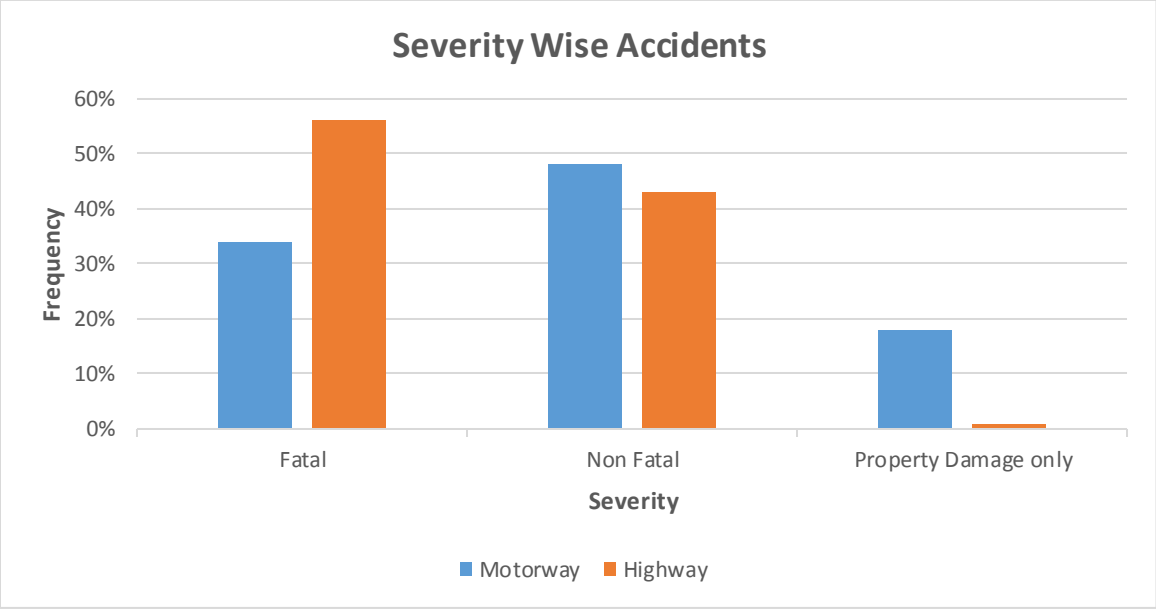

Figure 4. 15: Shows the composition of severity of accidents on Motorway and Highway.

4.5.6 CASUALTY WISE ANALYSIS

Casualty wise analysis means analysis based on number of people dead and injured throughout the study duration (2013-2017). Frequency of all the people dead and injured are calculated and then determined that how many people dead and injured in case of both the sections. Also found out the year in which more number of people dead and injuries occurred. On Motorway the number of people dead are 622 and injured are 2541 while on Highway the dead are 531 and injured are 1094. Table 4.14 shows the number of people dead and injured.

Section	**People Dead**	**People Injured**
Motorway	622	2541
Highway	531	1094

Table 4. 16: Number of people dead and injured

Figure 4.13 below shows the people dead and injured on both Highway and motorway.

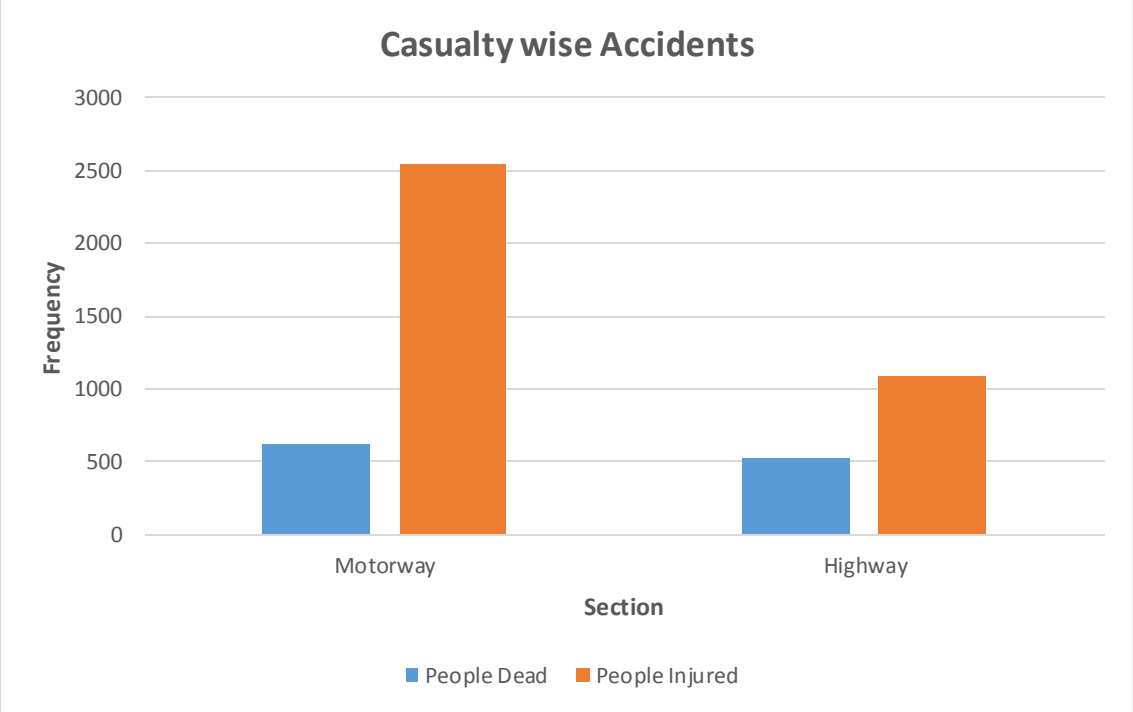

Figure 4. 16: shows the Number of people dead and injured on both Highway and motorway

4.5.7. SEVERITY INDEX WISE ANALYSIS

Severity index= Total accidents/No of people dead

The severity index for all the five years are determined for both Motorway and Highway. These values are then compared to know the intensity of occurrence of fatalities in each year. On Motorway the Severity index is greater in the year 2017. While on Highway it is greater in the year 2016. Severity index means the rate of deaths per over all accidents. Table 4.14 shows the severity index of Motorway and Highways in each study year.

Year	Motorway	Highway
2013	0.64	0.63
2014	0.72	0.44
2015	0.49	1.09
2016	0.73	1.1
2017	1.34	0.93

Table 4. 17: Severity index of Motorway and Highways in each study year.

Figure 4.14 shows the severity index in each year of Motorways and Highways.

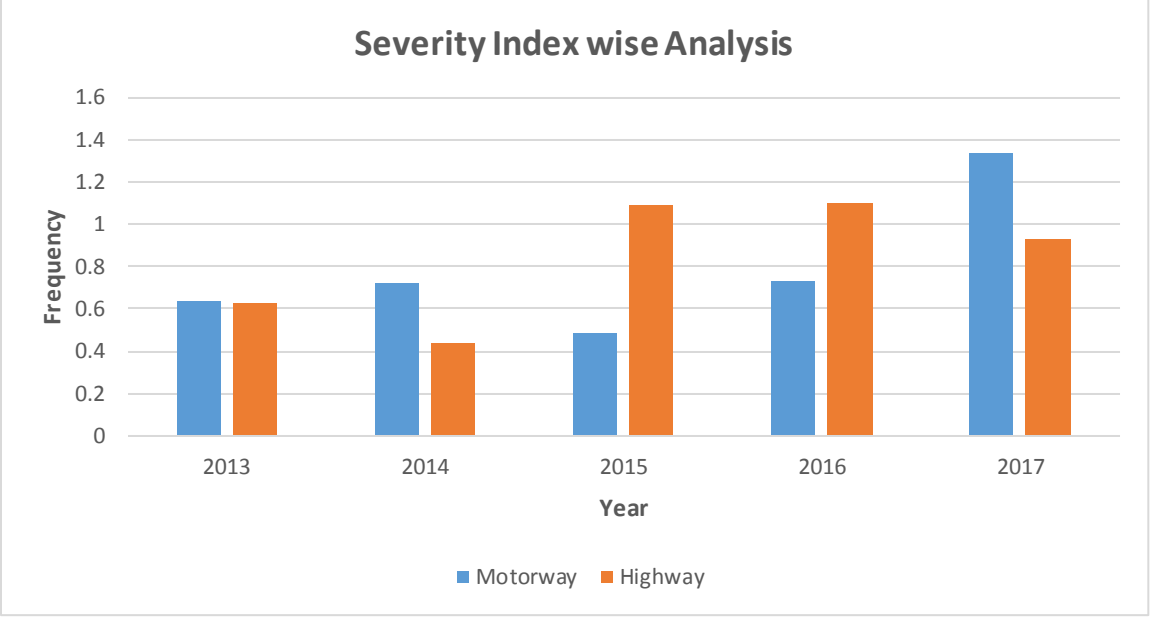

Figure 4. 17: Shows the severity index in each year of Motorways and Highways.

4.5.8 WEATHER WISE ANALYSIS

Most of the accidents are happening in bad weather like fog, smoke and rain. Accidents frequency is determined among fog, rain and dry weather for the five years duration for the selected routes. It is concluded from the study that mostly accidents occurred on both Motorway and Highway in dry weather. On motorway it is 94% and on Highway it is 96%. Accidents in fog on motorway and highway is 2% and 1% respectively. Also in case of rain it is both 3%. Table 4.15 shows the weather wise analysis of Motorway and Highways.

Weather	**Motorway**	**Percent**	**Highway**	**Percent**
Fog	16	2%	5	1%
Rain	30	3%	19	3%
Dry	819	94%	563	96%

Table 4. 18: Weather wise analysis of Motorway and Highways.

Figure 4.15 shows the weather wise analysis of Motorway and Highways.

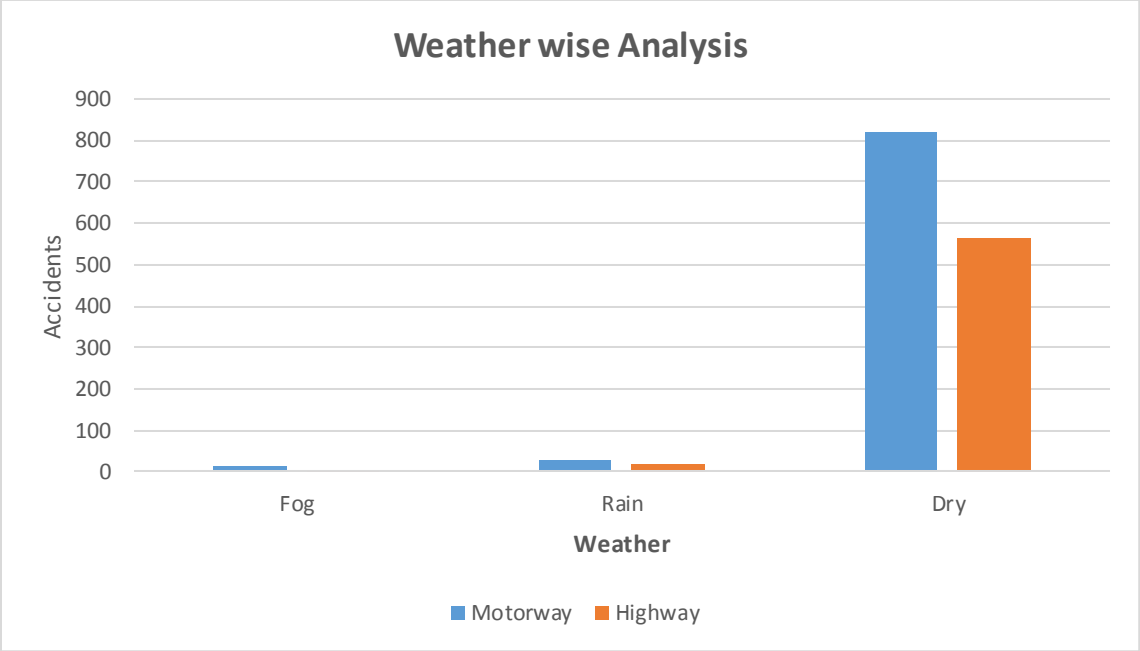

Figure 4. 18: Shows the weather wise analysis of Motorway and Highways.

4.5.9 ACCIDENTS CAUSE WISE ANALYSIS

Accidents are happened due to many reasons which are discussed here. In this study accidents are analyzed based on the following reasons and then compared on Motorway and Highway that which cause is the more frequent on Motorway and Highway. The various causes that are considered here are: Dosing at wheel, Brake Failure, Carelessness, Pedestrian Crossing, Dense Fog, Tire Burst, Slippery Road, Mechanical Fault, Others, Animal Crossing, Dense Smoke, Over Speeding, Short Circuit etc. In this it is concluded that mostly accidents occur on motorway is due to carelessness of the drivers 935%). Dosing at wheel (27%), Brake Failure (4%), Pedestrian Crossing (4%), Dense Fog (2%), Tire Burst (11%), Slippery Road (3%), Mechanical Fault (6%), Others (1%), Animal Crossing (0%), Dense Smoke (0%), Over Speeding (5%) and Short Circuit (1%).

The analysis of Highway show that the causes of accidents are to carelessness of the drivers (41%). Dosing at wheel (9%), Brake Failure (5%), Pedestrian Crossing (14%), Dense Fog (2%), Tire Burst (5%), Slippery Road (3%), Mechanical Fault (3%), Others (4%), Animal Crossing (2%), Dense Smoke (0%), Over Speeding (11%) and Short Circuit (1%).

Table 4.16 shows various causes due to which accidents occurred on highways and motorways.

Causes of Accidents	**Motorway accidents**	**Percent**	**Highway accidents**	**Percent**
Dosing at wheel	239	27%	55	9%
Brake Failure	36	4%	27	5%
Carelessness	310	35%	238	41%
Pedestrian Crossing	33	4%	83	14%
Dense Fog	17	2%	12	2%
Tyre Burst	92	11%	28	5%
Slippery Road	30	3%	20	3%
Mechanical Fault	51	6%	17	3%
Others	7	1%	0	4%
Animal Crossing	3	0%	22	0%
Dense Smoke	2	0%	14	2%
Over Speeding	42	5%	63	11%
Short Circuit	13	1%	8	1%

Table 4. 19: Causes due to which accidents occurred on highways and motorways

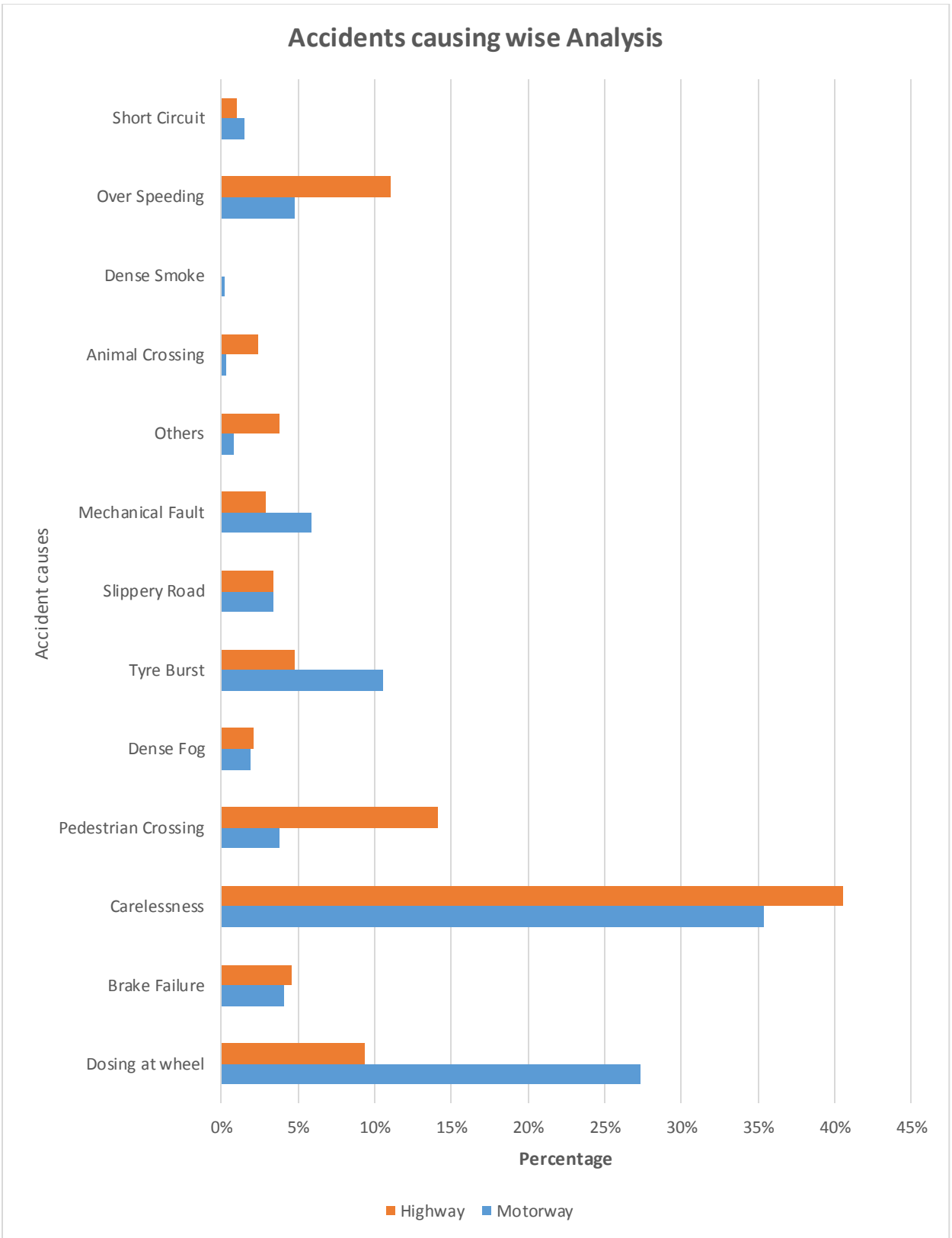

Figure 4. 19: Causes of accidents on Motorway and Highway

4.5.10 VEHICLE INVOLVEMENT WISE ANALYSIS

Accidents are also analyzed in order to know about that which vehicle is more vulnerable to accidents on both the routes. Accidents frequencies for all the said vehicles are obtained for all five years. These values are then compared in order to find out which vehicle causes more accidents. The vehicles which are considered in this study are Bus, Truck, Pick up, car, jeep, van, trailer, unknown, Hiace, Mazda, coaster, carry van, container, milk container, oil tanker, shahzor, water container, cycle, motor cycle, rickshaw, tractor etc. After analysis it was found that on motorway the vehicle that are highly vulnerable are car (42%), truck (15%), bus (13%) etc. While on Highway the highly vulnerable vehicle to accidents is Motorcycle (24%), truck (18%), bus (6%). Table 4.17 shows composition of vehicles exposed to accidents.

Vehicle Involvement	**Motorway**	**Percent**	**Highway**	**Percent**
Bus	112	13%	34	6%
Truck	130	15%	108	18%
Pickup	63	7%	10	2%
Car	367	42%	123	21%
Jeep	25	3%	7	1%
Van	66	8%	25	4%
Trailer	38	4%	18	3%
Unknown	8	1%	8	1%
Hiace	4	0%	25	5%
Mazda	36	4%	30	5%
Coaster	7	1%	6	1%
Carry Van	5	1%	19	3%
Container	3	0%	1	0%
Milk Container	2	0%	0	0%
Oil Tanker	3	0%	0	0%
Shehzore	5	1%	5	1%
Water Tanker	1	0%	0	0%
Cycle	0	0%	8	1%
Motorcycle	0	0%	142	24%
Mini Bus/Wagon	0	0%	5	1%
Rickshaw	0	0%	8	1%
Tractor	0	0%	6	1%

Table 4. 20: Composition of vehicles exposed to accidents

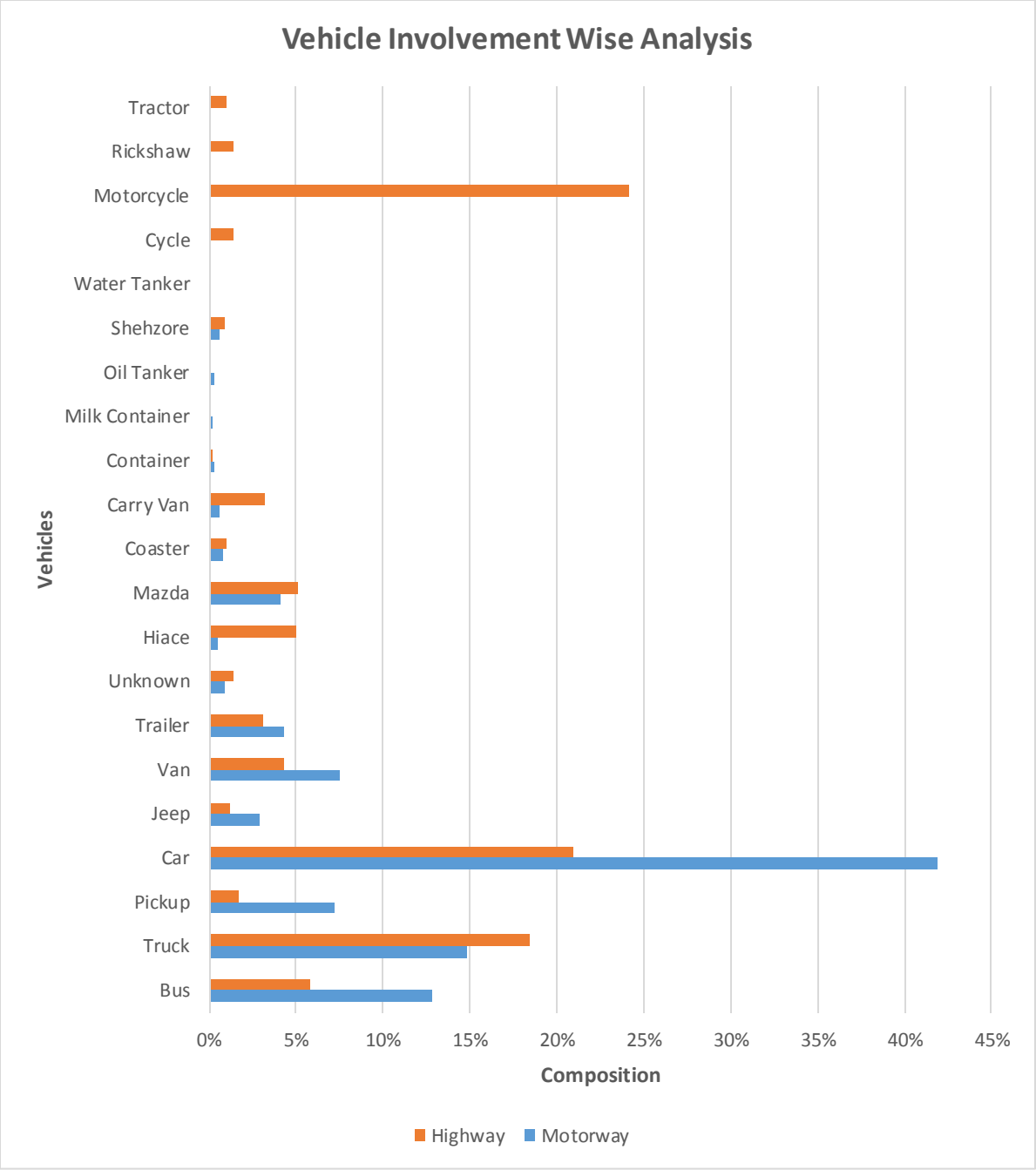

Figure 4. 20: shows vehicle involvement of accidents.

4.6. MOTORWAY BLACKSPOTS IDENTIFICATION ANALYSIS

4.6.1 RANKING OF MOTORWAY BLACKSPOTS

There are about 875 accidents occurred on M-2 during the year 2013-2017. This is due to carelessness of the drivers as they travel very fast on this roadway. M-2 is also accessible at various

location so the congestion created and accidents occur. Further analysis showed that total number of people killed are 622 and people injured are 2541 during the analysis period.

The top three ranked accidents blind spots are spotted at Kallar Kahar at km 229 (14 accidents), km 233 (7 accidents), km 223 (10 accidents), km 47 and km 195. Blackspots are identified numerically by counting the reoccurrences of accidents within patch of 1 km. Relative importance of parameters involved show that fatal is given more importance because property damage detail is not recorded in Pakistan in term of financial and insurance loss. Following are reoccurrence of accidents at same location on Motorway M-2 Lahore to Islamabad. Table 4.18 shows ranking of black spots on M-2.

Km	Fatal	Total	Ranking
229	4	14	1
223	3	10	2
233	2	7	3

Table 4. 21: Ranking of black spots on M-2.

4.6.2 FACTS OF MOTORWAY BLIND SPOT

Following are some facts of blind spots:

- Top three accident locations show that Salt range is the most problematic area.
- In this procedure the accident blackspots identification depends upon fatal accidents not on number of accidents.
- All type of accidents get appropriate portion in the finding formula, with priority wise proportion.
- This procedure may lead to a suitable accident prone location because recorded data is not in detail regarding finance and insurance related to property damage, so fatality remains the priority.
- Ranking procedure describes blackspots in descending order.
- Salt Range can be observed as a most dangerous zone from the blackspots identification procedure because of higher fatal accidents.

4.7 HIGHWAY BLACKSPOTS IDENTIFICATION ANALYSIS

There are about 587 accidents occurred on N-5 North during the year 2013-2017. This is due to carelessness of the drivers as they travel very fast on this roadway. N-5 is also accessible at every location so the congestion created and accidents occur. Further analysis showed that total number of people killed are 531 and people injured are 1094 during the analysis period.

The top three ranked accidents blind spots are spotted at Beat 05 from Sos Swan (1533 km) to Gulyana, Gujjar Khan (1490 km). Blackspots are identified numerically by counting the reoccurrences of accidents within patch of 1 beat. Relative importance of parameters involved show that fatal is given more importance because property damage detail is not recorded in Pakistan in term of financial and insurance loss. Following are reoccurrence of accidents at same location on N-5 North Lahore to Islamabad. Table 4.18 shows ranking of beats on M-2.

Beats	Total Accidents	Ranking
5	162	1
6	147	2
7	80	3
8	29	6
9	26	7
10	55	5
11	88	4

Table 4. 22: Ranking of beats on N-5 North

4.8 SUMMARY

Nowadays government prioritize road safety. There are many stages that are required to achieve the road safety goals. This chapter has discussed the accidents analysis of motorway (M-2) and highway N-5 and present condition of road and law enforcement. In addition summarized the data of road accidents in all possible way. In this study find the causes of the accidents. The various causes that are considered here are: Dosing at wheel, Brake Failure, Carelessness, Pedestrian Crossing, Dense Fog, Tire Burst, Slippery Road, Mechanical Fault, Others, Animal Crossing, Dense Smoke, Over Speeding, Short Circuit etc. Motorways and Highways of Pakistan

act as corridor of National Trade Corridor Project which is designed to link three sea ports Karachi, Bin Qasim and Gwadar with other part of the county then leading to Afghanistan, Central Asia and China. Selection is of this 358 km long Motorway section (M-2) and N-5 North 278 km connection Lahore to Islamabad for accident study was considered under current circumstances of increasing safety issues, especially after the accident of a school bus at Kallar Kahar causing 37 fatalities. From the results of the analysis, it is concluded that this Motorway and Highway section needs improvement from safety point of view. Accidents are majorly caused by Careless Driving, Dozing at wheel, Tyre Burst, Brake Failure and Pedestrian Crossing. From the blackspots identification, from fifteen accidents prone location two sections were found problematic on the basis of location problems. Most frequent accident spot is Salt range, a large number of accidents occurring over such a small section of Kallar Kahar (salt range) 221 km to 229 km, 8 km length due to a combination of 7% slope and less than 100 m radii curves causing brake failure. Second section was near Lahore, as pedestrian accidents near Lahore from 0 km to 18 km are also making a range of blackspots. Counter measures for salt range salt range under different geometric design options with respect to economic feasibility has been discussed. Safety issues with the Motorway and Highway should be strongly addressed.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 SYNOPSIS OF THE RESEARCH

This research study, addressed the comparison of road traffic accidents analysis of Highways and Motorways of Pakistan. The road section from Islamabad to Lahore is selected for the study. Motorway from Islamabad to Lahore is designated as M-2 which has total length of 358 km while Highway is designated as N-5 North which is total length of 278 km. The study is initiated with a general review of literature, both at national and international level. Review of international studies helped to identify major factors pertinent to road crash injuries and the variety of approaches followed in different countries for predicting road crash injuries. Study of causes and consequences of injuries resulting from road traffic crashes enhanced understanding of the severity of the problem at hand. The literature review also helped highlight the gaps in current practice and data availability problems. Similarly, review of past national studies brought attention to issues associated with data reporting and recording systems. Past study also help to understand the road crash trend, pattern, causes and other contributing elements that causes road accidents.

Data is collected from National Highways and Motorways Police (NH&MP) and National Transport and Research Center (NTRC). For this study five years analysis period such that from 2013-2017 is selected. The data obtained gives all relevant information about the accidents. After data collection comparative analysis is done for Motorway and Highway. The data is analyzed according to time wise, sector wise, beat wise, direction wise, severity wise, casualty wise, severity index wise, weather wise, accidents causing wise and the vehicles involved in accidents. Various graphs are obtained which shows the accidents, trends, pattern and other contributing elements that causes road accidents. It is concluded from the study that major causes of accidents on Motorway and Highway are dosing at wheel, brake Failure, carelessness, pedestrian crossing, dense fog, tire burst, slippery road, mechanical fault, others, animal crossing, dense smoke, over speeding, short circuit etc. After findings all the causes and other contributing elements of road accidents, the remedial measures are also identified for each and every cause of accident. Some of the remedial measures that are suggested are alarming system and proper health check up for careless drivers, tyre and other mechanical fault check up at various locations by motorway and highway officials. For motor cycle users on highway wearing of helmet law should strictly reinforced by the police officials etc.

5.2 RESEARCH FINDINGS AND CONCLUSIONS

After analysis of the detail accident data following are the various conclusions that are drawn for this research.

5.2.1 INCORRECT DATA

Data available with NH&MP and NTRC is incomplete and incorrect. Usually accidents occurred on Highway are not reported by the concerned agencies while accidents occurred on Motorway are usually reported. Therefore the Number of accidents are more on Motorway as compared to Highway but in reality mostly accidents occurred on Highway due to high traffic density and less obeying traffic rules by public.

5.2.2 TIME WISE ANALYSIS OF MOTORWAYS AND HIGHWAYS

- On motorway more accidents occur in the year 2015 (308 accidents) and also on highway in 2015 (209 accidents).
- On motorway more accidents occur in the month of March 87 (9.94%) and on highway in July 62 (10.6%).
- On motorway more accidents occur on Sunday and Saturday, 143 (16.3%) and on highway on Saturday 98 (16.7%).
- On motorway mostly accidents occur between 0400 to 0600 hours, 116 (13.3%) and on highway between 1200 to 1400 hours, 74 (12.6%).
- On motorway mostly accidents at night time, 514 (59%) and on highway at day time, 391 (67%).

5.2.3 SECTOR WISE ANALYSIS OF MOTORWAYS AND HIGHWAYS

- On Motorway M-2 North portion has higher number of accidents of 56% while M-2 south portion has lower number of accidents 44%.
- On Highway 66% of accidents are occurred on North-2 and 34% of accidents occurred on North-3.

5.2.4 BEAT WISE ANALYSIS OF MOTORWAYS AND HIGHWAYS

- On Motorway most frequent accident occurring beat is Beat 07 which starts from Balkasar to Lillah and it has a total length of 52 km. Total accidents recorded are 166 (19%).

- On Highway mostly the accidents occurred on Beat 05 which starts from SOS Swan, (km 1533) to Gulyana, Gujjar Khan (km 1490) which is total length of 43 km. The accidents occurred on Beat 05 are 162 (28%).

5.2.5 DIRECTION WISE ANALYSIS OF MOTORWAYS AND HIGHWAYS

- On Motorway the accidents occurred on Alpha direction are 51% and on Bravo direction these are 49%.
- On Highway the accidents on Alpha direction are 44% and on Bravo direction these are 56%.

5.2.6 SEVERITY WISE ANALYSIS OF MOTORWAYS AND HIGHWAYS

- On Motorway the composition of accidents are fatal 34%, non fatal 48% and Property damaged are 18%.
- On Highway the composition of accidents are fatal 56%, non fatal 43% and property damaged are 1%.

5.2.7 CASUALTY WISE ANALYSIS OF MOTORWAYS AND HIGHWAYS

- On Motorway the number of people dead are 622 and injured are 2541.
- On Highway the number of people dead are 531 and injured are 1094.

5.2.8 SEVERITY INDEX WISE ANALYSIS OF MOTORWAYS AND HIGHWAYS

- On Motorway the Severity index is greater in the year 2017 (1.34).
- On Highway the Severity index it is greater in the year 2016 (1.1).

5.2.9 WEATHER WISE ANALYSIS OF MOTORWAYS AND HIGHWAYS

- On both Highway and Motorway mostly accident occurred during dry weather. On Motorway accidents in dry weather are 819 (94%), in rain 30 (3%) and fog 16 (2%).
- On Highway accidents in dry weather are 563 (96%), in rain 19 (3%) and fog 5 (1%).

5.2.10 CAUSE WISE ANALYSIS OF MOTORWAYS AND HIGHWAYS

- On Motorway causes of accidents are carelessness of the drivers (35%), Dosing at wheel (27%), Brake Failure (4%), Pedestrian Crossing (4%), Dense Fog (2%), Tire Burst (11%),

Slippery Road (3%), Mechanical Fault (6%), Others (1%), Animal Crossing (0%), Dense Smoke (0%), Over Speeding (5%) and Short Circuit (1%).

- On Highway causes of accidents are to carelessness of the drivers (41%), Dosing at wheel (9%), Brake Failure (5%), Pedestrian Crossing (14%), Dense Fog (2%), Tire Burst (5%), Slippery Road (3%), Mechanical Fault (3%), Others (4%), Animal Crossing (2%), Dense Smoke (0%), Over Speeding (11%) and Short Circuit (1%).

5.2.11 VEHICLE INVOLVEMENT WISE ANALYSIS OF MOTORWAYS AND HIGHWAYS

- On motorway the vehicle that are highly vulnerable to accidents are car (42%), truck (15%), bus (13%) etc.
- On Highway the highly vulnerable vehicle to accidents is Motorcycle (24%), truck (18%), and bus (6%) etc.

5.3 COUNTER MEASURES FOR CAUSES OF ACCIDENTS

5.3.1 COUNTER MEASURES FOR CARELESS DRIVING

Highest cause of accident needs to be dealt by the licensing authority, some policy related to drivers mental grooming should be made. Year wise or whenever there is a license renewal or procedure related to refresher course should be adopted that can increase the mental level and skill of driving.

- Driving license should be linked with CNIC/NADRA.

- A National Licensing Regulatory Authority (NLRA) should be established to regulate the licensing policy.

- Driving training schools should be established at District level and their training is made mandatory for driving license.

- Computerized point scoring system for licenses must be introduced under NHSO 2000.

- Provincial governments (RTA) should enlist renowned private vehicle manufacturers for vehicular testing and issuance of fitness certificates through their workshops.

- Trauma centers should also be developed for emergency treatment, usually heavy loss are occurring due late treatments to the injured passengers.

For Officials (NH&MP)

- One of the most critical zones of Motorway (M-2) patrolling should be increased usually observed that police have no speed guns for this section in the night and patrolling is poor. This section should be enforced with permanent check posts and speed guns active for 24 hrs.

- The Fine in the region of Salt range should be doubled for over speeding that will make drivers more careful.

- Number of Speed check post should be increased in Salt range as drivers tend to over speed in the mid of two check points.

- Data collection procedure takes usually four days to compile which makes procedure less reliable, it should be converted to online system and Excel sheet should contain as many rows as in the form(i.e. 77)while the existing excel sheet contains(26).Detail remains missing to analyze accidents.

- Under reporting should be avoided.

5.3.2 FOR DOSING AT WHEAL

The second highest cause of accidents is dosing on wheal. Use dosing alarms and give proper education to drivers. The intelligent device is designed to detect when the driver is in danger of falling asleep and immediately alert / companions to avoid possible accident. Gadget of low weight is put on the left ear and activates an alarm monitor driver's drowsiness as shown in Figure 5.1. Motorway Police should introduce these devices to drivers while entering motorway and can be collected back at end points. This device has prices from range of 0.5$ to 30$. Procedure can be adopted by Motorway Police, from the AADT one can easily calculate that the vehicles per hours, maximum time for covering the distance of 358 km is 5 hours.

For buses while entering the motorway during video making device should be installed on driver ear ,and all the passengers should be given indication about working of device that whenever

driver try to sleep that beep will alarm. Thus passenger will also remain alert regarding dozing of drivers. For drivers of cars or individual drivers, device should be installed or given during toll collection. That beep will remain a hindrance against dozing. That device could be collected back at the interchanges when vehicles going out from motorway territory. This process should be first tested on some sample of vehicles then can be tested.

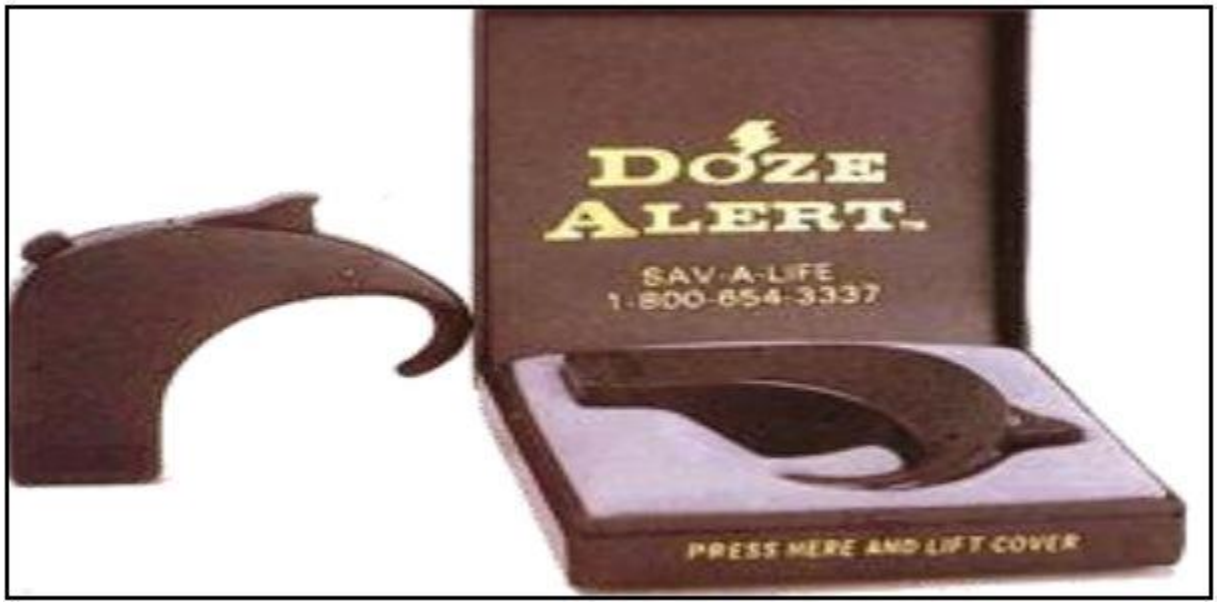

Figure 5. 1: Dosing alert alarm to overcome dosing

Figure 5. 2: Dozing Alert Alarm Mechanism –Buzzing on 15 Degree Head Bend..

5.3.3 FOR TYRE BURST

Tyre burst is also one of the major causes of accidents. NH$MP police officials need to check the quality of drivers. Doubted vehicles should be checked. If the tyres of vehicles seem doubted then it should be checked. The tyre gauging device costs $4 to $41. If 20 devices are kept at each interchange then it should then it would costs nearly 200000/- at a rate of $5 per 400 vehicles.

Procedure: Usually never use tires older than six years, regardless of whether it was or not. To check the age of tires looking DOT number stamped on the sidewall of the tire, it will look something like "DOT XXXX 2209", and in this example, the tire was manufactured in the 22nd week of 2009. Through equipment following is the procedure:

1. Locate the Tread. Tread depth of the tire is formed grips the road. It consists of a central structure of the groove width of three-quarters of the tire and the entire outer circumference. The depth of these slots should be uniform in all parts of the tread shin. Less grip, the less traction and driving safety may be different auditing standards have. There tire brand of depth variation. This approach can be further developed in the discussion of this issue with the companies producing tires.

2. Tread-Depth Gauge. Carefully inspect the tire and remove small objects stuck in the tread. Check the wear is extremely uneven. Specify the driver to replace the tire immediately if you notice excessive wear, dents, cracks or deep cuts the tread or sidewall. Pavement wear indicator integrated search. They are usually found at the bottom of the central groove tires. Check the wear indicator is visible on the same level with the surrounding tread, if so, the driver should be penalized. Input for excessive tread wear in calibration of measuring points, as shown in Figure 5.3. If irregular wear of course, put the template in the game with the most worn part begins. Keep the meter perpendicular to the ground; put it between two blocks of wear indicators.

Figure 5. 3: Tyre Checking Procedure with Gauge.

Then extend the little finger of the dipstick at the back of the throat. Now read the value of this prevails. Minimum required and analyzed depth of winter tires should be at least 5.0 mm. Summer tires should be at least 3.0 mm. If the depth of the tread on these figures, it is time to change tires. Please note that these values are ideal for road safety, because they are much higher than the legal minimum depth of 1.6 mm. For different types of vehicles, standard varies as the standard of the design and shape of tyre also changes. Motorway Police can check the tread depth with a gauge at entering locations like toll plazas. The vehicle entering the toll plaza showed is

observed while passing by naked eye, suspect tyres should be stopped and checked by gauge. It takes few seconds to pay toll and collecting Card and same is the duration of checking vehicle tyre without interrupting traffic, even if observation takes time, the suspect vehicles can be sidelined and then checked in detail.

5.3.4 BRAKE FAILURE

It is the fourth highest cause of accidents. To avoid this problem emergency climbing ramp should be provided. Usually it is long sand or stone/gravel track to brake safely. This is adjacent to road with steep slope. Climbing ramp is provided in figure 4.

Figure 5. 4: Climbing ramp provided to prevent brake failure.

5.3.5 FOR PEDESTRIAN CROSSING

Pedestrian crossing is not the problem on Motorway but it have high problem on Highway.

- **Pedestrian under Pass:** Pedestrian underpass can be constructed to provide suitable passage, two underpasses in all critical zones which are four thus at least four or more underpasses should be constructed as population is growing day by day.

Figure 5. 5: Pedestrian under pass

5.3.6 ROLE OF MEDIA IN SAFETY AWARENESS

Media power is recognized as one of the most effective way to increase mass awareness.

- **Broad Cast Yourself**: Usually media is found one of the most impressive way of spreading information, so it can be used to educate public about the safety issues of traffic especially about motorways so that people take care of those principles which confer the safety maintenance and efforts by governments.

Motorway police should be connected with the media, so that fast awareness through electronic media could spread. The meaning full skits, adds can be originated to convince and teach safety issues and traffic rules to the public. Print media should also be considered for awareness.

- **Training/Education.**

Literacy rate of Pakistan is very low; especially the drivers of HTV are educated almost nil so special procedures should be designed to educate them. Following are some points to increase driver's education level.

• Driver's education process should be formulized in such a way that awareness of consequences of driving mistakes should be increased. Usually driving learning procedure in Pakistan is through relations, thus the limited education is transferred to the new drivers. This program can develop the standard a lot.

• Process of precautionary measures to avoid or removing obstacles causing accidents should be done in such a way that driver are forced to follow rules and other factors like pedestrians and animals should be enforced to keep away from Motorway M-2.

• Although higher price of fines can also be recommended but may lead to divert traffic towards other routes so this option is not as better than other law enforcement options.
• Safety pamphlets should be distributed among drivers to educate them with the key causes of accidents like, mechanical problems, drivers carelessness, dozing on wheel so that they may take care of those issues.

• Driver learning courses should be connected with the driving license renewal procedure and strict transparency should be adopted during this procedure. Highway safety department should take the test about the sufficient knowledge related to traffic safety. Gulf Countries like standard procedure could be adopted to increase the worth of Pakistan driving license.

5.4 RECOMMENDATIONS AND DIRECTION FOR FUTURE RESEARCH

This research study, addressed the comparison of road traffic accidents analysis of Highways and Motorways of Pakistan. The road section from Islamabad to Lahore is selected for the study. The accidents data are analyzed in detail and find the causes. Mitigation measures are addressed for the issues of traffic safety. All the analysis are done on data from police and this is the most reliable source of the traffic safety. Road crash fatalities and injuries have emerged as a moral challenge for societies around the world. Reliable information on total traffic injuries and identification of factors responsible for high traffic crash injury rates is therefore an important issue and the first step towards initiating remedial measures. A broad and comprehensive accident data reporting and recording system is recommended for Pakistan. Government need to make separate department for reporting of accidents. Also, the country needs a dedicated research center where new methods are adopted to conduct road safety research and counter measures are developed that help reduce road crash injuries in the country.

In future detail accidents analysis must be done to find the exact causes, patterns of accidents on highways and Motorways. Experts suggest suitable remedial measures for these causes. Government needs facilitate traffic safety researchers and also allocate specific funds to

mitigate these causes. Survey questionnaires must also be distributed to know the perceptions of citizens regarding accidents.

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