An Analysis of Legislation and Level of Compliance of Key Crash Risk Factors- A Case Study of Islamabad

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Certified that contents and form of thesis entitled **“An Analysis of Legislation and Level of Compliance of Key Crash Risk Factors-A Case Study of Islamabad, Pakistan ”** submitted by Mr. Muhammad Umer Farooq have been found satisfactory for the requirement of the degree.

Supervisor: _______________________

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"To my beloved father, Prof. Mukhtiar Ahmad"

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LIST OF ACRONYMS

WHO	World Health Organization
RTC	Road Traffic Crashes
RCF	Road Crash Fatalities
DUI	Driving Under Influence of Drugs or Alcohol
MVO	Motor Vehicle Ordinance
GOP	Government of Pakistan
ITP	Islamabad Traffic Police
SDGs	Sustainable Development Goals
PBS	Pakistan Bureau of Statistics
TRB	Transportation Research Board
NHTSA	National Highway Traffic Safety Administration
IORAP	International Organization of Road Accident Prevention
NCIPC	National Center of Injury Prevention and Control
BAC	Blood Alcohol Concentration
CRS	Child Restraining System
TSC	Transport Safety Council
NOPUS	National Occupant Protection Use Survey
FHWA	Federal Highway Administration
NSUBS	National Survey on the Use of Booster Seats
ASAP	Alcohol Safety Action Plan
NHMP	National Highway and Motorway Police
NCIPC	National Center of Injury Prevention and Control

ABSTRACT

In the present study an analysis of legislation and level of compliance of key crash risk factors (speeding, drink driving, seatbelt, helmet and child restraint) for Islamabad city has been carried out. The data on legislation of key crash risk factors and penalties related to different offenses were obtained from Islamabad Traffic Police (ITP) and National Highway and Motorway Police (NHMP). The data on legislation revealed that both enforcing agencies follow Motor Vehicle Ordinance of 1965 with few recent amendments. It was found that there is no legislation on child restraint in Pakistan. However, for seatbelt and helmet use there are well defined laws but the penalty in cases of seatbelt or helmet law violation are substantially low. In addition, comprehensive legislation exists on speeding but practically there is no/very low speed enforcement. Also, appropriate legislation exist for driving under influence with heavy fines and imprisonment up to 6 months.

Thenceforth, the level of compliance of key crash risk factors was carried out by conducting self-reported questionnaire survey, speed monitoring by radar gun and interviews from traffic wardens. The survey revealed 67.44 %, 65.8 % and almost negligible, compliance of seatbelt, helmet and child restraint laws respectively. Similarly, speed monitoring revealed an overall 35.22% speed violation with the highest percentage violation on collector roads. Seatbelt usage data modeled using binary logistic regression revealed a low likelihood of seatbelt usage among (1) male drivers (2) taxi drivers (3) drivers with low level of education (3) drivers without history of past crashes (4) drivers that self-reportedly violate speed limits (5) drivers never penalized on seatbelt violation and (6) drivers with no seatbelt auto alarm installed in their vehicles. Also, application of binary logistic model on helmet use data revealed that there is a low likelihood of helmet use in (1) young and novice riders (2) riders without valid driving license (3) riders who reportedly face visibility issues at night due to wearing helmet and (4) riders who reportedly face rearview visibility issues due to helmet use. Interview of selected traffic wardens revealed that opium, hashish and cannabis are commonly consumed drugs and there are no testing equipment like alcohol or pot Breathalyzer that could

test drug use among drivers. This is an exploratory study and findings can be useful for enforcement agencies to take appropriate measures such as enhanced enforcement to improve road users' safety in Pakistan.

Chapter 1

INTRODUCTION

1.1 Background

There are a number of factors that cause road traffic crashes. These factors stem from various components of the system that consists of roads, the environment, vehicles, road users and their mutual interaction. Among these factors, some are responsible for the occurrence of collision and subsequent crash causation. Other factors ensue exacerbation of the impacts of the collision. Consequently, contributing to trauma severity. The complications that are manufactured in shape of road causalities and subsequent deaths and injuries are now contemplated as a universal phenomenon which has driven national and regional transportation authorities throughout the world to undertake combative actions against the exponential growth in the amount of on-road crash fatalities and injuries. Among these factors, few are key risk factors that are predominantly involved in most of the traffic crashes. Accordingly, making it necessary to identify the risk key factors that set off road traffic crashes so as to discover and identify those necessary interventions, upon application of which risk associated to these factors may be reduced.

World Health Organization (WHO) has identified that RTCs are a primary source of fatalities globally, similarly the major cause of fatalities among those aged 15-29 years (WHO, 2015). These on-road calamities emerge as a huge encumbrance on the economic productivity of any country. Hence, making it indispensable to be addressed by the Sustainable development goals (SDGs). The annual fatalities caused by RTCs globally are almost 1.3 million and almost 20-50 million bear non-fatal injuries. It has been anticipated by WHO that over the next 20 years, there will be an exponential increase in the rate of fatalities and non-fatal injuries by approximately 65 %, if there aren't any necessary remedial measures taken to improve the current state of road safety across the world (WHO, 2015).

For some modest and low income countries like Indonesia, Somalia, Pakistan, India, Nigeria, Ethiopia etc., road traffic crashes emerge as a serious public health issue since it prompts a profligate amount of injuries and fatalities. Though these countries have a total share of just 48 % of the whole registered vehicles globally, it is distressing to acknowledge that 90 % of fatalities are occurring just in these countries, that makes it a huge loss for public health sectors. This situation is exacerbated further by the high indirect cost of road crashes. It is anticipated, that the total economic cost of road fatalities exceeds over US$ 100 billion annually (WHO, 2015).

It has been reported that globally, there are only one third of countries that have a proper nationwide strategic program for road safety that is supported by their governments. Consequently, for those countries where there is no consultation among authorities for road safety, it is indispensable to make road safety laws more understandable and enforcement more effective so as to curtail traffic crashes. Provided with today's elevated proliferation of motorization worldwide, the amount of fatalities and injuries due to traffic crashes is prone to escalate further in most regions of the world unless a suitable remedial measure is taken. For which, entire consortium of stakeholders are required to step forward with mutual discourse on the issue of on-road traffic fatalities and injuries.

WHO has identified in global status report on traffic safety 2015 that among several factors that contribute to traffic crashes and their consequent causation of fatalities and injuries, the major factors are over speeding, non-compliance to seat belt use, driving under influence of alcohol and drugs, defiance to the use of helmet and non-conformity to the use of child restraint in vehicles for the safety of minors. Traffic laws addressing the above mentioned key risk factors are believed to be enforced on about 10 % of the global population. It is also witnessed that among these risk factors, speeding and drink driving are major contributors to on-road traffic crashes (WHO, 2015).

This research aims to analyze key risk factors responsible for traffic crashes in Islamabad, the 10th largest and the capital city of Pakistan. In order to discern the existing traffic conditions, survey on key crash risk factors is carried out in compliance with the factors that WHO focuses on i.e. Speed, Seat belt, Helmet, Child restraints and Driving under influence (DUI/DWI). Speed survey is performed using speed radar gun on major and minor arterials while seat belt, helmet and child restraint surveys are performed randomly from major trip generators with the intention to ensure random sampling. In the interim, Interviews from traffic wardens are also obtained on the context of driving under influence of drugs or alcohol, so as to know the rate of influenced drivers that are encountered usually by traffic wardens and what actions are taken against them. The data on later stages is evaluated statistically and effective recommendations are made.

1.2 Problem Statement

Injuries and fatalities caused by traffic crashes continue to be a significant public health issue on global, regional and national domain. With the intention to effectively and sustainably prevent road traffic injuries and fatalities, concerted efforts are needed. Unfortunately, on national level, there isn't much consideration given to combat the rising number of traffic crashes which is a sizable public health challenge.

- According to WHO Global status report on road safety 2015, Pakistan has the eleventh highest number of fatalities due to traffic crashes around the globe.
- Majority of traffic crashes are due to lack of appropriate legislation and suitable compliance.
- Effective road safety measures can only be introduced if the extent of the problem and its underlying factors are thoroughly explored.
- There exists exigency for analyzing key risk factors and their impact on road safety.
- Sufficient differences between level of exposure, governmental policies and road environment between developed countries and Pakistan demands research efforts on key crash risk factors using local data.

1.3 Research Objectives

In September 2015, United Nations has unanimously adopted a historic sustainable development goal (SDGs). Among these SDGs one of the crucial goals is to reduce the global number of deaths and injuries caused from on-road traffic crashes to halve by the end of 2020. Reminiscent to the global trends of road safety problems, Pakistan is also subjected to high risks that are imposed due to numerous instances of traffic crashes causing fatalities and severe injuries. This research aims to achieve the following objectives:

- To provide a comprehensive picture of current legislation on key crash risk factors in Pakistan.
- To investigate the current level of compliance of key crash risk factors in Islamabad.
- To identify factors affecting compliance level of seatbelt and helmet laws using econometric techniques.

1.4 Overview of Research

The afore-mentioned objectives of the research are achieved through methodology including the following research tasks:

- Literature review of the overall safety and key risk factors that lead to traffic crashes.
- Collection and collation of data on legislation and level of compliance of key crash risk factors through self-reported survey. Also known as pen and paper interview (PAPI).
- Collection of over-speeding data by conducting spot speed studies by speed gun in an attempt to envisage percentage of drivers that violate posted speed limits on various major and minor arterials in Islamabad.
- Analysis of collected data followed by model estimation for compliance of key crash risk factors.
- Conclusions and Recommendations.

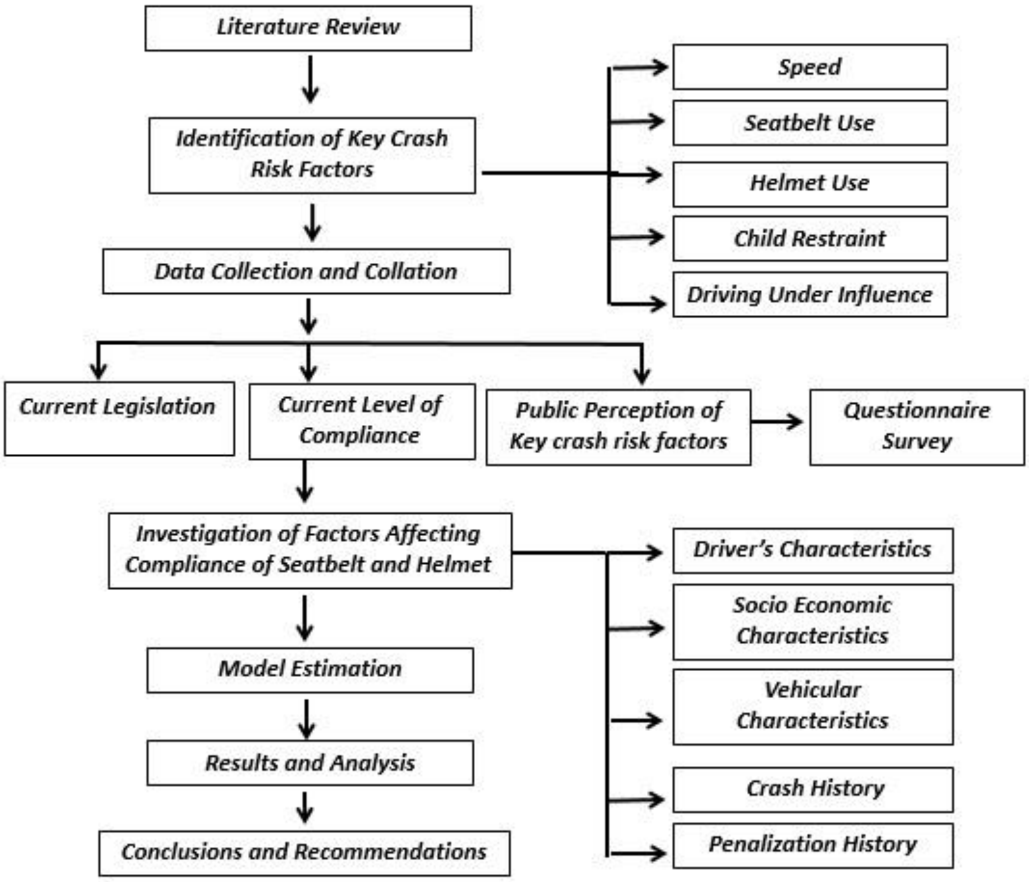

Figure 1: Conceptual Framework of the Research

1.5 Organization of the Thesis

This research is structured in five chapters. An introduction and need for focusing on investigating key crash risk factors in an attempt to reduce road crashes is presented in Chapter 1. Chapter 2 presents literature review of the overall traffic safety and key crash risk factors that lead to road crashes. Chapter 3 presents data collection and collation with comprehension discussion on the procedures that were undertaken to collect the data regarding key crash risk factors. However, Chapter 4 describes the analysis of legislation and level of compliance of key crash risk factors and statistical procedure utilized to econometrically analyze the factors affecting the use of seatbelt and helmet in Islamabad. Lastly, research summary, conclusions and recommendations are presented in Chapter 5.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

RTCs can be designated as all those events that may cause injuries, property damage or fatalities due to involvement of at least a single vehicle on a way, road or street which is exposed to public traffic. These events can be of numerous sorts, viz. collision among two or more than two vehicles, impact of a vehicle with a pedestrian, impact of a vehicle with an animal or collision of a vehicle with any stationary physical structure like a building, barrier or a blockade (WHO, 2013).

WHO in the recent years has strived to recognize the global issue of road safety owing to voluminous injuries and fatalities; approximately 1.25 million fatalities each year are claimed by RTCs worldwide, resultantly causing a huge impact on the development of health sectors. RTCs not only hinder growth in public-health sectors but also impede economic productivity, as reported that almost 3% of GDP is dissipated annually by governments worldwide. It is also reported that among all countries, low and middle income countries are being hit the hardest, with 90% of global road traffic fatalities (WHO, 2015). Similarly, many other organizations like World Bank, Transport Research Laboratory (TRL), Transportation Research Board (TRB), World Road Statistics (WRS) and others have drew attention on the fact that in developing and transitional countries, the major cause of deaths are road crashes consequently, making it an international subject of massive proportions.

WHO is determined to make every effort to decline excessive number of traffic crashes worldwide and especially in middle and lower income countries because the resulting injuries and fatalities caused by RTCs set down a substantial encumbrance on the economic growth of governments as well as households. As deliberated, for low income countries RTCs afflict economically active age group creating a strain on workforce and disconcerting families who have a single person to earn. Consequently, driving several families deeper into deprivation and poverty by the loss of a single breadwinner. Conversely, in case of severe injuries or permanent disability due to RTCs, expenses of prolonged medical care adds more financial constraints on the family members (Jacobs et al., 2000; Prinja et al., 2015). In addition, burden on health services, insurance services and legal systems are also effected owing to the economic costs associated with injuries and fatalities. It has been witnessed by analyzing data on injuries and fatalities due to on-road crashes that low and middle income countries have approximately 5 % GDP losses due to traffic crashes. However, the global loss due to RTCs is estimated as 3% of GDP (Dahdah and Mcmahon, 2008).

2.2 General Factors of Road Traffic Crashes

Goose (2011) revealed that almost 90 % of the crashes befall owing to human errors making road hazard “a man-made crisis”. He pointed out that the challenge of road safety can be solved by implementing adequate measures. Moreover, Miguel (2001) stated that the quality of road transport system or inadequate equilibrium between environmental demand and the driver’s ability to act is the root cause of a road accident. Consequently, making it crucial to find ways where the ability of the road users can be increased so as to fulfil the needs of environment accordingly.

Khalfan (2010) revealed that 90% of traffic crashes happening in Dubai are caused by reckless driving behavior, as in driving in aggression or under the influence of drugs. Also, over speeding, changing lanes without signaling and violating traffic signals that envisaged offhand driving behaviors are also root causes of RTCs.

Traffic crashes are set off by numerous factors. These factors cover many factions of an ecological network that can either be a part of a physical or behavioral system. Physical factors cover a confluence of faults on roads as in shortfalls in structural or functional capacity of roads. For example, design defects, faults in vehicles, weather extremities however, behavioral system entails different attitudes and practices of driving such as drunk driving, reckless driving, unsafe lane changing, road rage, racing or drowsy driving, driver’s fatigue etc. Few possible causes or factors responsible for road traffic crashes are discussed in continuing paragraphs.

2.2.1 Driver Behavioral Factors

Drivers frequently involve in behaviors that cause a hazard to both themselves and to on-road users. Several of these unsafe actions are a result of intentional violations of traffic rules for example, violating traffic signals and stop signs and errors owing to paucity in experience, transitory mistakes, momentary slipups or inattention, deliberate actions or not, both disregard to rules and weakness of memory, judgmental faults, or situational awareness that substantially contribute in traffic collisions. Yet, this behavior may be improved through education, publicity campaigns, awareness, training and traffic police enforcement. Consequently, comprehending as well as improvement in driver behavior plays a key role in the improvement of road safety (Taylor et al., 2013).

A major setback in presenting the relations between drivers' character and their driving behavior is the paucity in steadfast and reliable tools that can collect suitable data concerning behavior of individuals while driving. There is an exigency of monitoring driving attitudes so that drivers who involve in hazardous driving practices can be prevented from crash involvement (Horberry et al., 2006).

Young and novice drivers have posed even more risk to road safety since they are considered as a vulnerable group of road users. An analysis done by Eman et al. (2014) showed that the main cause behind raised number for RTCs in young drivers is careless driving. Young drivers, in comparison to the rest are more liable to aggressive attitude that are manifested through traffic violation and high rate of fatalities in youngsters (Eman, et al., 2014).

2.2.2 Driver/Passenger Characteristics and Human Faults

It has been indicated that almost 25-33 % of RTCs are caused owing to driver's characteristics and human faults (NHTSA, 2009). These include over-speeding, driving while exhausted, falling asleep while driving, health issues, age, attitude, impairment, gender, driving while intoxicated or under the influence of drugs, tailgating and getting distracted by the surroundings. Among these factors, studies have highlighted that RTCs are extensively dependent on gender and age of the drivers. Evans (1991) highlighted that old drivers are more likely to sustain fatalities in case of an RTC as compared to young drivers. For instance, a 70 year elderly has 3 times more risk of undergoing fatality as compared to a young driver whose age is around 20 years. This is due to the reason that as age increases, there is a decline in the physical, mental and perceptive capabilities of drivers. Furthermore, Abdel et al. (1998) highlighted the relationship between driver's age and risk of crash involvement. It was observed that as the age increases, the severity of injuries in case of an RTC also increases.

Other major factor to cause RTCs is gender of the driver. It has been observed through research that female drivers are more prone to RTCs as compared to male drivers. Similarly, the rate of fatalities in female drivers is more than that of male drivers (Bedard, 2002). Furthermore, Sivak et al. (2011) reviewed 6.5 million RTCs between 1998 and 2007, which revealed that female drivers are more vulnerable behind the wheels as compared to male drivers. It also revealed that at junctions, female drivers are more likely to encounter RTCs as compared to male drivers. The cars driven by female drivers are often hit on the left side when maneuvering to make a right turn and vice versa (Sivak et al., 2011).

2.2.3 Technical Faults in Vehicles

Vehicle are designed in a way that adequate safety is ensured at all times during its operation. Among factors related to equipment failure that causes RTCs in vehicles, the major factors cited in the literature are brake failure, tire bursts, fault in headlights, eruption of windscreen, separation of tread, breakdown of axles, and failure in suspension or steering. Almost 5 % RTCs are caused due to faults/ failure in equipment of vehicles (NHTSA, 2005).

2.2.4 Failure to Benefit from Safety Devices

Many safety devices like seat belt, airbags, child restraint system, auto-alarm, energy absorbing steering system, head restraint and traction control system etc. are extensively used in vehicles to minimize the occurrence of traffic crashes. Many studies have proven that the use of safety devices substantially reduce the severity of injuries in case of an RTC. The significance of seatbelt use to ensure occupants' safety has been examined by several scholars in the last many decades. It is widely evident from the past research that seatbelt use by occupants of motor vehicles substantially reduces injuries and fatalities in case of traffic crashes. Seatbelt is thus featured as a life's savior. An increased compliance of seatbelt use can substantially decline the level of severity of injuries instigated by road traffic crashes (Evans, 1986). Public health experts have highlighted that upon fastening of seat belt by every occupant of a travelling vehicle, half of the number of fatal crashes can be avoided (Westlake, 1998).

Airbags in motor vehicles also help to substantially reduce the severity of injuries in case of an RTC. George et al. (2011) reported that there is a 25 % reduction in fatalities in those crashes where vehicle had air bags installed in them as compared to crashes involving vehicles with no air bags. The use of airbags in vehicles help to reduce the injuries that can damage central nervous system. Similarly, the magnitude of facial fractures and facial lacerations are also reduced if airbags are mounted in vehicles encountering traffic crashes (Intas and Stergiannis, 2011).

To ensure safety in children aged 12 years or less, child restraint system are used. Child restraint or child restraining system (CRS) are exclusively designed seats that are predominantly used to prevent children of minor ages to sustain injuries or fatalities during a motor vehicle crash. As per, National Center of Injury Prevention and Control (NCIPC) of USA, motor vehicle crashes are identified to be the major cause of fatalities among children with ages less than 8 (NCIPC, 2008).

From past studies it is evident that minor children who travel while properly buckled in child restraints undergo less amount of injuries and subsequent fatalities as compared to those children that aren't properly strained through child safety seats. It is important to note that child restraint used by the parents must fit the size of a travelling child. In case of crashes, the consequences that the children confront are more critical as compared to the effects of crashes on adults. Additionally, the effects of these crashes can be prolonged and acute in case of children. It is reported that in United States, on average 3 children sustain fatal crashes while 470 sustain injuries daily (NHTSA, 2013). Child restraint helps to decrease the severity of head injuries in children that can impose prolonged health issues in children.

Table 1: General Factors Causing Road Traffic Crashes

1. Driver / Passenger Behavioral Factors	Over speeding Driving under the influence of drugs or alcohol Lacking road disciplines Deferring to drive in a lane Violating traffic signals Road rage and aggressive attitudes while driving Hastily tailgating Driving in the wrong way Improper turning Running stop signs Imprudently parking on road side
2. Human errors	Errors in decision making Performance error Drivers recognition errors Nonperformance errors 'Zoning out' loosing attention
3. Technical faults/ defects In vehicles	Failure of braking system Tire bursts Engine seize Overloading Deficient headlights Steer jam Fissure/ Rupture in axles
4. Avoiding safety Devices	Noncompliance to seatbelt use Noncompliance to Child restraint use Forgoing Helmet Use
5. Environmental Factors	Snow/ Heavy rain/ wind storm/ Hail storms
6. Road/ Pavement conditions	Inadequate Skid resistance , Sharp slopes Inadequate sight distances Super elevation issues on horizontal curves Structural failure of roads like rutting etc. Functional failure of road i.e. high IRI and low PSI etc.
7. Other factors	Distraction while driving such as texting, adjusting mirrors while driving, adjusting radio Animals strolling across the roads Blind spots, Design defects in roads

2.2.5 Environmental Factors

Many studies have highlighted that several environmental factors are responsible for increased risk of crash involvement. After evaluating literature, it was observed that rainfall plays a considerable role in causing traffic crashes. Shankar et al. (1995) revealed that rainfall is a major cause of RTCs among other environmental factors. It was also reported that poor visibility and slippery roads due to rainfall are the main causes of RTCs (Shankar and Mannering, 1995). A similar study was also carried by Hijar et al. (2000) that showed that there is a definite association of traffic crashes with unfavorable environmental circumstances such as heavy rain, fog, and slippery roads.

Crashes occurring at night time are more severe and faulty street lights at night time increases the probability of fatal crashes (Huang et al. 2008). However, Wang et al. (2009) also found that light condition affects the crash injury severity. In the same way, a study conducted in Iran by Lankarani (2014) highlighted the relationship of environmental severities with traffic crashes. The study indicated that dusty weather conditions cause more crashes as compare to controlled weather conditions.

2.2.6 Road / Pavement Conditions

Pavement conditions and geometric design favorably effect the instances of traffic crashes. For those pavements with appropriate geometric features, a reduced level of RTCs are observed (NHTSA, 2011). Majumder et al. (1996) showed that road surface conditions are very important to ensure road safety. Different components of roads such as shoulder type, lane width, type of median etc. are the deciding factors to reduce the number of traffic crashes. Well-designed roads with adequate lanes and ways for pedestrians and cyclists are much safer than those who are deficiently provided with these road features.

In roadway characteristics, a combination of features like road design, location of roadway, highway medians, volume, capacity and density of roads, grades of horizontal and vertical curves, radius of curves, stopping sight distances etc. matter a lot. Duncan et al. (1998) showed that the existence of grades and wet grades increases the probability of RTFs . Lemp et al. (2012) found that occurrence of a crash on grade of +2% and -2% increases the probability of more severe crashes. It was also revealed that sometimes, the presence of such grades can decrease the likelihood of RTFs (i.e. heavy truck moving in a curve) because on such locations the driver is more careful. However, Chang and Mannering (1999) revealed that the presence of curve and inclining or declining grade influences the injury severity of the crash. Moreover, Wang et al. (2009) showed that number of lanes significantly influence the crash injury severity. Similarly, Majumder et al., (1996) reported that broader roads possess more likelihood of RTCs as compared to narrower roads.

2.3 Key Risk Factors

Ferguson (2003) identified age to be a key risk factor associated with the occurrence of RTCs i.e. young drivers especially who are newly licensed possess a very high risk of traffic crash. The author further indicated that few other key crash risk factors such as use of alcohol, noncompliance to seatbelt use, risky driving, distracted driving, physical exhaustion and choice of vehicles; directly or in combination with each other elevates the risk of traffic crashes among young drivers. Ewing et al. (2003) revealed that urban sprawl i.e. a widely dispersed population in a low-density inhabited area is a key risk factor that majorly contributes to traffic crashes.Based on police reported data records on traffic crashes in Wuhan China, Zhensheng et al. (2017) found that the risk of crash involvement is majorly dependent on driving experience, weather conditions, light conditions, type of road, direction of impact and risk taking driving behavior.

WHO in its global status report on road safety has highlighted that among several factors that cause traffic crashes, there are five key risk factors that are responsible for traffic crashes causing injuries and fatalities (WHO, 2015). These key risk factors are; speed, seatbelt, helmet, use of child restraint and driving under the influence of drugs or alcohol. On account of efforts executed by WHO to identify key risk factors of traffic crashes, progress was made in 17 countries that cover a population of 409 million people. The progress was made in terms of amendments of laws associated to these key crash risk factors to bring them in line with best practice. Efforts include amendment of traffic laws on key risk factors supported by strict reinforcement and sustainable implementation which was aided by public awareness (WHO, 2015).

Among these key risk factors, speed is declared as the most critical risk factor because the likelihood of a crash increases as average traffic speed increases. This risk of crash increases for the most vulnerable group of road users that are; pedestrians, cyclists and motorcyclists (Rosen, 2011). An adult pedestrian is anticipated to be at a 20 % less probability of dying if struck by a car whose speed is less than 50 km/h and 60 % more probability of dying if struck by a vehicle whose speed is 89 km/h or more (WHO, 2015). Only those countries have effectively declined the number of road injuries and fatalities who have developed safety prioritization while managing speeds of vehicles encountered on roads.

After speed, drink driving or driving under the influence (DUI) of drugs (also referred as Driving while influenced, DWI) is observed to be a major cause of injuries and subsequent fatalities. A normal blood alcohol concentration (BAC) of 0.05 g/dl is found to be an endurable limit for adult drivers. On the contrary, young and adolescent drivers, when under influence of alcohol or drugs are at increased risk of crash involvement as compared to adult and more experienced drivers. Hence, making it necessary for the authorities involved to enforce a lower BAC limit of 0.02 g/dl for young and adolescent drivers to minimize traffic crashes involving youngsters (WHO, 2015).

Motorcycle helmet use is strongly affiliated to the essential measures of reducing RTCs. Motorcycles and scooters, together known as “Powered Two Wheelers” (PTWs) are growing rapidly worldwide especially, in low and middle income countries owing to less cost of operation and maintenance. Consequently, causing an increased number of head injuries and subsequent fatalities. It is reported that helmet use is capable of reducing the risk of severe injury to almost 70% and risk of death to almost 40 % (WHO, 2015). Only 44 countries having a population of almost 1.2 billion people have laws that address helmet use for PTWs users, which is in fact, very less and threatening (WHO, 2015).

Seatbelt use is a significant factor that can prevent fatalities and injuries due to RTCs. Seatbelt use in any area of world can be ascertained by the “traffic culture” in those areas. The culture of wearing seatbelt while driving is dependent on driver’s behavioral skills, economic condition of a society, and infrastructural setup of that country that also includes types of vehicle used (Akba, 2010). Use of seatbelt is capable of reducing the risk of death in drivers and front seat passengers by almost 40-50 %, similarly for passengers on the rear seats, seatbelt use is capable of reducing minor injuries by almost 75 % and severe injuries by almost 25 %. It has been reported that only 5 countries having 36 million population have modified their seatbelt laws that are best suited for road safety. There are a total of 105 countries, that partakes 67% of global population have comprehensive regulations on the use of seatbelt for all occupants of the vehicle. Nevertheless, considerable efforts are desired to improve implementation of seatbelt laws by sustainable enforcement (WHO, 2015).

Child restraint plays a significant role in child road safety. Use of child restraint is a preliminary requisite of child road safety where parents partake a vital part in assuring the protection of their children. In order to assure the safety of minor children the main emphasis should be on the notion that while travelling children must have correctly fitted child restraint so that they can be comfortable in it and are suitable for their size (Alexander, et al., 2017). Use of child restraint helps to reduce the chances of deaths due to high impact crashes to almost 90 % among newborns and nursling kids. In addition, it is advisable to carry children in rear seats than in front seats (WHO, 2015).

The theoretical and methodological contributions endeavored by several scholars on key crash risk factors are discussed in ensuing paragraphs.

2.3.1 Speed

For a road transportation system, speed acts as a dominant factor of crash involvement among all other factors. The nature of speed to lead other key risk factors is that it affects every part of the system. A designed speed is undertaken primarily to safely expedite the flow of predicted traffic. Moreover, vehicles travel at a range of different speeds to carry people and goods to assorted destinations and are designed to operate on different roadway, weather and several other control conditions. Thus, a variety of choices are made by the people for the speed that they drive their vehicles at (ACC, 2000).

While evaluating the literature on speed as a key crash risk factor, it is observed that speed is deliberated as “hasty/elevated speed or unsafe speed”. The prior passes on to those cases when vehicle travels at a speed that violates the posted speed limits by any enforcing authority. While the later, refers to the speed when a vehicle travels in an unbefitting way which is inappropriate not only to the road but also to the traffic conditions. The distinction between a higher speed and inappropriate speed is important for the realization to the driver that what speed is illegal and what speed within the limit is appropriate (ETSC, 1995). Beyond any doubt, it is deliberated worldwide that over-speeding is a major highway safety problem (Crombe, 2002; Hunter et al., 1998).

Globally, it has been observed that speed limits are repeatedly contravened by drivers owing to existence of a common perception that “everyone speeds’. Some drivers are also observed travelling at speeds that are far higher than allowable speed limits. According to a telephonic survey conducted in Washington in 2002, it was investigated that about 66 % of respondents said that they had contravened the posted speed limits on interstate and non-interstate, major and minor arterials roads. While, 33 % respondent replied that they sometimes or often drove their vehicles at least 10 mph faster than nearby vehicles (Royal, 2002).

Speed subsists as a major motive behind death toll in Pakistan, and indeed in several other motorized countries throughout the world. It is a central participating factor causing traffic crashes which result in numerous injuries and fatalities. For those instances, where speed isn’t a contributing factor in RTCs, nevertheless it befalls as an imperative factor in envisaging the level of severities of injuries and fatalities caused by crashes. It is unfortunate that no efforts have been made to adequately comprehend the gravity of safety situation and the nature of problems that are faced due to over speeding practices in the country.

The first step to report safety issues linked with over speeding is to understand the relationship between risk of traffic crashes and vehicle speeds. Vehicle speed triggers two outcomes– it has an impact on the risk of involvement in an injury due to crashes as well as an impact on the severity of the consequences of traffic crashes. Maycock et al. (1998) reported that 77% of the variation in the speeds documented through different sources on several trunk roads in the UK were because of four important factors i.e. road type, road geometry, weather and surface conditions.

ACC (2000) has reported that in New Zealand, speeding is directly involved in causing severe injuries due to traffic crashes. Upon reviewing the road safety literature to investigate the relationship between the speed of vehicles and the risk of crash involvement, it is revealed that there exists many exploratory research findings that evaluated speed as a key risk factor. In the earliest attempts to examine speed as a key risk factor, scholars have endeavored to find out how vehicle speed effects the risk of crash involvement by using data on the speeds of those vehicles that were involved in crashes. The probable speed of the vehicles just before the crashes were documented either by police reports or by personal interviews from the drivers that were involved in the crashes. The speed data obtained was later compared with the speed of control vehicles that didn't undergo any crashes. The control vehicles were taken as those which were travelling in the same conditions as the crashed vehicles, viz. traveling on the same road and at the same time as that of those vehicles that were involved in crashes. Kloeden et al. (1997) comprehended this method to be sufficiently sound but in later stages it was observed that there existed many inherent setbacks with this approach. Especially, it was questionable that how accurate the documented pre-crash speeds of vehicles can be, since there existed no proper recording system like In-Vehicle Data Recording System (IVDR) that could record accurate speeds just before impact of the vehicles. Owing to these shortcomings, this approach was renounced in the later stages.

An alternative procedure to comprehend and illustrate a suitable relationship between speed and risk of crash-involvement was undertaken afterwards, by examining the rates of crashes before and after a change in the posted speed limits. Among the critiques on this methodology, one doubt was that these approaches didn't take in account other important factors other than change in the speed limits that can crucially effect crash rates, especially the level of enforcement of speed limits by the concerned authorities (Kloeden, et al., 1997). There were consistent findings from several studies on development of relationship between speed of travelling vehicles and their risks of crash involvement. These findings illustrated that increasing the speed limit increases the severity of the crashes and subsequent probability of fatalities and injuries however, by reducing the speed limits rates of crashes were reduced. Xue (2007) conducted a study to develop a statistical relationship between speed and frequency of RTCs. It was computed that reduction of 1 kph speed can cause 3% potential reduction in rate of crashes.

The literature appraised on the relationship between speed and crash risk can be concluded under following points;

- With the increase in mean traffic speed, the risk of crash involvement of a vehicle is also increased. Similarly speed variation has a considerable effect on the risk of crash involvement.
- For a segment of a roadways with lower mean speed are much safer than those with higher mean speeds.
- 25% reduction in crashes is observed by 1 kmh reduction in the mean speed.
- With an increase in mean speed from 100 kph to 120 kph, the probability of fatal crashes doubles.
- By increasing the speed, chances of misjudgment by surrounding drives also increases that increases the risk of crash involvement.
- Due to increase in travel speed, chances of rear-end crashes are increased if the driver can't effectively judge his increasing speed. This is due to the reason that an increased speed will increase the following distance subsequently causing a rear-end crash.
- Fast drivers unlike slow moving drivers are the main cause of hazard to road users. By educating all speeding drivers to slow down entails good results to ensure road safety.
- If crashes due to speed involves a pedestrian, the chances of fatalities also increases dramatically.

2.3.2 Seatbelt

It is universally recognized that the use of seatbelt reduces the risk of sustaining injuries in case of crash causation. As per WHO, laws on seatbelt should ensure the compliance of both front and rear seatbelts by all occupants of a vehicle. For front seatbelt the reduction in injuries is estimated to be 50 % for front seat occupants of a vehicle whereas, a 75 % reduction in injuries is observed due to the use of rear seatbelts for all real seat occupants (WHO, 2015).

The significance of seatbelt use to ensure occupants' safety has been examined by several scholars in the last many decades. It is widely evident from the past research that seatbelt use by occupants of motor vehicles substantially reduce injuries and fatalities in case of traffic crashes. Seatbelt is thus featured as a life's savior. An increased compliance of seatbelt use can substantially reduce the level of injury severity resulting from road traffic crashes (Evans, 1986). NHTSA (2006) has reported that seatbelt use is the simplest, economical and quickest tactic to avert injuries and fatalities due to RTCs. In order to do so, it has to be ensured that every single passenger is properly buckled up before starting any trip. Peterman (2013) revealed that as per police crash data, 2.36 million people suffered injuries and 33,561 ensued fatalities all in USA in 2013. Lap-shoulder seat belt has been identified to be the principal collaborator in approximately 50 % reduction of crash risk when fastened by front and rear seat occupants (NHTSA, 2009). Public health experts have highlighted that upon fastening of seat belt by every occupant of a travelling vehicle, half of the number of fatal crashes can be avoided (Westlake et al., 1998).

For passengers whose ages were older than 5, NHTSA annual report highlighted that 13,250 lives were saved owing to compliance of seatbelt use in 2008. Furthermore, from 2004-2008 an estimated 75,000 lives were saved due to seatbelt use (NHTSA, 2005). A Three point safety-belt restraint system was highlighted by Westlake et al. (1998) which features a combination of a "lap belt and shoulder to hip belt". This system helps to restrict the forward movement of the body upon an intense impact, which resultantly helps to protect internal organs from internal wounding. Similarly, it helps to avert rotation of pelvis that can be the central cause of impelling injuries to fatality. Furthermore, the identified system helps to deter head contacts with hard interior of the vehicles and prevents excessive neck motion that are potential to cause neck injuries. Similarly, Elvik (2004) reported that the compliance of seatbelt use reduces the chances of fatalities due to RTCs for the front seat occupants and rear ones by 40-50% and 25-75% respectively.

Besides research, many campaigns remained operational by different media outlets like television, radio, press and social media to deliver first handed awareness on the subject of traffic safety and the importance of using seatbelt. These campaigns endeavored to feature that the compliance to seatbelt use can impact positively to ensure traffic safety due to a considerable reduction in mortality and morbidity among those sufferers that underwent RTCs. An important point was indicated that seatbelt use helps to prevent ejection of an occupant from the vehicle in case of an intense crash. Ejection of occupant's causes maximum fatalities in case of traffic crashes (NHTSA, 2009).

Upon reviewing the literature, it is evident that many researchers have focused upon observing the factors that impact the rate of use of seatbelts. Generally, age, education, socio-economic conditions, weather severities, enforcement level, geometrical dynamics, time of the day and functional type of the roads" etc. were observed as the key factors that affect the use of seatbelt. The research mostly highlights the factors that are involved in usage or defiance of seatbelts, barely for front seat occupants only. Boontob et al. (2007) highlighted key factors that either motivated or discouraged the use of seatbelts. An extensive survey was carried out in Thailand through self-reported questionnaire survey and on-field inspections. Later, the conducted survey was statistically analyzed and it was observed that different demographic factors like age, gender, education, marital status, level of education, socio-economic status, income, type of vehicle and seating positions were key factors that predominantly influenced the use of seatbelts. Briggs et al. (2006) found that many racial differences affected the use of seatbelt similarly, women had more rate of seatbelt use as compared to men. However, youngsters had low rate of seatbelt use as compared to elders. Whereas, people having low income were more neglectors to use seatbelt as compared to people with high income.

In the context of Pakistan, an antecedent survey was conducted in order to monitor the rate of seatbelt use among Pakistani drivers and occupants sitting in front seats. The survey was conducted on five different types of roads on the basis of functional classification. Simple self-reported questionnaires were composed that investigated the factors that were mostly involved in convincing the passengers whether to use or abstain buckling a seatbelt. Enforcement of traffic police to ensure compliance to seatbelt use was also investigated through data extracted from previous year's enforcement records. An average seatbelt use rate of mere 20% was observed, whereas 53% was observed on freeways being the highest and 5% compliance of seatbelt use was observed in country sides and backward villages. Factors that effected the use of seatbelts came out to be unawareness, unavailability of seatbelt in vehicles, discomfort, travelling slowly, illiteracy and secondary laws on seatbelt use (Klaira and Arfan, 2014).

2.3.3 Helmet

Motorcycles are mostly preferred by a large percentage of individuals owing to its capacity of travelling at high speeds but it extends a reduced level of protection to the occupants and possess a higher risk of crash involvement as compared to other vehicles consequently, making it the most hazardous vehicle on roads. It is also observed that motorcycles possess the highest cost of crashes per mile (FHWA, 1999). In order to reduce the severity of fallouts because of a motorcycle crash, helmets are designated as the best defense expedient (Miller et al., 1990). Helmets are potentially capable to reduce fatalities due to head injuries to almost 29-35 %. Similarly, their use is the best way to reduce non-fatal brain injuries (NHTSA, 1989).

Macleod et al. (2010) highlighted that motorbikes possess a higher risk of crashes that result in fatalities or injuries yielding permanent disabilities. Head injuries are the most common damage to the victims which mostly end in death or long term disability. In literature, there exists an extensive discussion to find the level of risk attributed to a biker who doesn't wear a helmet while travelling. Motorcycle helmet use is strongly affiliated to the essential measures of reducing RTCs. Motorcycles and scooters, together known as Powered two wheelers (PTWs) are growing rapidly worldwide. Especially, in low and middle income countries owing to less cost of operation and maintenance. Consequently, causing an increased number of head injuries and subsequent fatalities. It is reported that helmet use is capable of reducing the risk of severe injury to almost 70% and risk of death to almost 40 %. (WHO, 2015). Upon assessment, it was observed that only 44 countries having a population of almost 1.2 billion people have laws that address helmet use for PTWs users, which is in fact, very less and threatening. There exists a sizeable policy debates in both public and legislative segments that has compelled the local governments and worldwide agencies to modify the laws on use of helmets so as to improve overall traffic safety on roads (Haworth et al., 1996).

Ouellet et al. (2006) analyzed pre-crash effects of helmet use in US and Thailand. A total of 1,869 RTCs were investigated that involved motorcycles. On both locations, almost 6% riders sustained fatal crashes while non-fatal crashes were recorded as 20-25%. It was estimated that for those riders who don’t use helmet, there is 2.5 times more likelihood of fatal crashes upon an intense impact of motorcycle with another vehicle or a firm obstruction. Similarly there is 3.5 % more likelihood of sustaining a head injury due to non-compliance of helmet use.

Kelly et al. (1991) collected data from eight medical institutes in Illinois on crashes that involved motorcycles and their subsequent admission in emergencies. The study was undertaken for a period of 7 months. It was observed that among 398 victims the rate of using helmet at the time of crashes was only 14.6 %. Similarly, among the victims there were 3 times more carrier of head injuries who didn’t wear helmets while encountering collisions as compared to the ones who used helmets.

Mertz and Weiss (2008) showed the comparison of head related fatalities in riders between a period from 2001-2002 and 2004-2005. The purpose of the study was to envisage the status of the overall improvement in the safety of riders. Upon investigation, it was observed that for every 1000 motorcycles, there was a 32.8 % increase in fatalities owing to brain injuries and 42.2 % increase in non-fatal head injuries. Moreover, a similar study to explore relationship between head injuries and rate of helmet use was carried out in Colorado by Glabella (1995). The study was done country-wide to locate those riders that underwent head injuries after collisions. The data in this respect was obtained from traffic accident reports and Colorado’s injury prevention program. Cases of 2 years from 1989-1990 were taken which revealed that for those riders who didn’t wear helmet had 3.34 more ratio of motorcycle crashes as compared to those who wore helmets.

In studies related to helmet use, it is imperative to find the reason that compels a rider to avoid wearing a helmet. Javad et al. (2014) documented responses from motorcyclists who underwent a traffic crash and were admitted to a local hospital in Kerman, Iran. Due to unavailability of reliable data, a pilot study was pursued. More than 370 surveys were taken from the victims of motorcycle crashes who didn't use helmets while encountering crashes. It was observed that the main reason of not using helmets turned out to be its heavy weight and subsequent uncomfortableness; almost 71 % of respondent expressed that due to the burden of helmets they didn't use it. Similarly, 71.5 % responded that they didn't use helmets because it caused heat and 69.4 % replied that neck pains were induced due to helmet use for which they had quitted the use helmets. Moreover, 67.7 % of the responses expressed that by wearing helmets, suffocation was caused while 59.6 % recorded un-easement to move head and neck while driving. In a nutshell, the study concluded that physical discomposure was the main reason behind low rate of helmet use by riders of the subject area.

In the context of Pakistan, a very low rate of helmet use is observed nationwide. Moreover, the helmets that are used aren't well harmonized with the international standards (Klair et al., 2015). Several laws have been implemented to ensure traffic safety, as reported in Pakistan's motor vehicle ordinance 1965, there are laws identical to universal practices but the challenge that the country faces is a considerable declivity in the level of enforcement on these already defined laws.

Ghafoor et al. (2014) conducted a study to find the factors responsible for low rate of helmet use in Pakistan. The authors conducted an observational study of 1239 riders which revealed that average helmet use rate is 20.63 %. Among riders who wore helmets, 70 % responded that they use helmet because of ensuring their personal safety while among those riders that didn't use helmets, 50% responded that owing to the irritation cause by helmets they didn't use helmets. It was also revealed than 27.7 % of the riders who used helmets responded that the reason of using helmet was just to prevent dust and smoke entering in eyes.

Upon a thorough review of literature on helmet use and its relation to risk inducing crash involvement in motorcyclist the following facts were observed;

- Overall fatality rate is considerably minimized by ensuring a high rate of helmet use among motorcyclists.
- Using safety helmets can effectively decrease the level of non-fatal head injuries.
- By implementing appropriate legislation on helmet use, a sizeable decrease in fatalities and head injuries can be observed.

2.3.4 Child Restraint

Child restraint or Child restraining system (CRS) are exclusively designed seats that are predominantly used to prevent children of minor ages to sustain injuries or fatalities during a motor vehicle crash. As per NCIPC (2008), motor vehicle crashes are identified to be the major cause of fatalities among children less than 8 years of age. Past studies have highlighted that minor children who travel while properly buckled in child restraints undergo less amount of injuries and subsequent fatalities as compare to those children that aren't properly strained through child safety seats. It is important to note that child restraints used by the parents must fit the size of a travelling child. Similarly, Parents partake a vital part in assuring the protection of their children, especially infants and toddlers because they are at a great risk of involvement in traffic crash due to adolescence.

In order to ensure the safety of minors who are travelling in vehicles, several matters must be tackled. Among these, the main emphasis should be on the notion that while travelling children must have correctly fitted child restraints so that they can be comfortable in it and are suitable for their size. Past research has revealed that that more than 70 % of child restraints are fitted improperly (Alexander, et al., 2017). Use of child restraint helps to reduce the chances of deaths due to high impact crashes to almost 90 % among newborns. In addition, it is advisable to carry children in rear seats than in front seats (WHO, 2015). Globally the compliance of CRS usage has been noticed in 53 countries which cover a total population of almost 1.2 people. Similarly, it is reported that CRS usage can reduce the chances of fatalities among infants to almost 70 %, whereas for young children aged less than 12 years, the reduction in fatality is estimated to be 54% -80% (WHO, 2015).

Past studies have revealed that socio-economic factors considerably effect the level of usage of CRS. For instance, a high rate of CRS usage was observed in cases of high income and good level of education. While in uneducated groups like minorities and immigrants a low level of CRS usage was observed (Miller et al., 1997). Bulger et al. (2008) has revealed that misuse of CRS plays a major role to aggravate the physical damage caused to the children in case of a crash. Similarly, Decina et al (2005) showed that after observing 5,000 children, 72.6 % of the children were found to be restrained incorrectly. Among many misuses of restraints, the most common misuses were found to be restrained safety seats with loose harness straps and loose fastening of child restraints by seatbelts with the main rear seats.

For side-impact crashes the children who were buckled up in forward-facing CRS sustained injuries, the significant factors behind these injuries were intrusions that penetrated inside child's occupant space and penetration of internal parts of vehicles towards spaces where CRS's were mounted. Similarly, rotation of child safety seats was also considered as a major reason behind injuries. The intrusions cause abdominal gastro-intestinal injuries with damage to kidneys (Arbogast , 2005). For this reason the use of three point belts was recommended instead of two point belts with CRS. The risk factor of abdominal injuries is doubled when CRS is used with two point belts instead of three point belts (Anund et al., 2003).

In the context of Pakistan, a study conducted by Emmadudin et al. (2014) highlighted the attitude of CRS usage among people form Karachi. A survey was conducted from 304 employees of a health care organization. The chosen employees owned cars and had children less than 10 years. Questionnaire surveys were developed that contained 36 diverse questions covering demographic factors like gender, age, income, level of education, driving experience, number of children less than 10 years, obtainability of valid driving licenses etc. From the survey a response rate of 72% was obtained having a majority of male respondents (59%). Similarly, CRS usage was found to be just 22 % though 79.2 % had some familiarity with CRS. When questioned about the reason of non-compliance to CRS usage, 26.7 % parents responded that they considered it unnecessary whereas, 22.2 % parents had no idea about CRS. Factors that contributed to non-compliance of CRS usage were non-availability of CRS, ignorance, refusal to CRS usage by children and a generic notion that a child held by an adult passenger is as safe as strapped in CRS or booster cushions.

2.3.5 Driving Under Influence (DUI)

Since the invention of motor vehicles in 1880's, driving under influence of alcohol or drugs has been recognized as a major factor that contributes to fatal or non-fatal crashes. Owing to crashes involving drink drivers, many amendments were made in US's legislations by 1910 to improve enforcement on drink driving. Since then, DUI was recognized as a deflated felony. Among many other social repercussions of alcohol addiction and its subsequent abuse, drink driving is considered as a main detrimental consequence. In US and many European countries, DUI is considered to be a major social problem (Questia, 2014).

Upon evaluating many harmful outcomes of drunk driving, NHTSA in 1970 started to sponsor many research projects that endeavored to decline the rate of drunk driving. Later, a wide-ranged strategic program on reducing DUI was launched that was named as Alcohol safety Action Plan (ASAP). This program intended to significantly reduce the cases of drink driving across the USA through robust initiatives like Addicts-Rehab programs, improvement of levels of enforcement on DUI and enhancing awareness among drivers. NHTSA has reported that crashes related to drink-driving cost $37 billion annually. There is more male percentage of drivers as compared to female that exhibit risk-taking while DUI (NHTSA, 2009).

In the arena of traffic safety, DUI is considered as a significant risk factor causing severe or fatal injuries. The risk of fatal and non-fatal injuries is aggravated to almost 78 times higher upon the rise of Blood alcohol limit (BAC) to 0.12 % or higher (Moller and Mette, 2015). After speed, drink driving or driving under the influence (DUI) of drugs (also referred as driving while influenced, DWI) is observed to be the major cause of injuries and subsequent fatalities. A normal blood alcohol concentration (BAC) of 0.05 g/dl is found to be an endurable limit for adult drivers. On the contrary, young and adolescent drivers, when under influence of alcohol or drugs are at more risk of road traffic crashes compared to adult and more experienced drivers. Hence, making it indispensable for the authorities involved to enforce a lower BAC limit of 0.02 g/dl for young and adolescent drivers to minimize traffic crashes involving youngsters (WHO, 2015).

Only 34 countries covering a population of 2.1 billion people were noticed to have strict laws on driving under influence. It has been reported by WHO that among other key factors causing RTCs, drink driving is a major factor (WHO, 2013). Across the globe, almost 30-40 % of on-road fatalities are caused owing to drink driving. Blincoe et al. (2002) showed that almost 10,322 fatalities occurred in US in 2000 where the cause of death came out to be DUI. Similarly, Room et al. (2005) reported that globally, drink driving contributes to 20 % of the total RTCs.

It has been highlighted in many past studies that drink driving effects on young and novice drivers are comparatively greater than adult drivers. The issue is aggravated even more at night time and on weekends respectively. Peck et al. (2008) revealed that upon studying a wide group of drunk drivers who underwent RTCs, majority were found to be young drivers aged 21 or less who showed positive BAC. Several studies have endeavored to develop a relationship between drink driving and risk of crash involvement. Young drivers with drinking habits while driving were observed to be a major factor of occurrence of RTCs. Moreover, these drivers inhibited repetition of drink driving offenses (Ferrante et al., 2001). A national drug strategy household survey (NDSHS) conducted in 2010 highlighted that in Australia 2.2 % of drivers aged at least 14 years have travelled while intoxicated or under the influence of drugs. The respective proportions of young drunk drivers were recorded to be 3.3 % in 2004 and 2.9 % in 2007. The percentage of young drunk drivers resembles greatly to that of United States. A survey conducted in US showed that 4.2 % of drivers aged between 12 to 17 years exhibited use of drugs and intoxication (NSDUH, 2011).

In the context of Pakistan, it is observed that there exists a relatively low percentage of drivers who drive under influenced of alcohol. However, use of drugs is a common practice in Pakistan, mostly among the drivers that operate commercial transport (Kayani et al., 2010). In Pakistan, it is observed that every 1 in 27 adults is dependent on drugs (United Nations Office on Drugs and Crime, 2013). According to Anti- Narcotics Department in Pakistan, the use of heroin in Pakistan raised from 7.5 % in 1983 to 51% in 1993 and 77 % in 2006 respectively that is shockingly alarming (Kayani et al., 2010). Data on drug consumption has highlighted that the drug use among professional drivers has drastically increased in the recent years, making drug use a major public health issue among professional drivers (Mir et al., 2012). A wide range of illicit drugs are observed to be used habitually among bus, truck and taxi drivers.

Mir et al. (2012) highlighted the use of alcohol and marijuana among professional drivers in Islamabad and Rawalpindi. A survey of 857 professional drivers, who drove bus and trucks was conducted from major commercial bus stations. From the survey, it was revealed that 10 % of truck drivers reported causal use of alcohol. Similarly, on observation it was noted that the use of alcohol among truck drivers was more than that of bus drivers. However, the use of marijuana was reportedly 23 % in the sample. A higher proportion of marijuana use was found in truck drivers (30%) as compared to bus drivers (14.7 %). Whereas, a combined use of alcohol and marijuana was reported to be sufficiently low among sample's population (4.6 %). Among various type of addictions, stimulant pills were also reported among drivers. Almost 8 % of professional drivers exhibited the use of stimulant pills to overcome fatigue and exhaustion while travelling on lengthy trips. Upon studying self-reported crash history, it was observed that drivers who underwent traffic crashes in the last 5 years had a higher rate of drug use (30 %) as compared to the drivers that didn't undergo traffic crashes (22 %).

2.4 Major Conclusions from Literature Review

Based on the review of the selected case histories related to key crash risk factors, major conclusions and knowledge gaps identified are as under:

- Limited studies on analysis of key crash risk factors for Pakistan.
- Past research has merely relied on descriptive statistics (% use of seatbelt or helmet etc. in different areas of Pakistan).

- Lack of an effective data management system for key crash risk factors in Pakistan.
- Lack of driver's behavioral studies to explore driver's risk perception and driving behavior.
- Advanced statistical procedures have not been utilized to investigate the factors effecting compliance of seatbelt and helmet laws.

Chapter 3

DATA COLLECTION AND COLLATION

3.1 Introduction

As per WHO, the key risk factors of road traffic crashes are speed, helmet, seatbelt, child restraint and driving under influence (WHO, 2013) .This section describes the collection of data on legislation and level of compliance of key risk factors. For collecting data on legislation, Motor Vehicle ordinance 1965 is reviewed however, for evaluating level of compliance of key crash risk factors, a comprehensive self-reported survey is carried out from random places in Islamabad to ensure unbiased results. The survey aims at identifying the key crash risk factors and take into account several responses of road users as to how they comprehend the essentiality of following the laws on these key risk factors. However, for those respondents who reportedly disobey the laws on traffic safety, the reasons behind defiance to laws on key crash risk factors are also enquired. Present study has helped to uncover many demographic factors i.e. age, gender, marital status, level of education, income etc., that predominantly effect the level of compliance of key crash risk factors. Later, the data collected on key crash risk factors is statistically analyzed and a statistical model is estimated to deliver an apt statistical understanding.

3.2 Plan of Study

The study is undertaken by collection of data on current state of legislation and level of compliance of key risk factors. In order to collect data on legislation on key crash risk factors, Motor vehicle ordinance 1965 is evaluated. However, Islamabad Traffic police is consulted to investigate the penalties and offences regarding defiance to key crash risk factors. Later, the level of compliance of key crash risk factors is evaluated by conducting questionnaire survey in order to find the reasons that cause non-compliance to key crash risk factors. Surveys are improved by dispensing pilot surveys in order to test the appropriateness and relevance of questionnaires. Afterwards, a final survey is designed and responses are documented.

In order to ensure unbiasedness in surveys, responses are taken from several places i.e. fuel stations, restaurants, universities, public transport stations, markets, shopping malls and offices with the intention to cover the maximum variation of demographic aspects of the respondents so that best representation of population is made possible. To know the rate of speed violations on existing roads of Islamabad, spot speed studies were conducted on major and minor arterials through speed gun and frequencies of violating speed limits were monitored. Similarly, to evaluate the level compliance of laws on DUI, detailed interviews were conducted from traffic wardens so as to know the percentage of drivers that were held for driving under influence and what type of drugs are consumed by the drivers. The research culminates by partaking a technical overview of the data collected on key risk factors through statistical evaluation and model estimation.

3.3 Data Collection and Collation

Data on key risk factors were extracted through different channels. Primarily, data is collected to find the legislation on each key risk factor i.e. speed, seatbelt, helmet, child restraint and DUI. Once the legislation on key risk factors was known, compliance of key risk factors is evaluated by conducting self-respondent questionnaire survey, detailed interviews and speed monitoring. Questionnaire surveys were designed to incorporate several demographic factors i.e. gender, age, education level, income level and driving experience etc. Through conducted surveys, a general public perception is obtained that helped to explore the factors that are responsible for the defiance of laws on key risk factors. Similarly, interviews from traffic wardens were also conducted in order to record their responses regarding difficulties or hindrances that shun proper enforcement on key risk factors.

3.3.1 Speed Legislation and Compliance

Data were collected from various sources to investigate the legislation and level of compliance of speed laws. In order to evaluate the current legislation on speed, Islamabad Traffic Police (ITP) and National Highway and Motorway Police

(NHMP) were consulted that helped to acquire adequate data on current speed legislation in Pakistan. It was revealed that both of these enforcing agencies follow Motor Vehicle Ordinance 1965 with few recent amendments made in 2013. However, to obtain an apt understanding of the level of compliance of speed, two separate procedures were undertaken.

At the outset, a questionnaire survey regarding speed was conducted from random spots in Islamabad to ensure unbiased results. The survey was conducted from 8th August to 22nd August in 2016, from Monday to Saturday in two different three hours shifts (10:00 to 13:00 and 14:00 to 17:00). The conducted survey recorded respondents' characteristics such as gender, age, level of education, income, awareness of posted speed limits, past crash history, penalization record for over speeding and maximum level of speed preferred by respondents in case of over speeding.

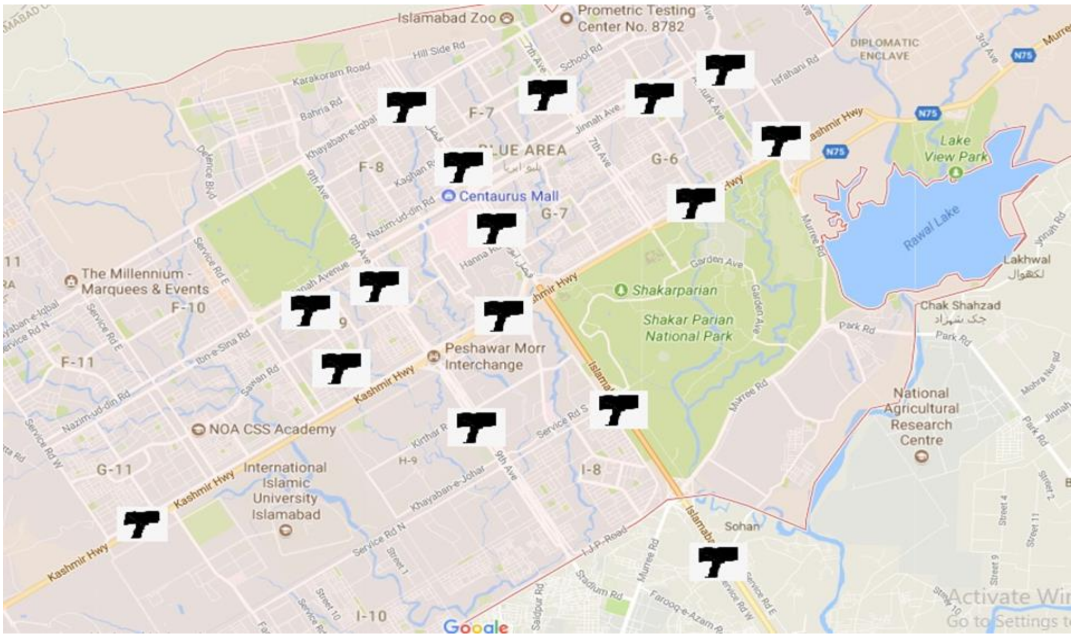

Figure 2: Speed Data Collection Locations

Afterwards, speed monitoring of 10,417 vehicles was performed by selecting 16 roads. These roads were divided into different classes on the basis of their function (Major arterials, Minor arterials and Collector streets). A hand-held Doppler radar unit with an accuracy of +/- 1 mph was used in the study that uses digital speed processing for accurate recording of speed of approaching and retreating vehicles. Moreover, the radar used in the study had a continuous mode of recording speeds of vehicles and showed the fastest speed when the trigger was released. In case of high flow of traffic where platoons were formed, only the first vehicle leading the platoon was monitored through speed gun because the vehicles following the platoon leader tend to move with less speed that causes inaccuracy in the study (Roess et al. 2004).

Table 3.1: Description of Locations andTotal Counts for Speed Study

Sr. No	Roads	Speed Limit (Km/hr)		Total Counts
		HTV	LTV	
1	Kashmir Highway Location 1	80	65	691
2	Kashmir Highway Location 2	80	65	631
3	Kashmir Highway Location 3	80	65	579
4	Kashmir Highway Location 4	80	65	819
5	Islamabad Highway Location 1	80	65	744
6	Islamabad Highway Location 2	80	65	549
7	Faisal Avenue Location 1	70	60	580
8	Faisal Avenue Location 2	70	60	683
9	9th Avenue Location 1	70	60	586
10	9th Avenue Location 2	70	60	590
11	Jinnah Avenue	70	60	701
12	Margalla Eve	70	60	702
13	7th Avenue	70	60	774
14	Rohtas Road	50	50	438
15	Mangla Road	40	40	747
16	AK Fazlul Haq Road	50	50	603
			Total	10,417

3.3.2 Seatbelt Legislation and Compliance

To collect the data on legislation of seatbelt use, Islamabad Traffic Police (ITP) and National Highway and Motorway Police (NHMP) were consulted. It was revealed that enforcing agencies follow Motor Vehicle Ordinance 1965 to regulate laws on seatbelt use. A penalty table was provided by the concerned authorities of ITP that mentioned the penalties and fines imposed on drivers in case of seatbelt violation. However, the level of compliance of seatbelt use in Islamabad was investigated by conducting a self-respondent survey from motor vehicle users. Before collecting the actual survey, a preliminary small scale pilot survey was conducted to check the appropriateness of questions for the target population and for the survey to be easily responsive (Brandendburg et al. 2002). Afterwards, a full scale survey with a sample size of N=476 was conducted from 8th August to 22nd

August in 2016, from Monday to Saturday in two different three hour shifts (10:00 to 13:00 and 14:00 to 17:00).

Self-respondent survey was preferred over an online survey in order to get a good response rate and prevent biasedness in sampling. For this purpose random places such as educational institutes, markets, bus stands and parking spaces of shopping malls and recreational areas were selected which helped to include variety of respondents having different socioeconomic factors such as respondent's age, level of education, income and marital status The purpose of self-respondent survey in this study was to explore the factors that cause compliance or defiance of seatbelt use, thus questions related to drivers' past crash history, penalization history and self-perception on the use of seatbelt were also asked.

Moreover, the survey also included questions that asked the respondents to rate the level of enforcement of seatbelt use in Islamabad. These questions were intended to document a general opinion of the respondents that how much effective they believe the enforcing agencies are to implement the laws on seatbelt use. Similarly, it was also enquired from the respondents that whether they would like the seatbelt law to continue in Islamabad or not. Furthermore, to investigate the behavior of commercial drivers to comply with the rules on seatbelt usage, types of vehicles was documented in the survey. Moreover, it was also documented that what percentage of drivers had seatbelt auto alarms installed in their vehicles.

3.3.3 Helmet Legislation and Compliance

In order to examine the legislation on helmet use, data were collected from Islamabad Traffic Police (ITP) and National Highway and Motorway Police (NHMP) in a similar manner as conducted for seatbelt use. The consulted authorities identified that they follow Motor Vehicle Ordinance 1965 which distinctly postulates laws on helmet use. However, for investigating the level of compliance of helmet use, a self-respondent survey with a sample size of N=363 was conducted from 22nd August to 29th August in 2016, from Monday to Saturday in two different three hour shifts (10:00 to 13:00 and 14:00 to 17:00). The survey included variety of riders having different characteristics like gender and age, availability of driving license, past crash history where helmet saved the rider, rider's behavior and personal opinion on the significance of helmet usage, record of past fines for violating laws on helmet use and problems faced by riders due to wearing helmet like uncomfortableness and heat, reduced night vision and reduction in hearing abilities.

The reason of documenting self-reported past crash history was to explore whether there existed any relationship between crash history and helmet use since the past findings have indicated a high compliance of helmet use among riders that were involved in a crash where helmet saved them (Keng, 2005; Van et al. 1998; Skalkidou et al. 1999). Moreover, the survey also included questions that asked the respondents to rate the level of enforcement of helmet use in Islamabad. These questions were intended to document a general opinion of the respondents that how much effective they believe the enforcing agencies are to implement the laws on helmet use. Besides documenting the use of helmet among riders, it was also investigated that what percentage of passengers accompanying the riders were using helmet.

3.3.4 Driving Under Influence Legislation and Compliance

In recognition of the fact that driving under the influence of drugs or alcohol impairs driving abilities and enhances the risk of crash involvement, an investigation of the laws governing driving under influence of drugs or alcohol was conducted. For this purpose, Motor Vehicle Ordinance 1965 was assessed which clearly mentions laws on driving under influence. However, to examine the level of compliance of laws on driving under influence, a comprehensive interview was conducted from traffic wardens of Islamabad Traffic Police (ITP). In the interviews, traffic wardens were enquired about the different types of drugs that they have observed so far among drivers and whether there is a high percentage of drug consumption among commercial drivers or non-commercial drivers. It was also enquired that in their opinion what percentage of drivers drive while intoxicated and how frequently they observe drivers to be under influence of drugs or alcohol. The interview also included questions that asked the officers whether there are any alcohol or drug testing equipment such as Alcohol Breathalyzer or Pot Breathalyzer with ITP that can investigate a possible case of driving under influence.

Keeping in view the international practices of monitoring drug use among drivers, the officers of ITP were also enquired that whether they have any drug evaluation and classification program (DEC) under which trained and certified drug recognition expert (DRE) officers could inspect the cases of driving under influence. In addition, to check the availability of any psychological observational program, the officers were also enquired about the existence of any psychological investigation technique for evaluating intoxicated drivers such as “walk and turn test”, “one leg stand test” an “finger to nose test”. After asking questions related to monitoring of drug use among drivers, officers were individually asked to state the penalty for driving under influence. They were asked whether they have reported any cases to the police’s crime control department or not.

The interview from traffic wardens also included questions that enquired the age of the drivers that are mostly involved in drug or alcohol consumption and the time of the day when most cases of driving under influence are observed. Similarly, it was also enquired that whether ITP has any rehabilitation countermeasures for drivers who are held for DUI. However, to know the rate of crashes among influence drivers, the officers were asked to report the number of drug or alcohol impaired driving crashes that they have witnessed so far. In the last, the opinion of traffic wardens was documented on the measures that ITP shall take to decrease the cases of driving under influence of drugs or alcohol.

3.3.5 Child Restraint Legislation and Compliance

Child restraint or Child restraining system (CRS) are exclusively designed seats that are predominantly used to prevent children of minor ages to sustain injuries or fatalities during a motor vehicle crash. Use of child restraint helps to reduce fatalities due to high impact crashes to almost 90 % among newborns. In addition, it is advisable to carry children in rear seats than in front seats (WHO, 2015). In Present study, legislation on child restraint in Pakistan was investigated. For this purpose, officials of Islamabad Traffic Police (ITP) were consulted and the laws on child restraint were investigated. Upon investigation, it was observed that on national or regional level, there are absolutely no laws that could address the need of child restraint in Pakistan.

However, to determine the current trends on child safety seat usage in Islamabad, a self-respondent observational survey with a sample size of N=476 was conducted. The survey enquired the percentage of drivers that allowed minors to sit in front seats and percentage of children found sitting in front seats during the observational survey. If a child was found in front seat, it was observed that whether he/she was properly secured in child restraint or not. Furthermore, it was also investigated that what percentage of the respondents were aware of the significance of child restraint.

Chapter 4

LEGISLATION AND LEVEL OF COMPLIANCE OF KEY CRASH RISK FACTORS

4.1 Introduction

World Health Organization has identified that speed, seatbelt, helmet, child restraint and driving under influence are the key risk factors for crashes worldwide (WHO, 2015). Present study is carried out to investigate legislation on key crash risk factors and their level of compliance in Islamabad. For this purpose, data is collected from different sources on legislation and level of compliance of key crash risk factors and is presented in this chapter.

4.2 Legislation on Key Risk Factors

4.2.1 Legislation on Speed

All provinces of Pakistan hold departments of traffic regulation and control. For example, national, regional, city and district traffic police and traffic control units. These departments are responsible to enforce legislation on key crash risk factors. The task of traffic police at district, city and regional levels is to ensure the compliance of motor vehicle ordinance of 1965. However, the penalties conferred to traffic violations in the ordinance are amended with the passage of time.

For Islamabad, traffic on a large number of roads are monitored and controlled by Islamabad Traffic Police (ITP). However, National Highway and Motorway Police covers some portions of the capital. The violations for both policing authorities stand the same, however, NHMP imposes a higher amount of penalty and imprisonment in some cases. Both of these policing authorities follow Motor Vehicle Ordinance 1965 to address laws on traffic violations and import charges or penalties accordingly. Laws on speed are comprehensively addressed in chapter VII and VIII of MOV 1965. Section 75 of MVO 1965 states that; *"No person shall drive* *a motor vehicle in a public place at a speed exceeding the maximum speed limit fixed by or under this ordinance or under any other law for the time being in force. The speed of motor vehicles shall be restricted to ensure convenience and public safety or because of the nature of any road or bridge. The posted speed shall be fixed to a limit that is fit for a motor vehicle or for motor vehicles to which a trailer is attached or on a particular road or roads, and where any such restrictions are imposed. "* (MVO-GOP, 1965).

Section 98 of MVO, 1965 states that*; "Whoever drives a motor vehicle in contravention of section 75 shall be punished with a fine which may extend to two hundred rupees, and when the vehicle is a transport vehicle, with a fine which may extend to five hundred rupees." (MVO-GOP, 1965).* However, for driving recklessly or dangerously, section 99 of MVO, 1965 addresses that*; "Whoever drives a motor vehicle at a speed or in a manner which is dangerous to human life or property having regard to all the circumstances of the case, including the nature, condition and use of the place where the vehicle is driven and the amount of traffic which actually is at the time or which might reasonably be expected to be in the place, shall be punished with imprisonment of either description for a term which may extend to six months, or with fine which may extend to five hundred rupees, and if the vehicle be a transport vehicle, with imprisonment which may extend to one year and with a fine which may extend to one thousand rupees."* (MVO-GOP, 1965).

A well-defined legislation is addressed for cases where drivers are involved in illegal racing or trials of speeds. Section 103 of MVO 1965 asserts that; *"Whoever, without the written consent of Government, permits or takes part in a race or trial of speed between motor vehicles in any public place shall be punished with imprisonment for a term which may extend to six months, or with fine which may extend to one thousand rupees, or with both."*

A penalty table issued by National Highway and Motorway Police (NHMP) sets a fine of Rs. 1000-2000 and imprisonment up to 1 month for cases where drivers are involved in unauthorized race or trial of speed. Similarly, driving at speed 40 km/h higher than posted speed limit is punishable by a fine of Rs. 750-1500 and imprisonment up to 1 month (Table 4.1). However, for exceeding speed limits by less than 40 km/hr, a fine of Rs. 750 is imposed with no imprisonment (Table 4.1). Islamabad Traffic Police (ITP) on 13th September 2013 has also issued a penalty table [(Schedule XII, PCPPI-SSP (HQ)] that addresses 71 violations among which 23 are directly or indirectly related to key crash risk factors (Table 4.2). The fines imposed in cases of traffic violations are relatively low as compared to the fines of NHMP. For instance, in case of speed violation, a fine of Rs. 200 is imposed. Similarly, reckless and negligent driving is punishable by a fine of Rs. 500 (Table 4.2).

After analyzing the legislation on speed, it is found that there exist no measures in the ordinance that could disqualify or suspend driving license in cases when a driver commits a serious speeding offence as compared to those cases when a driver commits a minor speeding offence. A serious speeding violation is generally defined as breaking the posted speed limit by over 40 mph for which the driver shall be banned to drive for 7 to 56 days depending on the facts of the case. Similarly, the legislation doesn’t discuss any Penalty Points and Disqualification System (PPDS) practiced in many developed countries such as the UK and USA which gives penalty points to drivers in case of speed violation that range from 3 to 11 and determines whether a violator is obligatory disqualified or discretionary disqualified.

Table 4.1: Penalty table issued by NHMP related to key crash risk factors

Violations	Penalty	Imprisonment
Willful disobedience or obstruction of lawful orders.	Rs. 1000-2000	Up to 6 months
Taking part in unauthorized race or trial of speed.	Rs. 1000-2000	Up to 1 month
Driving at speed 40 km/hr. higher then specified.	Rs. 750-1500	Up to 1 month
Driving when mentally or physically unfit to drive or under influence of drug or alcohol	Rs. 5,000-10,000	Up to 1 month
Driving Recklessly	Rs. 500-1000	Up to 1 month
Exceeding speed limits by less than 40 km/h	Rs. 750	No imprisonment
Committing violation subsequently	Rs. 1000	No imprisonment

4.2.2 Legislation on Seatbelt

Section 89-B of the Motor Vehicle Ordinance 1965 addresses the laws on seatbelt use. According to the legislation, it is necessary for the drivers of all types of motor vehicles (except few where seatbelt law doesn’t apply) to fasten seatbelts. As quoted in chapter VII on control of traffic, few important subsections on seatbelt are instructed as; *" (1) A person who is driving a motor car, motor cab, light transport vehicle or a heavy transport vehicle on a notified road shall fasten a seatbelt. (2) The provision of sub-section (1) shall not apply if– (a) the person who is driving has a medical exemption certificate issued by a qualified medical practitioner; (b) no seatbelt is fitted in the vehicle by the manufacturer; (c) the vehicle is a two or three wheel vehicle or a delivery van, an emergency vehicle, or a goods vehicle; or (d) the person driving the vehicle is performing a reverse maneuver; (3) The Government may exempt a class of vehicles, a vehicle, a person or a class of persons from the application of this provision and may charge a prescribe amount of fee for the exemption. (4) The Government shall notify roads for the purposes of this section."*

Upon analyzing current legislation on seatbelt use in Pakistan, it is found that for cases where no seatbelt is fitted in the vehicle by the manufacturer, drivers are not obligated to wear seatbelts. Thus there must be an amendment in the legislation that could address manufacturers to necessarily install seatbelts in all types of vehicles. It is also revealed from assessing the penalty table (Table 4.2) issued by ITP that a fine of Rs. 300 is imposed in cases of seatbelt violations which appears to be substantially low. In order to discourage seatbelt violation among drivers, the government should impose heavy fines.

4.2.3 Legislation on Helmet

Motorcycles are mostly preferred by a large percentage of individuals owing to its capacity of travelling at high speeds but it extends a reduced level of protection to the occupants and partake a higher risk of crash involvement as compared to other vehicles. Consequently, making it the most hazardous vehicle on roads. Section 89-A of MVO, 1965 states that: *"No person shall drive, or ride the pillion seat of, a two-wheeled motor vehicle except when he is wearing a crash helmet."* (MVO-GOP, 1965). Similarly, NHMP has identified in its penalty list under offence code B-43 that the penalty of driving a motorcycle without safety helmet is a fine of Rs. 200.

Table 4.2: Penalty table issued by ITP related to key risk factors

S.No	Violations	Penalty
1	Exceeding prescribed speed limit	Rs. 200
2	Violation of Manual Traffic Signals	Rs. 200
3	Following too closely or cutting too sharply	Rs. 200
4	Jumping traffic queue	Rs. 100
5	Failure to observe stop sign	Rs. 100
6	Riding Motorcycle without safety helmets	Rs. 100
7	Reckless and negligent driving	Rs. 500
8	Disobeying traffic signals	
	(i) Amber flashing	Rs. 100
	(ii) Red thinking	Rs. 200
	(iii) Red light	Rs. 500
9	Careless driving	Rs. 200
10	Driving without driving license	Rs. 500
11	Driving an unregistered vehicle	Rs. 200
12	Driving a transport vehicle without or with a defective speedometer	Rs. 200
13	Failing to stop when required by traffic police	Rs. 300
14	Driving in violation of law or rules not otherwise provided	Rs. 300
15	Driving any vehicle without fastening seat belt by the driver and front seat passenger	Rs. 300
16	Using hand-held mobile phone while driving for voice calls, text message or videoing	Rs. 300
17	Repeating the same violation	Rs. 500
18	Encouraging someone for above violations	Rs. 500
19	Driving when disqualified	Rs. 500
20	Taking part in unauthorized race or trial of speed	Rs. 500
21	Driving when mentally or physically unfit to drive	Rs. 500
22	Driving Under the influence of drugs or alcohol	Rs. 500
23	Repeating to drive under the influence of drugs	Rs. 500

23 out of 71 violations related to key risk factors from Schedule XII, PCPPI-SSP (HQ) — 13-9-2013, ITP

Upon observation of the legislation of helmet use in Pakistan, it was observed that the government hasn’t yet devise any standards to maintain the quality of the helmets used in Pakistan. There are no regulations that could make sure that the helmet used by the riders comply with a safety standard that prescribe rigorous testing. Such standards are adopted to ensure that helmets available in the markets are strong enough to avoid head injuries in cases of crash involvement. More than 50 countries worldwide follow a “UN Regulation No. 22” – also known as ECE-22 which regulates the production and testing of an effective motorcycle crash helmet. In a similar manner, the government should also endorse and adopt such standard so that the crash helmets produced by the manufacturers in Pakistan are safe and effective.

4.2.4 Legislation on Child Restraint

Upon consultation from ITP and NHMP, it was uncovered that in Pakistan, there are absolutely no laws that could address the obligation of the use of child restraint among children of minor ages. The government should introduce new laws to encourage the drivers to use child restraint for children aged less than 12 years. Similarly, it must be ensured that children are not permitted to sit in front seat. Violation of the child restraint law should be declared as a standard offense and must be punished by heavy fines. However, for children with disabilities and medical conditions, disabled person's seatbelt or child restraint designed for their needs must be used. The legislation should include the use of car seat, booster seat or seatbelt according to the age, height and weight of the passenger children. The following pattern should be followed to ensure the use of CRS among children.

- Birth up to age 2 years– For infants and children of minor ages, rear-facing car seats should be used. It must be made sure that the car seats are placed in the back seat of the car.
- 2-5 years age – For children aged 2-5 years, forward-facing car seat should be used. The use of forward-facing car seat is advisable when the children outgrow their rear-facing seats due to increase in weight and height.
- Age 5 years up until that age when seatbelt fits properly – For children aged 5 years or more, booster seats should be used. The use of booster seat is advisable when children outgrow their forward-facing car seats by reaching the upper height or weight limit of forward facing car seat. Booster seat shall be used among children until the time when the lap belt lays across upper thighs and the shoulder belt lays across the chest. It must be ensured that the boosters are properly buckled up in the back seat to ensure safety.
- Once seat belt fits properly without a booster seat – There is no need to use booster seats among children once seat belt fits them properly. For better protection, children must be buckled up in the back seat.

4.2.5 Legislation on Driving Under Influence

Section 100 of Motor Vehicle Ordinance 1965 addresses the laws on driving under influence of drugs or alcohol. The section states that: *"Whoever while driving or attempting to drive a motor vehicle is under the influence of drink or a drug to such an extent as to be incapable of exercising proper control over the vehicle, shall be punishable with imprisonment for a term which may extend to six months, or with fine which may extend to one thousand rupees, or with both, and if having been previously convicted of such an offence, shall again be guilty of an offence punishable under this section, shall be subject for every such subsequent offence to imprisonment of either description for a term which may extend to two years, or with fine which may extend to one thousand rupees, or with both."* Moreover, NHMP has imposed a heavy fine of Rs. 5,000-10,000 and imprisonment up to 1 month for drivers who are caught under the influence of drugs (Table 4.1). The laws on driving under influence of drugs and alcohol are suitable if enforced effectively.

4.3 Level of Compliance of Key Crash Risk Factors

4.3.1 Level of Compliance of Speed

Level of compliance of laws on speed was investigated by undergoing two procedures. At the outset, speed monitoring of 10,417 vehicles was performed on major arterials, minor arterials and collector streets in Islamabad to know the percentage of vehicles that violate posted speed limits (Table 4.3, 4.6, 4.9). Afterwards, questionnaire survey regarding speed was conducted from random spots in Islamabad to ensure random sampling. The self-reported questionnaire survey investigated the percentage of drivers that were aware of the speed limits, percentage of drivers who violated speed limits and maximum speeds that the drivers travelled on if they self-reportedly admitted to violate speed limits. The sample size selected for spot-speed studies and questionnaire survey ensured a good representation of the population. A total of 476 questionnaire surveys were collected from different locations in the city and an average response rate of 75.9 % was observed.

A total of 16 roads (Table 4.4) were selected in this research for undertaking speed studies. These roads were divided into different classes on the basis of their function (major arterials, minor arterials and collector streets). A hand-held Doppler radar unit with an accuracy of +/- 1 mph was used in the study that uses digital speed processing for accurate recording of speed of approaching and retreating vehicles. Moreover, the radar used in the study had a continuous mode of recording speeds of vehicles and showed the fastest speed when the trigger was released.

In order to ensure that the selected sample is a true representation of the entire stream of traffic, a random sampling procedure was undertaken. In case of high flow of traffic where platoons were formed, only the first vehicle leading the platoon was observed through radar gun because the vehicles following the platoon leader tend to move with less speed that causes inaccuracy in the study (Roess, et al., 2004). In this study a speed group of 2 mph (3.21 km/h) range was selected, since larger speed group cause a negative effect on the overall accuracy and precision of the computations involved in speed studies. Tally sheets were used to mark the speeds of observed vehicles in the field study. The marked field sheets were then used to find the frequency distribution table that helped to find the percentages of violating vehicles.

Spot speed studies is a representation of speeding trends in a sample of vehicles selected from virtually infinite population. Thus they can never be computed with 100 % confidence and precision. Thus most common method of undergoing these studies is to take 95 % confidence interval so as to compute the sample mean as an estimator of the true mean. The determination of required sample size for a spot speed study is very useful in order to obtain those measurements that satisfy a predetermined precision and confidence level. For different values of confidence intervals, the precision of tolerance (e) is given by;

$$95\ \%: \quad e = 1.96\ E = 1.96\left(\frac{s}{\sqrt{n}}\right) \tag{1}$$

$$99.7\ \%: \quad e = 3.0\ E = 3.0\left(\frac{s}{\sqrt{n}}\right) \tag{2}$$

Table 4.3: Sample Size Computation for spot speed studies

Tolerance	**Confidence Level**	
	95 %	**99.7 %**
1.0	96	225
0.5	384	900

For most traffic engineering studies a tolerance of +/- 1.0 mph and a confidence level of 95 % are quite sufficient (Roess, et al., 2004). Thus a sample size of 384 was selected for speed studies.

$$n = \frac{3.84\ s^2}{e^2} \text{ (For 95 \% confidence Interval)} \tag{3}$$

$$n = \frac{9.0\ s^2}{e^2} \text{ (For 99.7 \% confidence Interval)} \tag{4}$$

Table 4.4: 15th and 85th Percentile Speeds Calculated from Cumulative Frequency Distribution Curves

Sr. No	**Functional Classification**	**Location**	**Percentile Speed (Km/h)**	
			15th	**85th**
1	Major Arterials	Kashmir Highway Location 1	42.0	75.3
2		Kashmir Highway Location 2	41.5	74.8
3		Kashmir Highway Location 3	51.7	74.4
4		Kashmir Highway Location 4	46.2	70.7
5		Islamabad Highway Location 1	40.7	80.6
6		Islamabad Highway Location 2	48.0	71.9
7	Minor Arterials	Faisal Avenue Location 1	41.5	72.6
8		Faisal Avenue Location 2	48.6	78.4
9		Jinnah Avenue	45.4	68.4
10		9th Avenue Location no 1	39.4	82.2
11		9 th Avenue Location no 2	46.2	76.4
12		Margalla Eve	45.9	71.1
13		7th Avenue	44.9	87.5
14	Collectors	Rohtas Road	41.4	55.0
15		Mangla Road Near	38.5	52.9
16		AK Fazlul Haq Road- Blue Area	35.7	49.4

Table 4.5: An Illustrative Frequency Distribution Table of Spot Speed Studies

Speed Group					
Lower Limit (mi/hr)	**Upper Limit (mi/hr)**	**Middle Speed S (mi/hr)**	**Observed Freq. in Group N**	**% Frequency in Group N (%)**	**Cumulative Frequency in percentage (%)**
18	20	19	0	0	0
20	22	21	6	1.4	1.4
22	24	23	21	4.8	6.2
24	26	25	26	5.9	12.1
26	28	27	35	8.0	20.1
28	30	29	113	25.8	45.9
30	32	31	132	30.1	76.0
32	34	33	52	11.9	87.9
34	36	35	26	5.9	93.8
36	38	37	1	0.2	94.1
38	40	39	5	1.1	95.2
40	42	41	3	0.7	95.9
42	44	43	7	1.6	97.5
44	46	45	7	1.6	99.1
46	48	47	4	0.9	100.0
48	50	49	0	0	100.0
50	52	50	0	0	100.0
52	54	51	0	0	100.0
54	56	52	0	0	100.0
56	58	53	0	0	100.0
58	60	54	0	0	100.0
60	62	55	0	0	100.0
62	64	56	0	0	100.0
64	66	57	0	0	100.0
		Total	438	100	100

In the present study, Pace is computed graphically using the frequency distribution curve to highlight the central tendency of the distribution of speed. The area under pace accounts for the highest percentage of vehicles (Roess, et al., 2004). Similarly, to deliver a general perception about the highest and lowest speed on a specific stream of traffic, 15th and 85th percentile speeds were computed. The study showed that for major arterials 85th percentile speed varies from 75 km/hr to 80 km/hr (Table 4.4). Moreover, for minor arterials and collectors the respective 85th percentile speeds ranged from 71-87 km/hr and 48-55 km/hr respectively (Table 4.4).

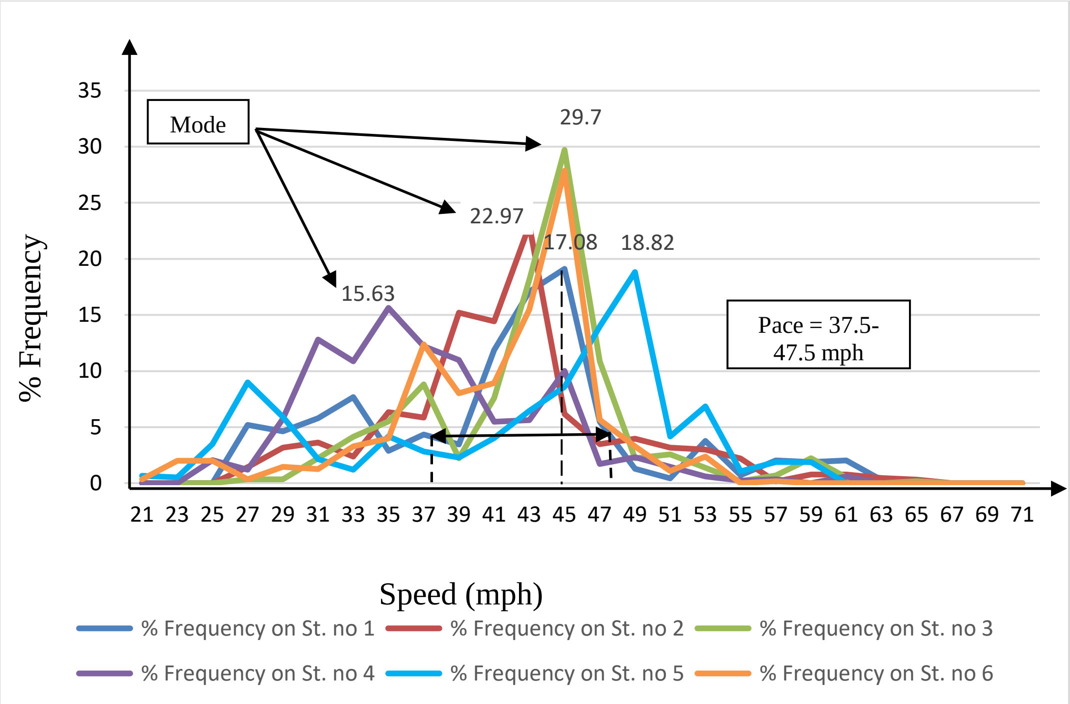

Figure 3: Frequency Distribution Curves Obtained from Spot-Speed Studies on Major Arterials

Major arterials are high-capacity urban roads whose fundamental function is to deliver traffic from minor arterials to freeways and between urban centers at high levels of service. A total of 6 major arterials were chosen in Islamabad and spot speed studies were performed by using Doppler radar gun. Speeds of approximately 3,135 vehicles (Table 4.6, Table 4.9, and Table 4.10) were observed through radar gun and separate counts were taken for passenger cars, SUVs, trucks/wagons and motorcycles. The maximum number of vehicles on major arterials were found to be travelling at a speed of approximately 72 km/hr with highest percent frequency of 29.7 % (Table 4.7).

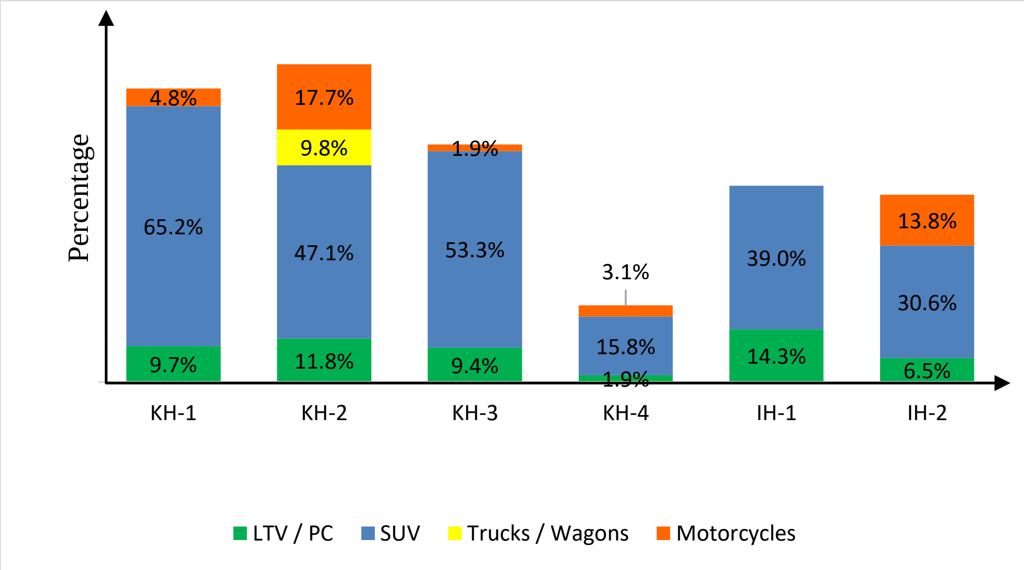

Figure 4: Speed Violation by Different Vehicular Classes on Major Arterials

Table 4.6: Vehicular Counts on Major Arterials

Roads	**Speed Limit (Kph)**		**Total Counts**			
	LTV	**HTV**	**PC**	**SUV**	**Trucks**	**Motorcycles**
Kashmir Highway Location 1	80	65	484	46	80	84
Kashmir Highway Location 2	80	65	509	17	41	62
Kashmir Highway Location 3	80	65	481	30	44	54
Kashmir Highway Location 4	80	65	574	101	43	98
Islamabad Highway Location 1	80	65	497	100	21	126
Islamabad Highway Location 2	80	65	417	36	30	65

Table 4.7: Speed Violations by Vehicular Classes on Major Arterials

Roads (Major Arterials)	**% of violation by Vehicle Type**			
	PC	**SUV**	**Trucks**	**Motorcycles**
Kashmir Highway Location 1	9.7	65.2	0.0	4.8
Kashmir Highway Location 2	11.8	47.1	9.8	17.7
Kashmir Highway Location 3	9.4	53.3	0.0	1.9
Kashmir Highway Location 4	1.9	15.8	0.0	3.1
Islamabad Highway Location 1	14.3	39.0	0.0	0.0
Islamabad Highway Location 2	6.5	30.6	0.0	13.8

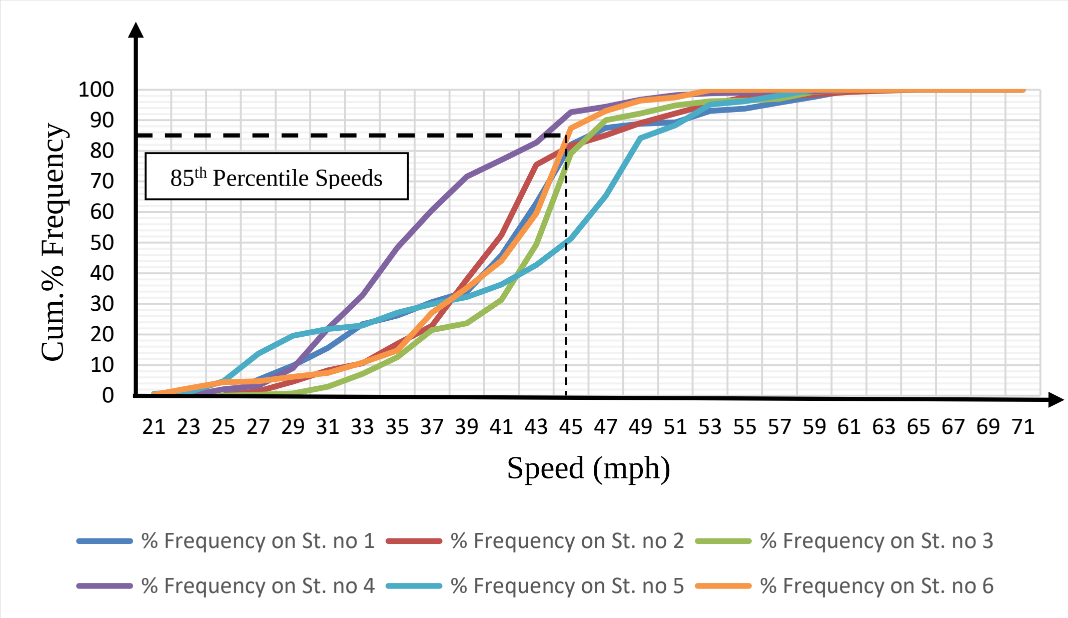

Figure 5: Cumulative Frequency Curves for Major Arterials

Table 4.8: Overall Percentage Violation of All Vehicles on Major Arterials

Roads (Major Arterials)	Overall Percentage Violation of All Vehicles
Kashmir Highway Location 1	11.67
Kashmir Highway Location 2	13.20
Kashmir Highway Location 3	10.18
Kashmir Highway Location 4	3.68
Islamabad Highway Location 1	14.78
Islamabad Highway Location 2	8.58

Minor arterials are low quality roads in comparison to major arterials. They provide service for trips involving moderate lengths unlike major arterials. However, these roads offer a higher level of connectivity to the arterial system. For an urban area, minor arterials help to connect major arterials with collectors (FHWA, 2013). In this study 4 minor arterial were selected i.e. Faisal Avenue, Jinnah Avenue, 9th Avenue and Magalia Eve and on these roads spot speed studies were performed on 7 stations.

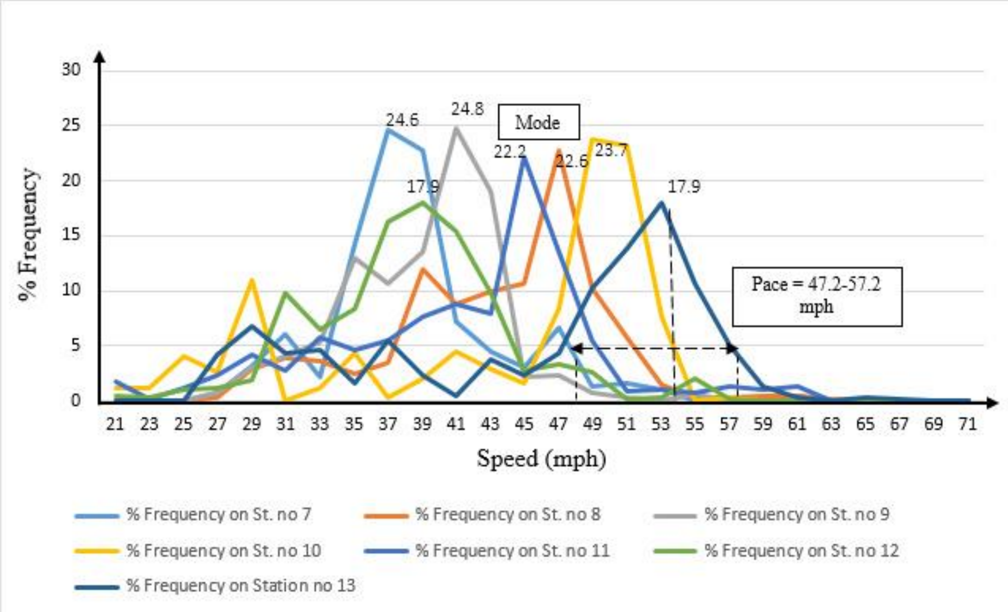

Figure 6: Frequency Distribution Curves for Minor Arterials

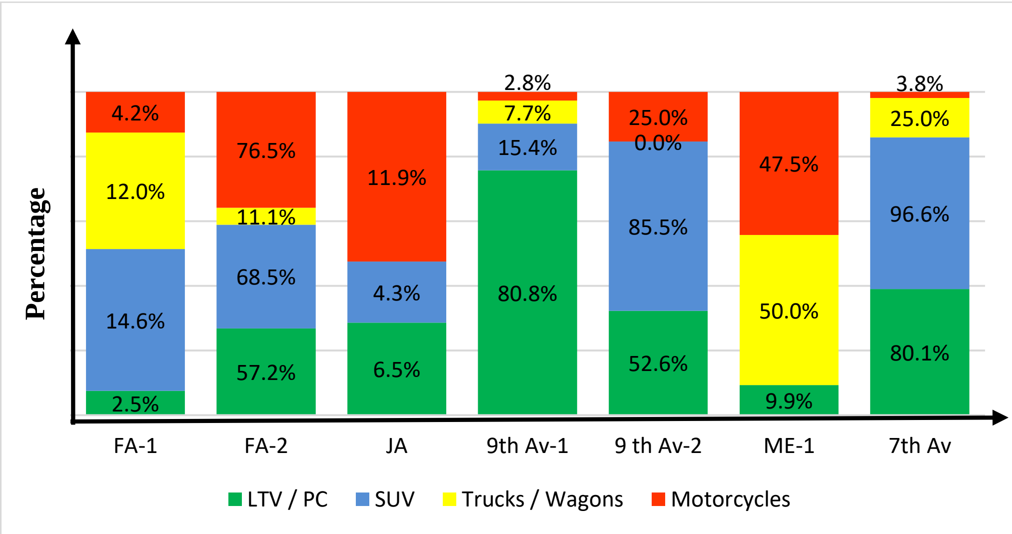

Figure 7: Speed Violation by Vehicular Classes on Major Arterials

A highest percentage in volition of speed limits was observed on 9th Avenue towards IJP road which showed 65.47 % of speed violation (Table 4.10). Similarly, it was found that among the mix of vehicles, SUVs were travelling at higher speeds and accounted for 85.45 % violation of speed limits on 9th Avenue towards Pakistan Secretariat (Figure 5).

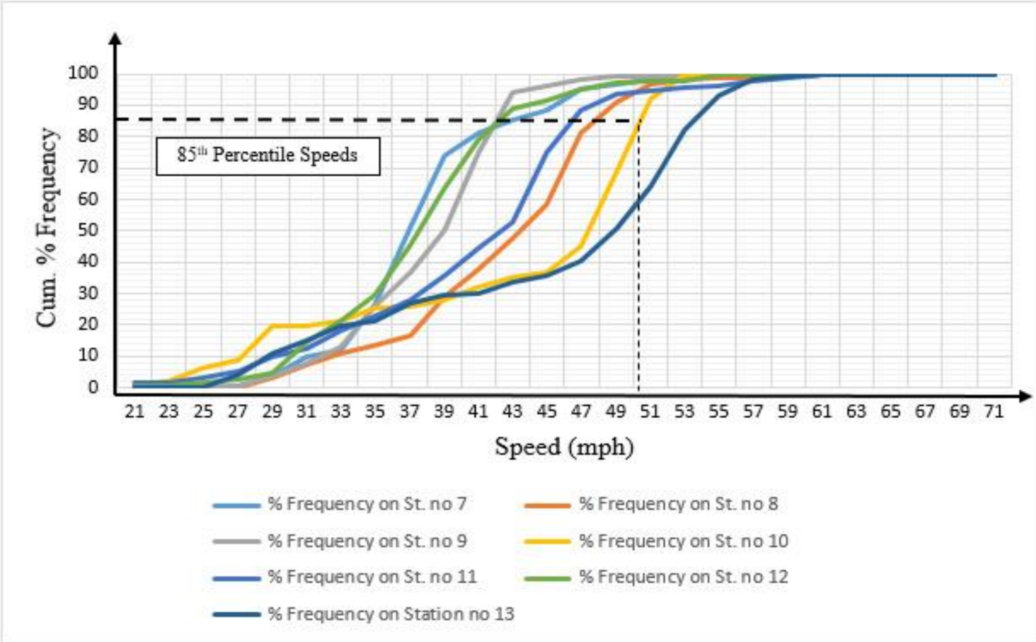

Figure 8: Cumulative Frequency Distribution Curves for Minor Arterials

Table 4.9: Vehicular Counts on Minor Arterials

Roads	Speed Limit (Kph)		Total Counts			
	LTV	HTV	PC	SUV	Trucks/Wagons	Motorcycles
Faisal Avenue Location 1	70	60	484	48	25	24
Faisal Avenue Location 2	70	60	552	54	27	51
Jinnah Avenue	70	60	507	70	56	67
9th Avenue Location 1	70	60	458	65	26	36
9th Avenue Location 2	70	60	445	55	27	64
Margalla Eve	70	60	574	49	16	61
7th Avenue	70	60	602	29	12	131

Table 4.10: Speed Violations on Minor Arterials

Roads (Minor Arterials)	No Of Vehicles Violating Speed Limit				% of violation by Vehicle Type			
	PC	SUV	Truck	Bike	PC	SUV	Truck	Bike
Faisal Avenue Location 1	12	7	3	1	2.0	14.6	12.0	4.2
Faisal Avenue Location 2	316	37	3	39	57.2	68.5	11.1	76.5
Jinnah Avenue	33	3	0	8	6.5	4.3	0.0	11.9
9th Avenue Location 1	370	10	2	1	80.8	15.4	7.7	2.8
9th Avenue Location 2	234	47	0	16	52.6	85.5	0.0	25.0
Margalla Eve	57	0	8	29	9.9	0.0	50.0	47.5
7th Avenue	482	28	3	5	80.1	96.6	25.0	3.8

Table 4.11: Overall Percentage Violation of All Vehicles on Minor Arterials

Roads (Minor Arterials)	Overall Percentage Violation of All Vehicles
Faisal Avenue Location 1	3.96
Faisal Avenue Location 2	57.75
Jinnah Avenue	6.29
9th Avenue Location 1	65.47
9th Avenue Location 2	50.25
Margalla Eve	13.43
7th Avenue	66.93

The collector roadway system is comprised of those roads that have shorter lengths and are used to connect residential sectors with minor arterials. Collector roads are also called as distributor roads which are a low to moderate capacity roads (FHWA, 2013). In this study 3 collector roads were chosen for undergoing spot speed studies. Speeds of 1,627 vehicles were observed through speed gun (Table 4.12) and it was observed that among all roads the maximum violation was found on Rohtas road with a percent violation of 87.07 % (Table 4.13).

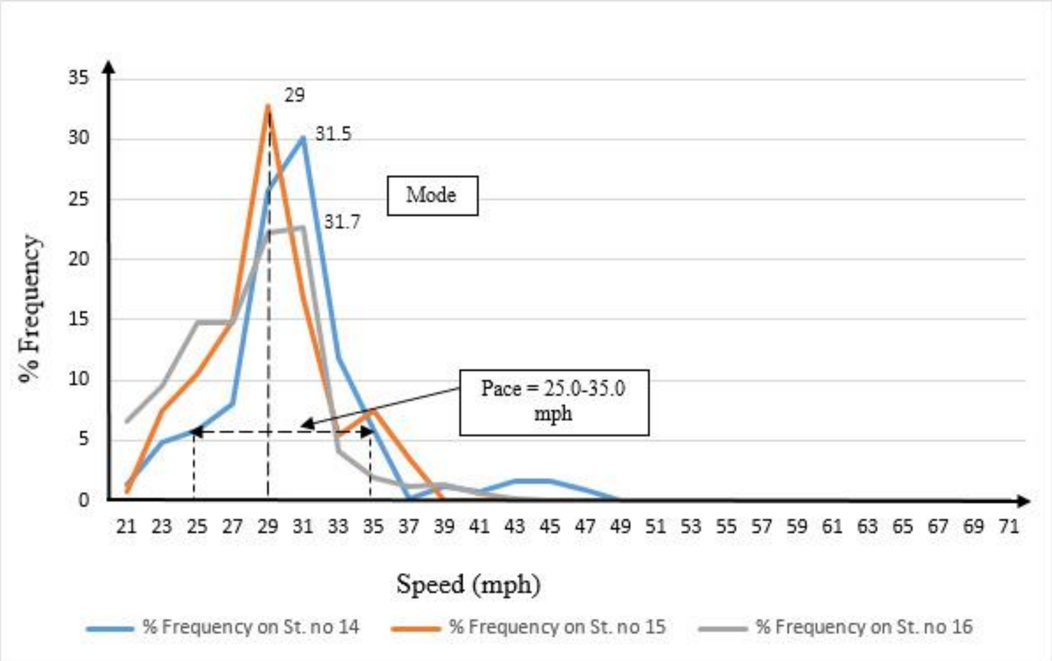

Figure 9: Frequency Distribution Curves for Collector Streets

The posted speed limits on collector roads were 50 km/h for light vehicles and 40 km/h for heavy vehicles respectively. SUVs showed the maximum percentage of speed violation (96.6 %) followed by passenger cars (89.4 %) (Figure 8).

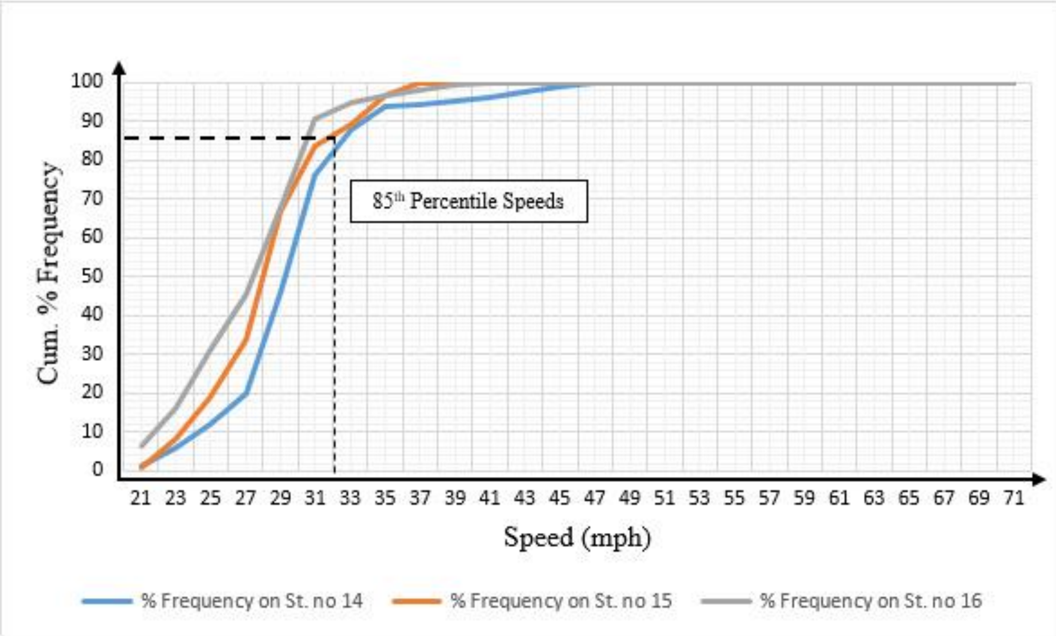

Figure 10: Cumulative Frequency Distribution Curves for Collector Streets

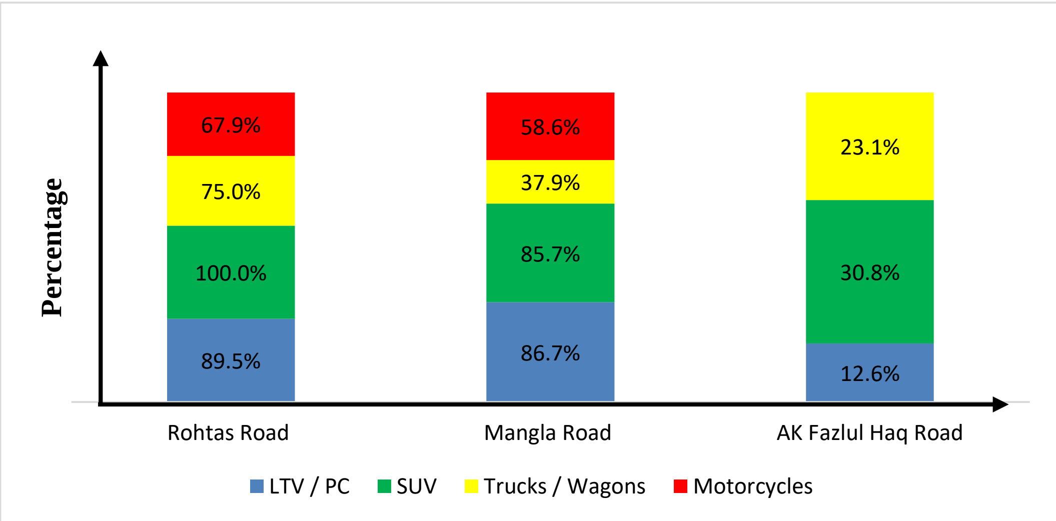

Figure 11: Speed Violation on Collector Streets

Upon overall observation of speed violation it was found that there persisted a higher rate of speed violation on collector roads as compared to major and minor arterials (Figure 10). This might be because of the reason that on collector roads the presence of traffic wardens is unlikely that encourage drivers to over speed. For collector roads the maximum noted speed violation was 87.1 % whereas, for major and minor arterials 14.8 % and 65.5 % violation was observed respectively.

Table 4.12: Vehicular Counts on Collector Streets

Roads	Speed Limit (Kph)	Total Counts			
		PC	SUV	Trucks/Wagons	Bike
Rohtas Road	50	370	14	4	53
Mangla Road	40	488	21	153	58
AK Fazlul Haq Road- Blue Area	50	365	26	10	69

Table 4.13: Speed Violations on Collector Streets

Roads (Major Arterials)	No Of Vehicles Violating Speed Limit				% of violation by Vehicle Type			
	PC	SUV	Truck	Bike	PC	SUV	Truck	Bike
Rohtas Road	331	14	3	36	89.4	100	75.0	67.2
Mangla Road	423	12	58	34	86.6	85.1	37.9	58.2
AK Fazlul Ha Road	46	8	3	0	12.6	30.7	23.0	0.00

Table 4.14: Percentage Violation of All Vehicles on Collector Streets

Roads (Collectors)	Overall Percentage Violation of All Vehicles
Rohtas Road	87.07
Mangla Road	73.91
AK Fazlul Haq Road, Blue Area	12.05

Among major arterials the highest percentage of violation was observed at Kashmir Highway Location 1 i.e. 11.7 % (Figure 10), while for minor arterials and collector streets the highest percentage of violation was 65.5 % and 87.1 % on 9th Avenue and Rohtas Road respectively. The spot speed studies indicated that drivers who travel at collector streets are more susceptible to speed violations as compared to major and minor arterials (Figure 10).

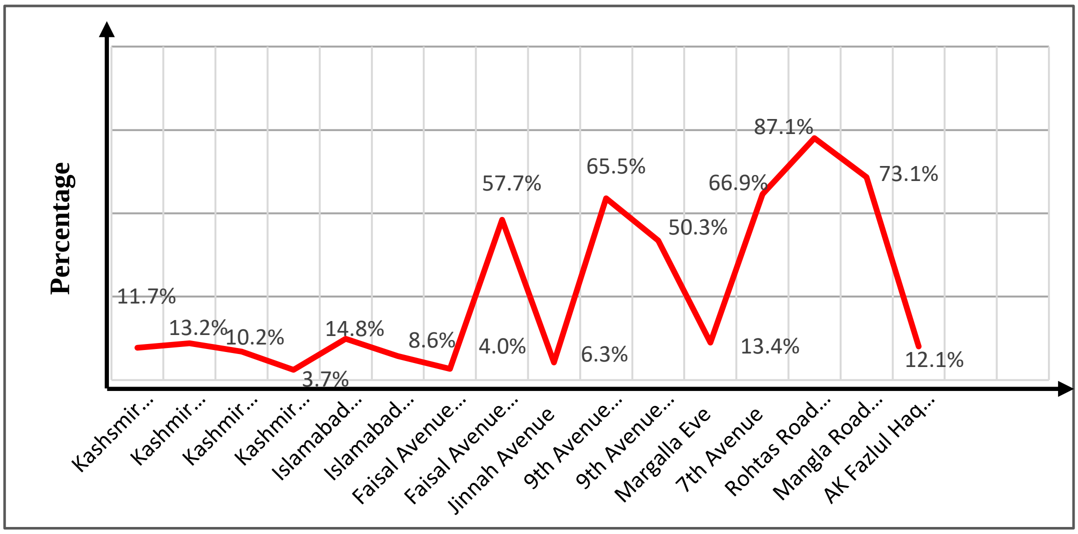

Figure 12: Overall Pattern of Violations Observed on all Classes of Roads

The level of compliance of laws on speed was also examined by conducting self-reported survey from 476 respondents. The survey highlighted that among the respondents, 59.46 % drivers had no idea regarding the posted speed limits of the roads that they were travelling (Table 4.15). The survey showed that 33. 49 % of the drivers didn't follow the speed limits. However, 22.27 % drivers followed the speed limits just to avoid penalty and not for ensuring their personal safety. Furthermore, 56.51 % of the drivers responded that they like to over speed. Among those drivers that exhibited violation of speed limits, 13.66 % responded that they like to over speed above 120 kph (Table 4.15).

From the data documented on speed, a very low level of compliance of laws on speed was demonstrated in Islamabad. When enquired form Islamabad traffic police (ITP) about the possible causes of an increased level of speed violation, it was noted that since 2015 there has been a complete halt on speed checking cameras and radar meters owing to political reasons. Based on conducted survey, it was revealed that among drivers who are engaged in speed violations, 94.54 % of the drivers were never penalized or fined despite violating laws on speed limits under motor vehicle ordinance, 1965 (Table 4.15). The remaining 5.46 % of drivers were those that were penalized for over speeding but they were fined for committing speed violations before 2015. As for now, there is no system for monitoring or controlling the speeds of vehicles (ITP, 2016).

In order to evaluate speed violations among motorcycle riders, self-reported survey was conducted form drivers of motorcycles and questions were asked regarding speed. From the survey it was observed that 41.88 % of motorcycle riders were aware of the speed limits of the roads they were travelling on (Table 4.16). Moreover, 60.96 % of riders responded that they follow speed limits for personal safety while 29.11 % of riders self reportedly admitted to violate speed limits (Table 4.16).

Table 4.15: Summary Statistics of Speed Survey from Motor Vehicle Users

Basic Characteristics of Survey	**Categories**	**Percentage**
Awareness of speed limits	Drivers aware of posted speed limits	59.46
	Drivers unaware of posted speed limits	40.54
Reasons of following speed limit	Speed limit not followed	33.40
	No response	1.05
	Personal safety	43.28
	To avoid penalty	22.27
Reported over speeding	Drivers that over speed	56.51
	Drivers that didn't over speed	43.49
Preference of speed limit in case of over speeding	80-100 kph	28.36
	100-120 kph	11.97
	Above 120 kph	13.66
	Drivers that don't over speed	43.49
	No response	2.52
Reported penalization in past for over speeding	Drivers who were reportedly never penalized due to over speeding	94.53
	Drivers who were penalized due to over speeding	5.46

Table 4.16: Summary Statistics of Speed Survey from Riders of Motorcycles

Basic Characteristics of Riders' Survey	**Categories**	**Percentage**
Awareness of speed limits	Riders aware of speed limits	41.88
	Riders unaware of Speed limits	58.12
Reasons of following speed limits	Personal safety	60.92
	No response	22.12
	Other	16.96
Reported over speeding	Riders that reportedly over speed	29.20
	Rider that didn't reportedly over speed	70.79

4.3.2 Level of Compliance of Child Restraints

Child restraint or Child restraining system (CRS) are exclusively designed seats that are predominantly used to prevent minors from sustaining injuries or fatalities during a motor vehicle crash. Present study conducted a survey on the use of CRS among motor vehicle users in Islamabad.

Table 4.17: Summary Statistics of Child Restraint Survey

Basic Characteristics of CRS Survey	Categories	Percentage
Allowing minor child to sit in front seat	Yes	69.75
	No	30.25
Minors observed sitting in front seat	Yes	35.71
	No	64.29
Child sitting in properly secured CRS	Yes	0.00
	No	100.00
Airbags installed	Yes	75.42
	No	24.58

It was observed that children travelling in motor vehicles lacked the use of child restraints or booster seats. The survey showed that 69.75 % of the respondents of child restraint survey admitted that they allow minor children to sit in front seat (Table 4.17). Moreover, in 35.71 % of cases, children were observed riding in the front seats, that too without any provision of properly secured child restraint (Table 4.17).

4.3.3 Level of Compliance of Driving Under Influence

In the arena of traffic safety, driving under influence of drugs or alcohol is considered as a significant crash risk factor causing severe or fatal injuries. In order to examine the level of compliance of laws on driving under influence, a comprehensive interview was conducted from traffic wardens of Islamabad Traffic Police (ITP), acknowledging the fact that alcohol consumption is a crime in Pakistan for Muslims according to Pakistan penal code 1979. In the interviews, traffic wardens were enquired about the different types of drugs that they have observed so far among drivers and whether there is a high percentage of drug consumption among commercial drivers or non-commercial drivers. The officers responded that opium, weed and cannabis are frequently observed drugs in drivers however, the rate of drug consumption is higher in commercial drivers as compared to non-commercial drivers. It was also enquired that in their opinion what percentage of drivers drive while intoxicated and how frequently they observe drivers to be under influence of drugs or alcohol. The responses from traffic wardens revealed that in their opinion, approximately 5-15 % of drivers in Islamabad consume drugs while driving however, the response obtained on questioning the frequency of cases of drug impaired driving was varied. Some officers responded that they observe cases of DUI on monthly basis while some responded that they observe drivers under influence on daily basis. The interview also included questions that asked the officers whether there are any alcohol or drug testing equipment such as Alcohol Breathalyzer or Pot Breathalyzer with ITP that can investigate a possible case of driving under influence, which revealed that currently ITP has no testing equipment that could detect drivers under the influence of drugs or alcohol.

Keeping in view the international practices of monitoring drug use among drivers, the officers of ITP were also enquired that whether they have any drug evaluation and classification program (DEC) under which trained and certified drug recognition expert (DRE) officers could inspect the cases of driving under influence, which revealed an absence of any such program. In addition, it was also revealed that the officers were not aware of any psychological observational techniques that are followed internationally such as “walk and turn test”, “one leg stand test” an “finger to nose test” to evaluate possible cases of driving under the influence of drugs or alcohol.

The interview from traffic wardens also included questions that enquired the age of the drivers that are mostly involved in drug or alcohol consumption which revealed that drivers aged 30-50 are mostly involved in drug impaired driving. Similarly, it was also enquired that whether ITP has any rehabilitation countermeasures for drivers who are held for DUI which revealed that ITP hasn’t its own drug rehabilitation center however, in instances of any reported cases, addicted drivers are referred to private drug rehabilitation centers in Islamabad. In addition, to evaluate the rate of crashes among influence drivers, the officers were asked to report the number of drug or alcohol impaired driving crashes that they have witnessed so far, which revealed that the maximum number of crashes reported by the officers was seven. The interview also revealed that currently, ITP lacks any data management system that could record data related to number of cases of driving under the influence of drugs or alcohol.

4.3.4 Level of Compliance of Seatbelt

The level of compliance of seat belt law was observed through self-reported survey. A total of 476 pen-paper surveys were conducted from respondents who were driving vehicles on different locations in the city. The sample size of the conducted survey was greater than the required sample size at 95 % confidence level and 0.5 tolerance for infinite population (Table 4.3). From the survey it was observed that 67.44 % of drivers were properly buckled. However, 4.62 % of cases were found where both front and rear seatbelts were buckled up (Figure 11). As compared to other key risk factors, seatbelt use was found to be the most adhered among drivers. This was owing to the reason that in case of non-compliance to seatbelt use the probability of getting penalized was the greatest among all other offences related to key risk factors.

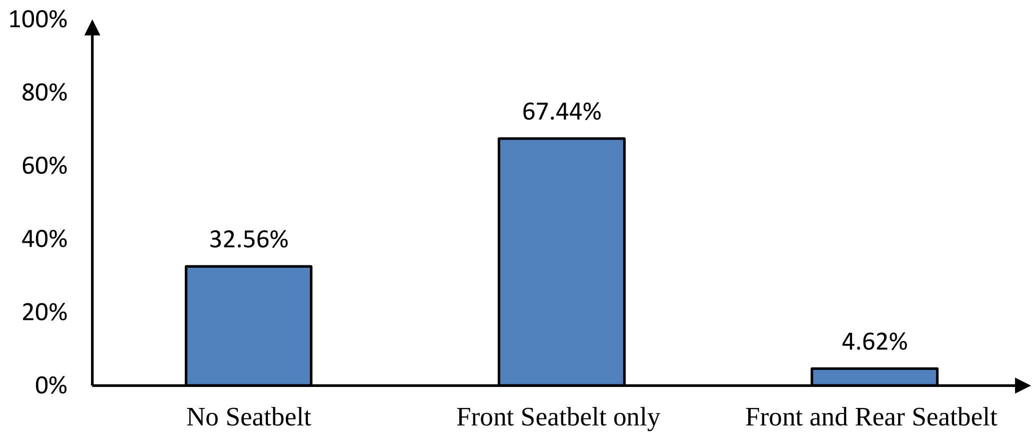

Figure 13: Overall Percentage of Seatbelt Use

The rate of seatbelt use in respondents having different demographic characteristics in Islamabad was recorded by undergoing a self-reported questionnaire survey. Before collecting the actual survey, a preliminary small scale pilot survey was conducted to check the appropriateness of questions for the target population and for the survey to be easily responsive (Brandenburg et al. 2002). Afterwards, a full scale survey was conducted with a sample size of 476. The survey was conducted from 8th August to 22nd August in 2016 from Monday to Saturday in two different three hours shifts (10:00 to 13:00 and 14:00 to 17:00).

The conducted survey recorded the respondents' gender and age, marital status, level of education, income, availability of driving license, past accident history, violation and penalization records and respondent's personal opinion on the effectiveness of enforcement level on seatbelt use. The basic characteristics of the survey are presented in Table (3.19). The descriptive statistics revealed that 74.16 % of the respondents possessed valid driving license.

When total respondents were disaggregated into various categories, majority of the respondents had age between 30-40 (48.69 %) and driving experience between 5-10 years (57.98 %) respectively. It was observed from the collected data that a majority of the respondents (23.24 %) had intermediate level/12th grade education (Table 4.19). To examine the relationship between income and seatbelt use, monthly income was also documented from respondents that indicated that 37.39 % of the respondents had an income between 40,000-60,000 PKR, similarly the least percentage of respondents on the basis of income was recorded to be those with monthly income more than 200,000 PKR (2.94 %).

In order to investigate the behavior of commercial drivers to comply with the rules on seatbelt usage, types of vehicles was documented in the survey. The sample had 57.77 % of cars, 16.80 % of Vans, 9.87 % of SUVs and 15.55 % of Cabs/ Taxis. Similarly, the survey included questions regarding self-reported past crash histories of the drivers. The survey revealed that 24.36 % of the respondents met a crash only once while 7.773 % of respondents met a crash more than once.

Table 4.18: Description of Response and Explanatory Variables

S.No.	Selected Variable and Description
1	**Seatbelt indicator** (1 if respondent is wearing a seatbelt, 0 otherwise)
2	**Gender indicator** (1 if respondent is a male, 0 otherwise)
3	**Marital Status** (1 if respondent is married, 0 otherwise)
4	**Age less than 20 indicator** (1 if respondent's age is less than 20 years, 0 otherwise)
5	**Age 20-30 indicator** (1 if respondent's age is 20-30 years, 0 otherwise)
6	**Age 30-40 indicator** (1 if respondent's age is between 30-40 years, 0 otherwise)
7	**Age 40-50 indicator** (1 if respondent's age is between 40-50 years, 0 otherwise)
8	**Age 50-60 indicator** (1 if respondent's age is between 50-60 years, 0 otherwise)
9	**Age above 60 indicator** (1 if respondent's age is above 60 years, 0 otherwise)
10	**No Education indicator** (1 if respondent's has no education, 0 otherwise)
11	**5th Grade indicator** (1 if respondent has primary education, 0 otherwise)
12	**10th Grade indicator** (1 if respondent's education is matric, 0 otherwise)
13	**12th Grade indicator** (1 if respondent's education is intermediate, 0 otherwise)
14	**Graduate indicator** (1 if respondent is a graduate, 0 otherwise)
15	**Car indicator** (1 if the vehicle is a car, 0 otherwise)
16	**Taxi indicator** (1 if the vehicle is a taxi, 0 otherwise)
17	**SUV indicator** (1 if the vehicle is a SUV, 0 otherwise)
18	**Suzuki or Van indicator** (1 if the vehicle is a Suzuki or van, 0 otherwise)
19	**Driving experience less than 1 year indicator** (1 if driving experience is less than 1 year, 0 otherwise)
20	**Driving experience 1-5 year indicator** (1 if driving experience is 1-5 year, 0 otherwise)
21	**Driving experience 5-10 year indicator** (1 if driving experience is 5-10 year, 0 otherwise)
22	**Driving experience more than 10 year indicator** (1 if driving experience is more than 10 years, 0 otherwise)
23	**Posted speed limit awareness indicator** (1 if driver knows the posted speed limit, 0 otherwise)
24	**Admitting speed limit violation indicator** (1 if driver admits to violate speed limit, 0 otherwise)
25	**Wearing seatbelt for personal safety indicator** (1 if driver wears seatbelt for personal safety, 0 otherwise)
26	**Wearing seatbelt for avoiding penalty indicator** (1 if driver wears seatbelt just to avoid penalty, 0 otherwise)

Table 4.18: Description of Response and Explanatory Variables (continued)

S.No	Selected Variable and Description
27	**Reported single crash in past indictor** (1 if driver met a crash only once, 0 otherwise)
28	**Reported more than one crash in past indicator** (1 if driver met a crash more than once, 0 otherwise)
29	**Reported no injury in past crash indicator** (1 if driver reported no injury in past crash, 0 otherwise)
30	**Reported minor injury in past crash indicator** (1 if driver reported minor injury in past crash, 0 otherwise)
31	**Reported severe injury in past crash indicator** (1 if driver reported severe injury in past crash, 0 otherwise)
32	**Reported very severe injury in past crash indicator** (1 if driver encountered very severe injury in a crash, 0 otherwise)
33	**Reported once penalized in past for seatbelt violation indicator** (1 if driver was penalized once for seatbelt violation, 0 otherwise)
34	**Reported more than once penalized in past for seatbelt violation indicator** (1 if driver was penalized more than once for seatbelt violation, 0 otherwise)
35	**Seatbelt auto alarm indicator** (1 the vehicle has a working auto alarm system for seatbelt, 0 otherwise)
36	**Unemployed indicator** (1 if driver is unemployed, 0 otherwise)
37	**Driver's monthly income under 10,000 PKR indicator** (1 if driver's monthly income is less than 10,000 PKR, 0 otherwise)
38	**Driver's monthly income between 10,000-20,000 PKR indicator** (1 if driver's monthly income is between 10,000-20,000 PKR, 0 otherwise)
39	**Driver's monthly income between 20,000-40,000 PKR indicator** (1 if driver's monthly income is between 20,000-40,000 PKR, 0 otherwise)
40	**Driver's monthly income between 40,000-60,000 PKR indicator** (1 if driver's monthly income is between 40,000-60,000 PKR, 0 otherwise)
41	**Driver's monthly income between 80,000-100,000 PKR indicator** (1 if driver's monthly income is between 80,000-100,000 PKR, 0 otherwise)
42	**Driver's monthly income between 100,000-200,000 PKR indicator** (1 if driver's monthly income is between 100,000-200,000 PKR, 0 otherwise)
43	**Driver's monthly income more than 200,000 PKR indicator** (1 if driver's monthly income is more than 200,000 PKR, 0 otherwise)
44	**Low perception of effectiveness of seatbelt law indicator** (1 if driver self reportedly rate low to effectiveness of seatbelt law, 0 otherwise)
45	**Moderate perception of effectiveness of seatbelt law indicator** (1 if driver self reportedly rate moderate to effectiveness of seatbelt law, 0 otherwise)
46	**High perception of effectiveness of seatbelt law indicator** (1 if driver self reportedly rate high to effectiveness of seatbelt law, 0 otherwise)

Level of injury sustained in case of a crash was also enquired from the respondents which revealed that 55.88 % of respondents sustained no injuries while 4.2 % of respondents sustained very severe injuries. Furthermore, self-reported violation records and penalization history was also recorded from respondents which revealed that 6.722 % of respondents were only penalized once on seatbelt violation while 2.31 % of respondents were penalized more than once.

Table 4.19: Summary Statistics of Seatbelt Survey

Basic Characteristics	Categories	Percentage
Seatbelt Use	Yes	67.44
	No	32.56
Gender	Male	84.25
	Female	15.75
Marital Status	Single	34.76
	Married	65.24
Age	Less than 20 years	8.961
	20-30 years	11.47
	30-40 years	48.69
	40-50 years	24.15
	50-60 years	5.252
	Above 60 years	1.472
Education Level	No education	13.45
	Primary/ 5th Grade	20.67
	Matric/ 10th Grade	23.21
	12th Grade	23.24
	Graduate	19.43
Monthly Income (PKR)	under 10,000	8.823
	10,000-20,000	12.60
	20,000-40,000	22.68
	40,000-60,000	37.39
	80,000-100,000	7.142
	100,000-200,000	8.452
	More than 200,000	2.941
Valid Driving License	Yes	74.16
	No	25.82
Reportedly penalized only once	Yes	6.722
	No	93.27
Vehicle Type	Car	57.77
	Taxi/Cab	15.55
	SUV	9.871
	Suzuki/Van	16.80
Driving Experience	Less than 1 year	6.432
	1-5 years	9.654
	5-10 years	57.98
	More than 10 years	25.93
Awareness of posted speed limit	Yes	40.54
	No	59.46

Table 4.19: Summary Statistics of Seatbelt Survey (Continued)

Basic Characteristics	**Categories**	**Percentage**
Reported speed violation	Yes	60.50
	No	39.49
Wearing Seatbelt for Personal safety	Yes	13.65
	No	86.35
Driver who reportedly met a crash only once	Yes	24.36
	No	75.64
Driver who reportedly met a crash more than once	Yes	7.773
	No	92.22
Reported no injury in past crash	Yes	55.88
	No	44.12
Reported minor injury in past crash	Yes	34.56
	No	65.44
Reported severe injury in past crash	Yes	5.437
	No	94.56
Reported very severe injury in past crash	Yes	4.201
	No	95.79
Reportedly penalized more than once for seatbelt violation	Yes	2.310
	No	97.68

The estimation of parameters exhibits error if there exists a perfect linear relationship between independent variables. In case of linearity between two variables, it is termed as collinearity whereas, for more than two independent variables, the mutual relationship is called multicollinearity. Hosmer and Lemshow (2000) indicated that logistic regression is dependent on collinearity between explanatory variables.

For this reason, Tolerance (TOL) and Variance Inflation Factor (VIF) are imperative diagnostic indices that are used to identify multicollinearity among independent variables (Khattak et al., 2016; Chatterjee and Haid, 2015; Greene, 2008; O'brien, 2007). To negate multicollinearity among independent variables, those variables were excluded that had VIF > 10 and TOL < 0.1 (Zhu and Hong, 2006). The significant variables used in the model lack multicollinearity (Table 4.20).

Table 4.20: Multicollinearity Diagnosis Indexes for Significant Variables

Significant Variables	**Collinearity Statistics**	
	TOL	**VIF**
Male indicator	0.917	1.091
SUV indicator	0.910	1.098
Graduate level of education indicator	0.908	1.101
Reported over speeding indicator	0.694	1.440
Reported single crash in past indicator	0.726	1.378
Reported more than one crash in past indicator	0.769	1.300
Reported no injury in past crash indicator	0.749	1.335
Reported once penalized in past for seatbelt violation indicator	0.771	1.298
Reported more than once penalized in past for seatbelt violation indicator	0.801	1.248
Auto alarm indicator	0.633	1.579
Low perception of effectiveness of seatbelt law indicator	0.625	1.600
Moderate perception of effectiveness of seatbelt law indicator	0.831	1.091

Dependent Variable: Seatbelt Use (TOL: Tolerance; VIF: Variance Inflation Factor)

The use of binary logistic regression for evaluating the rate of helmet use is also found in past research efforts (Yannis et al. 2011; Frank et al. 2015; Micheal et al. 2012; Hung et al. 2006; and Li et al. 2008). The major assumptions of binary logistic regression model are: (1) the model must take binomial categorical variables as dependable variable —that is, when the dependent variable can only take two values, “0” and “1”, (2) The data used for estimation of binary logistic model shall lack any outlier values, (3) There shall be no high inter-correlations (multicollinearity) among explanatory variables (Tabachnick and Fidell, 2012), (4) There shall be a linear relationship between all explanatory variables and odds ratio or Exp(β). Linearity among explanatory variables and odds ratio can be checked by categorizing all ordinal independent variables in different categories of equal intervals and applying binary logistic models by incorporating all categorical variables with respect to a reference category. If the Beta coefficients in model result increase or decrease in linear steps, linearity is warranted among odd ratios and independent variables (Garson, 2009). The logistic regression model has the form shown in Equation (5).

$$\ln\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_3 X_3 + \varepsilon \qquad (5)$$

Where
π = the proportion of success
β_0 = the Y intercept
$\beta_1, \beta_2, \beta_3$……………..……. Bn = coefficients
X_1, X_2, X_3 ………………. Xn = independent variables
ε = random error

In terms of proportion of success (π), the general logistic regression model takes the form shown in Equation (6)

$$\pi = \frac{e^{\beta 0 + \beta 1 X1 \, + \, \beta 2 X1 + \, ... + \, \beta n \, Xn \, + \, \varepsilon}}{1 + \, e^{\beta 0 + \beta 1 X1 \, + \, \beta 2 X1 \, + \, ... + \, \beta n \, Xn \, + \, \varepsilon}} \qquad (6)$$

Binary logistic regression utilizes maximum likelihood estimation (MLE) instead of ordinary least squares (OLS) estimation to estimate the best fit model, for which log-likelihood function is used.

$$Log\ L = \sum_{i=1}^{n} y_i \, Log \left(\frac{\pi\,(x_i)}{1-\pi(x_i)}\right) + \sum_{i=1}^{n} Log\ [1 - \pi(x_i)] \qquad (7)$$

Where
L = likelihood of observing parameters for all the observations
y (i) = Result of the ith observation
n = number of observations, and
π = probability of response variable

During the development of binary logistic model, 46 explanatory variables were selected out of which 12 were significant at 95% level of confidence. Due to categorical nature of all independent variables and most of them having several classes, the model development utilized dummy variables to specify each category of categorical variables. In addition, a baseline or reference category was selected for all categorical variables. For all explanatory variable with N categories, N-1 dummy variables were incorporated in the model so as to explore the difference in each category with respect to dependable variable. The use of N-1 dummy variables ensured the model to be free of "Dummy Variable Trap" (Tranmer, et al., 2008; Bursac, et al., 2008).

Table 4.21: Descriptive Statistics of Significant Independent Variables

Variable	Mean	Std. Deviation
Male indicator	0.8424	0.0167
SUV indicator	0.0990	0.0140
Graduate level of education indicator	0.0820	0.0130
Reported over speeding indicator	0.6051	0.0221
Reported single crash in past indicator	0.2445	0.0204
Reported more than one crash in past indicator	0.0781	0.0121
Reported no injury in past crash indicator	0.2186	0.0191
Reported once penalized in past for seatbelt violation indicator	0.2084	0.0190
Reported more than once penalized in past for seatbelt violation indicator	0.0712	0.0121
Auto alarm indicator	0.3687	0.0226
Low perception of effectiveness of seatbelt law indicator	0.2756	0.0201
Moderate perception of effectiveness of seatbelt law indicator	0.7182	0.0243

Binary logistic modeling utilizes Wald chi-squared test to determine whether a certain predictor variable is significant or not (Collet, 1991). Similarly, the use of t-test isn't apposite in binary logistic regression because the errors in logistic regression aren't normally distributed as they are in t-test that uses Ordinary Least squares (Fey, 2002). On the contrary, binary logistic modeling uses Maximum Likelihood Estimation instead of Ordinary Least Squares to estimate the coefficient of parameters. Similarly the homogeneity of variance doesn't need to be satisfied in binary logistic modeling (Strauss, 1999).

Likelihood ratio test (-2 Log Likelihood) is used to identify the deviance of an estimated binary logistic model. The deviance is the measure of lack of the fit of the model or how much variation is left unexplained by the estimated model. In binary logistic regression, the model fit is compared by comparing the deviance of two models –that is, the null or initial model and the fitted model. The calculated deviance follows a chi-square distribution where number of parameters are accounted as degrees of freedom (Hosmer and Lemeshow, 2000).

$$-2\ Log\ L = \sum_{j}^{n} W_j f_j \log(\pi_j) \quad (8)$$

Where
$-2\ Log\ L$: Log likelihood criterion (deviance)
W_j = Weight of the jth observation
f_j = frequency of values of the jth observation, and
π_j = estimated probability of the observed response

The odds of a binomial response variable equated by a distinct linear arrangement of independent variables is equal to the exponential function of linearly combined independent variables. The odd ratio helps to indicate how logistic regression performs as a link function linking the likelihood of response variable and the linearly regressed equation (Hosmer & Lemeshow, 2000). Moreover, the odds ratio (OR) is the proportion of two odds- that is, the proportion of the likelihood of occurrence of an event in one group (X) to the likelihood of occurrence of an event in another group (Y). A value of OR=1 corresponds to the same odds of two events. Similarly for OR > 1, the odds of the event (X) are higher than the event (Y) and for OR<1, the odds of event (X) are less than the event (Y) (Harrell, 2001).

$$Odds = e^{\beta 0 + \beta n\ Xn} \quad (9)$$

$$Odds\ Ratio = \frac{Odds\ X}{Odds\ Y} = \frac{\pi}{1-\pi} = e^{\beta n} \quad (10)$$

Where
π = probability of success
1- π = probability of failure

As show in Table 4.23, a binary logistic model was estimated and all variables significant at the 95% confidence interval were retained for further analysis. From the model results, 12 variables were found that exhibited statistical significance with the dependent variable on the basis of Wald test results (Washington, et al., 2003).

The detailed mathematical formulation including significant independent variable for the estimated binary logistic framework in Equation (7) can be written as;

$$\ln\left(\frac{\pi}{1-\pi}\right) = \text{Logit (Pi)}$$

$= \beta_0 + \beta_1$ (Male indicator) $+\beta_2$ (SUV indicator) $+\beta_3$ (graduate indicator)
$+\beta_4$ (over speeding indicator) $+\beta_5$ (Driver who met a crash once indicator)
$+\beta_6$ (Driver who met a crash more than once indicator)
$+\beta_7$ (No injury in case of a crash indicator)
$+\beta_8$ (Penalized once for seatbelt violation indicator)
$+\beta_9$ (Penalized more than once for seatbelt violation indicator)
$+\beta_{10}$ (Seatbelt auto alarm indicator)
$+\beta_{11}$ (Low effectiveness of enforcement level of seatbelt indicator)
$+\beta_{12}$ (High effectiveness of enforcement level of seatbelt indicator) (11)

Table 4.22: Binary logistic regression results of Seatbelt Use

S.No	Variable	Baseline Category	Coeff	Wald Stat	P value	Odd Ratio
1	Constant	-	4.161	19.55	0.000	64.167
2	Male indicator	Female indicator	-2.221	6.915	0.008	0.108
3	SUV indicator	Taxi / Cab indicator	1.357	4.543	0.033	3.887
4	Graduate indicator	No education indicator	1.859	5.030	0.024	6.419
5	Reported over speeding indicator	No reported over speeding indicator	-1.100	6.310	0.012	0.332
6	Single crash in past indicator	No crash in past indicator	1.185	4.203	0.040	3.271
7	More than one crash in past indicator	No crash in past indicator	1.876	4.223	0.040	6.527
8	Reported no injury in past crash indicator	Reported severe injury in past crash indicator	-2.293	14.75	0.0001	0.100
9	Reported once penalized in past for seatbelt violation indicator	Reported never penalized in past for seatbelt volition indicator	2.25	7.348	0.0002	9.487
10	Reported more than once penalized in past for seatbelt violation indicator	Reported never penalized in past for seatbelt violation indicator	2.564	14.35	0.006	12.995
11	Seatbelt auto alarm indicator	No seatbelt auto alarm	2.249	18.08	0.000	9.482
12	Low perception of effectiveness of seatbelt law indicator	High perception of effectiveness of indicator	-3.885	54.98	0.000	0.020
13	Moderate perception of effectiveness of seatbelt law indicator	High perception of effectiveness of seatbelt law indicator	-0.943	4.357	0.036	0.3892

(Note: Model summary statistics: Number of observations=476; degrees of freedom = 12; log likelihood = -99.0957; restricted log likelihood = -302.5165, McFadden's Pseudo rho-squared (ρ2) = 0.6724. Dependent variable Seatbelt Use particulars: Drivers wearing seatbelt coded 1, Driver not wearing seatbelt coded 0.)

For comparing the impact of different independent variables of seatbelt use and to check the responsiveness of the response variable pertaining to the significant explanatory variables, elasticity of the significant independent variables were computed (Washington, et al., 2003). Elasticity is the percent change in the response variable with respect to incremental change in an independent variable. For continuous variable, elasticity values are used to check for the impact on dependable variable with respect to independent variable whereas, in discrete variables pseudo-elasticity values are used because elasticity cannot be defined in a standard way (Chang and Mannering, 1999).

$$E_{\mathrm{x_{ink}}}^{\mathrm{P(i)}} = e^{\beta_{\mathrm{ink}}} \frac{\sum_{i=1}^{n} e^{\beta i' x_{\mathrm{n}}}}{\sum_{i=1}^{n} e^{\Delta(\beta i' x_{\mathrm{n}})}} - 1 \tag{12}$$

This way, when the discrete variable varies numerically from one value to another value, the variation in choice likelihood of a discrete variable is easily described (Shankar and Mannering, 1996). Equation 8 explains how direct pseudo-elasticity,$E_{\mathrm{x_{ink}}}^{\mathrm{P(i)}}$, of any dependent variable (k) is obtained from variable x_{n} (Ulfarsson and Mannering, 2004).

The variables with the lowest pseudo-elasticity values show the lowest impact on the dependent variable; which in this case is seatbelt auto alarm indicator which has the lowest impact on seatbelt use (Table 4.24). In order to check the elasticity of an explanatory variable relevant to independent variable having the lowest elasticity value, the relevant pseudo-elasticity values are computed by taking a ratio of the pseudo-elasticity values of each predictor by the pseudo-elasticity values of that variable which has the least impact on the dependent variable. This procedure helps to classify all independent variables on the basis of their impact on the dependent variable.

Table 4.23: Pseudo-elasticity (ei) and Relevant Pseudo-elasticity (ei*)

Variable	*ei*	*ei**
Male indicator	0.19	13.60
SUV indicator	0.02	1.09
Graduate level of education indicator	0.02	1.06
Driver that over speed indicator	0.10	7.29
Single crash experience indicator	0.04	2.78
Many crash experience indicator	0.01	1.01
No injury indicator	0.11	8.08
Penalized once for seatbelt violation indicator	0.06	4.01
Penalized more than once for seatbelt violation indicator	0.12	8.31
Auto alarm indicator	0.01	1.00
Low Effectiveness indicator	0.23	16.43
Moderate Effectiveness indicator	0.10	6.95
Constant	-	-

The goodness of fit of the model is checked by Likelihood ratio test and McFadden's Pseudo R-squared (R^2) which cautiously indicate that how data set is adequately fitted in a Logit model (Menard, 2002). The R-squared (R^2) equal to 1 represents that the model perfectly fits the dataset however, 0 indicates the absence of any dependence of explanatory variables on response variable (Ayalew & Yamagishi, 2005). For values of Pseudo R-squared (R^2) higher than 0.2, a reasonably better fitted model is presented (Clark and Hosking, 1986). (R^2) value of 0.6724 is obtained in this study which is greater than 0.2 and assures adequate model fit. The findings are consistent with the past research that utilized the same criteria to investigate goodness of fit of the model (Yannis et al. 2011; Ozdemir, 2011).

Table 4.24: Determination of Goodness of Fit of the Model

Information Statistics For Discrete Choice Model	**Value**
Number of Parameters	13
Log likelihood LL(0) (Restrained Model)	-302.5065
Log likelihood LL(B) (Fitted Model)	-99.0957
McFadden's Pseudo R-squared	0.672428
Likelihood Ratio Test	Restrained against fitted model
LR= -2 [LL(B)-LL(0)]	406.8416
Degrees of Freedom	12
Critical X^2 at 95 % level of confidence	21.03
Number of Observations	476

Likelihood Ratio Test (LLT) is the measure of deviance which shows the lack of fitness of the model. Lower values of deviance means higher model fit (Hosmer and Lemeshow, 2000). The test compares the log likelihood of restrained model with the log likelihood of the model at convergence. A lower value of log likelihood of fitted model in comparison to the null model meets the criteria (Cohen, et al., 2002). The deviance of model at convergence is subtracted from deviance of restrained model in order to evaluate the contribution of explanatory variables in the model. The difference in deviance is later assessed on a chi-square distribution where the number of parameters estimated account for the degrees of freedom. In this study the criteria is met since, LR= -2 [LL (B)-LL (0)] = -2 [(-99.09)-(-302.50)] = 406.841 > 21.03 =X^2 for twelve *dof* and for a 95 % level of confidence. This represents that the computed model is statistically suitable as compared to that model having no predictors, and the predictors included are considered statistically significant. The results are consistent with past studies performed by Yannis et al. (2011) and Gourieroux, et al. (1982).

The sign of the coefficient of each explanatory variable in the model highlights the impact that the corresponding variable has on the response variable (Yannis, et al., 2011). The negative sign of gender indicator shows that there is a low likelihood of seatbelt compliance in male drivers as compared to female drivers (baseline category). The odds ratio reveals that the odds of using seatbelt among male drivers are 0.108 times the odds of using seatbelt among female drivers. The finding is intuitive and consistent with the past research that highlighted that female drivers are more cautious than male drivers (Özkan, et al., 2006; Türker, et al., 2005; Rhodes, et al., 2011).

The positive sign of vehicle type "SUV" suggests that the probability of seatbelt usage in drivers using SUVs is 3.88 times higher than those drivers that drive taxis or cabs (baseline category). The finding is consistent to the past research that reveals that commercial drivers (taxi or cab drivers) exhibit more risk taking behavior as compared to non-commercial drivers (Burns, et al., 1995; Iversen, et al., 2002). Similarly the results revealed that educated drivers are more probable of seatbelt usage as compared to uneducated drivers i.e. seatbelt usage among drivers who were graduates were 6.41 times more likely to use seatbelts as compared to uneducated drivers (baseline category). The results are similar to the past research that indicates a strong association between demographic factors like level of education and compliance of seatbelt use (Shinar and David, 1993; Shinar et al., 2001; Lerner et al., 2001).

The results uncovered that crash histories of the drivers predominantly effect the usage of seatbelt. The model estimated a positive coefficient for crash indicator that highlights that those drivers that self reportedly met a crash only once in their past were 3.27 times more likely to wear seatbelt as compared to those drivers that didn't meet a crash. Similarly, for those drivers who met more than one crash, the probability of using seatbelt was increased to 6.52 times of that of those drivers who didn't report a crash (baseline category). The findings are insightful and analogous to past research that identify crash histories as a significant factor of seatbelt compliance (Kweon and Kockelman, 2003; Hunter et al., 1993). Level of injury sustained in case of a past crash was also found to be a significant factor of seatbelt usage among drivers. For those respondents that didn't sustain an injury in a past crash, the probability of wearing a seatbelt was 0.1 times the probability of those respondents that sustained severe injuries in a past crash (baseline category).

Self-reported violation records of respondents were also found to be strong detriments of seatbelt usage. The model results reveal that the odds of using seatbelt among drivers that admitted to violate posted speed limits are 0.223 times as compared to those drivers that followed the posted speed limits. Similarly, penalization record for seatbelt violation was also found to be a significant factor of seatbelt usage. Drivers that were penalized only once and more than once were respectively 9.49 times and 12.99 times more likely to wear seatbelts as compared to those drivers that had no penalization record. The results are intuitive and consistent to past research (MacKillop 1978 ; Dissanayake et al., 2007).

Seatbelt auto alarm proved to be a substantial factor of increased rate of seatbelt usage. This relation is indicated by the positive coefficient of seatbelt auto alarm indicator. The results revealed that the probability of wearing seatbelt by drivers that had seatbelt auto alarm system in their vehicles was 9.49 times greater than those drivers that had no seatbelt auto alarm system installed in their vehicles. The results also revealed that those respondents who believed that there is a low effectiveness of enforcement level on seatbelt use indicated a low probability of seatbelt use as compared to those drivers that believed the enforcement level to be strong. The odds ratio indicates that the probability of wearing seatbelt in those respondents who believe enforcement level to be low and moderate are respectively 0.02 and 0.38 times the probability of wearing seatbelt of those respondents who believe enforcement level to be strong.

4.3.5 Level of Compliance of Helmet

The rate of helmet use by motorcycle riders in Islamabad was recorded by collecting self-reported questionnaire survey. Before collecting the actual survey, a preliminary small scale pilot survey was collected to check the appropriateness of questions for the target population and for the survey to be easily responsive (Brandenburg et al. 2002). Afterwards, a full scale survey was collected with a sample size of 363. The survey was collection from 23rd – 29th August in 2016, from Monday to Saturday in two different three hours shifts (10:00 to 13:00 and 14:00 to 17:00).

The conducted survey recorded the rider's gender and age, availability of valid driving license, reported past crash history where helmet saved the rider, rider's behavior and personal opinion on the effectiveness of helmet use, reported penalization in past for violating laws on helmet use, and problems faced by riders due to wearing helmet like uncomfortableness and heat, reduced night visibility and reduction in hearing abilities.

The basic characteristics of the survey are presented in Table 4.27. The descriptive statistics showed that 65.84 % of the respondents exhibited prevalence of helmet use. Similarly, 62.25 % of the respondents possessed valid driving license. When the total respondents were disaggregated into various categories, majority of the respondents had age between 20-30 (33.60 %) and driving experience between 1-5 years (43.8 %) respectively.

Table 4.25: Description of Explanatory Variables for Helmet Use

S.No.	Selected Variable and Description
1	**Gender indicator** (1 if respondent is a male, 0 otherwise)
2	**Age less than 20 indicator** (1 if respondents age is less than 20 years, 0 otherwise)
3	**Age 20-30 indicator** (1 if respondents age is between 20-30 years, 0 otherwise)
4	**Age 30-40 indicator** (1 if respondents age is between 30-40 years, 0 otherwise)
5	**Age 40-50 indicator** (1 if respondents age is between 40-50 years, 0 otherwise)
6	**Age 50-60 indicator** (1 if respondents age is between 50-60 years, 0 otherwise)
7	**Age above 60 indicator** (1 if age is above 60 years, 0 otherwise)
8	**Valid driving license indicator** (1 if rider possess a valid driving license, 0 otherwise)
9	**Driving experience less than 1 year indicator (**1 if driving experience is less than 1 year, 0 otherwise)
10	**Driving experience between 1-5 year indicator** (1 if respondent's driving experience is 1-5 year, 0 otherwise)
11	**Driving experience between 5-10 year indicator** (1 if respondent's driving experience is 5-10 year, 0 otherwise)
12	**Driving experience more than 10 year indicator** (1 if respondent's driving experience is more than 10 years, 0 otherwise)
13	**Speed limits awareness indicator** (1 if the rider knows the speed limit on the road he is riding on, 0 otherwise)
14	**Reported penalized in history for helmet violation indicator** (1 if the rider has been penalized due to violation of helmet laws, 0 otherwise)
15	**Rider saved in past by helmet in a crash indicator (**1 if a rider was saved by helmet in a crash, 0 otherwise)
16	**Rider wearing helmet because of legislation compliance indicator (**I if respondent wears the helmet because of law, 0 otherwise)
17	**Rider who think helmet provides safety indicator (**I if rider wears a helmet for personal safety, 0 otherwise)
18	**Rider wishing helmet law to continue indicator** (1 if the respondent wants helmet law to continue, 0 otherwise)
19	**Rider with helmeted pillion rider indicator** (1 if the passenger on pillion seat is wearing a helmet, 0 otherwise)
20	**Helmet use in low traffic area Indicator** (1 if the rider wears a helmet in low traffic area, 0 otherwise)
21	**Helmet use in high traffic area indicator** (1 if the rider wears a helmet in high traffic area, 0 otherwise)
22	**Helmet use in every traffic condition indicator** (1 if the rider wears a helmet in every traffic condition, 0 otherwise)
23	**Riders reportedly facing issues in observing rearview indicator** (1 if the rider faces a problem to observe rearview while wearing helmet, 0 otherwise)
24	**Rider reportedly facing visibility issues at night or in rain due to helmet indicator** (1 if the rider faces reduction in visibility due to wearing a helmet, 0 otherwise)
25	**Rider reportedly facing listening issues due to helmet indicator** (1 if the rider faces reduction in ability to listen due to wearing a helmet, 0 otherwise)
26	**Cellphone use indicator** (1 if the rider uses cellphone while riding, 0 otherwise)
27	**Uncomforted indicator** (1 if the rider faces uncomforted and heated due to wearing a helmet, 0 otherwise)

It was observed from the collected data that a high rate of physical discomposure was observed in riders because of wearing helmet; 60.05 % of riders faced reduction in hearing abilities, 53.16 % of riders encountered effect on visibility at night, 51.23 % of riders met issues to observe rearview while 54 % of the riders were uncomforted or heated because of wearing helmet (Table 4.27).

Table 4.26: Summary Statistics of Helmet Survey

Basic Characteristics	Categories	Percentage
Age	Age Less than 20	28.37
	Age 20-30	33.60
	Age 30-40	25.89
	Age 40-50	6.060
	Age Above 50	6.080
Driving experience	Less than 1 year	10.19
	1-5 years	43.80
	5-10 years	23.14
	More than 5 years	22.87
Valid driving license	Yes	62.25
	No	37.74
Helmet use	Yes	65.84
	No	34.16
Rider saved by helmet in a crash	Yes	29.20
	No	70.70
Rider who think helmet is for safety	Yes	34.15
	No	65.84
Rider wearing helmet because of legislation compliance	Yes	41.50
	No	58.40
Rider reportedly facing visibility issues due to helmet	Yes	53.16
	No	46.83
Rider reportedly facing issues in hearing due to helmet	Yes	60.05
	No	39.94
Riders reportedly facing issues to observe rearview	Yes	51.23
	No	48.76
Awareness of posted speed limits	Yes	41.87
	No	58.13

The survey included questions regarding self-reported past crash histories of the riders where helmet saved them. The selection of this variable was warranted because riders with past crashes are likely to show compliance of helmet use because they develop a protective and cautious attitude after facing a crash (Iversen, et al., 2002). Many researchers have endeavored to find the subjective factors influencing the defiance of helmet use. The possible factors include weather extremities in Pakistan such as warm climate and scorching sun in summers that cause physical discomfort and discomposure upon wearing helmet. Thus variables such as; discomfort or heat, observing rearview issues, visibility issues and hearing issues were used in the questionnaire survey (Hung et al., 2008;Gisolfi et al., 1988; Javad et al., 2014).

Table 4.27: Descriptive Statistics of Significant Independent Variables

Variable	Mean	Std. Deviation
Age less than 20 years indicator	0.2837	0.4514
Driver experience less than one year indicator	0.1019	0.3029
Driver experience 1-5 years indicator	0.4380	0.4968
Speed limit awareness indicator	0.4187	0.4940
Rider saved in past by helmet in a crash indicator	0.2920	0.4553
Rider wearing helmet because of legislation compliance indicator	0.4160	0.4935
Rider who think helmet provides safety indicator	0.3416	0.4749
Rider reportedly facing rearview visibility issues indicator	0.5124	0.5005
Valid driving license indicator	0.6226	0.4854
Rider reportedly facing visibility issues due to helmet indicator	0.5317	0.4996
Rider with helmeted pillion rider indicator	0.1460	0.3536

Table 4.28: Multicollinearity Diagnosis Indexes for Significant Variables

Significant Variables	Collinearity Statistics	
	TOL	VIF
Age less than 20 years indicator	0.514	1.945
Driver experience less than one year indicator	0.789	1.267
Driver experience 1-5 years indicator	0.580	1.723
Speed limit awareness indicator	0.681	1.468
Rider saved in past by helmet in a crash indicator	0.937	1.067
Rider wearing helmet because of legislation compliance indicator	0.325	3.073
Rider who think helmet provides safety indicator	0.366	2.731
Rider reportedly facing rearview visibility issues indicator	0.844	1.185
Valid driving license indicator	0.771	1.297
Rider reportedly facing visibility issues due to helmet indicator	0.592	1.688
Rider with helmeted pillion rider indicator	0.773	1.294

Dependent Variable: Helmet Use, TOL: Tolerance; VIF: Variance Inflation Factor

The estimation of parameters exhibits error if there exists a perfect linear relationship between independent variables. In case of linearity between two variables, it is termed as collinearity whereas, for more than two independent variables, the mutual relationship is called multicollinearity. Hosmer and Lemshow (2000) indicated that logistic regression is dependent on collinearity between explanatory variables. For this reason, Tolerance (TOL) and Variance Inflation Factor (VIF) are imperative diagnostic indices that are used to identify multicollinearity among independent variables (Khattak et al., 2016; Chatterjee and Haid, 2015; Greene, 2008; O’brien, 2007). To negate multicollinearity among independent variables, those variables were excluded that had VIF > 10 and TOL < 0.1 (Zhu and Hong, 2006). The significant variables used in the model lack multicollinearity (Table 4.29).

In order to model helmet use in Islamabad, binary logistic regression was used because the response variable had only two outcome (Helmet on =1, No helmet =0). Cox (1958) introduced binary logistic regression to statistics to analyze probabilities and proportions having a binomial distribution instead of normality in proportions. The regression technique highlighted a dependence structure, where binary dependent variable exhibited response to a set of categorical explanatory variables. The use of binary logistic regression for evaluating the rate of helmet use is also found in previous research (Yannis et al. 2011; Frank et al. 2015; Micheal et al. 2012; Hung et al. 2006; Li et al. 2008). The major assumptions of binary logistic regression model are: (1) the model must take binomial categorical variables as dependable variable —that is, when the dependent variable can only take two values, “0” and “1”, (2) The data used for estimation of binary logistic model shall lack any outlier values, (3) There shall be no high inter-correlations (multicollinearity) among explanatory variables (Tabachnick and Fidell, 2012), (4) There shall be a linear relationship between all explanatory variables and odds ratio or Exp(β). Linearity among explanatory variables and odds ratio can be checked by categorizing all ordinal independent variables in different categories of equal intervals and applying binary logistic models by incorporating all categorical variables with respect to a reference category. If the Beta coefficients in model result increase or decrease in linear steps, linearity is warranted among odd ratios and independent variables (Garson, 2009). The logistic regression model has the form shown in Equation (13).

$$\ln\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_3 X_3 + \varepsilon \quad (13)$$

Where

π = the proportion of success

β_0 = the Y intercept

$\beta_1, \beta_2, \beta_3$…………..………. Bn = coefficients

$X_1, X_2, X_3 +$ ………………. Xn = independent variables

ε = random error

In terms of proportion of success (π), the general logistic regression model takes the form shown in Equation (6)

$$\pi = \frac{e^{\beta 0+\beta 1X1 + \beta 2X1+ .....+ \beta n\, Xn + \varepsilon}}{1 + e^{\beta 0+\beta 1X1 + \beta 2X1 + ...+ \beta n\, Xn + \varepsilon}} \tag{14}$$

Binary logistic regression utilizes maximum likelihood estimation (MLE) instead of ordinary least squares (OLS) estimation to estimate the best fit model, for which log-likelihood function is used.

$$Log\ L = \sum_{i=1}^{n} y_i\, Log\left(\frac{\pi\,(x_i)}{1-\pi(x_i)}\right) + \sum_{i=1}^{n} Log\,[1-\pi(x_i)] \tag{15}$$

Where
L = likelihood of observing parameters for all the observations
y (i) = Result of the ith observation
n = number of observations, and
π = probability of response variable

During the development of binary logistic model, 27 explanatory variables were selected out of which 11 were significant at 95% level of confidence. Due to categorical nature of all independent variables and most of them having several categories, the model development utilized dummy variables to specify each category of categorical variables. In addition, a baseline or reference category was selected for all categorical variables. For an explanatory variable with N categories, N-1 dummy variables were incorporated in the model so as to explore the difference in each category with respect to dependable variable. The use of N-1 dummy variables ensured the model to be free of "Dummy Variable Trap" (Tranmer et al., 2008; Bursac et al., 2008).

Binary logistic modeling utilizes Wald chi-squared test to determine whether a certain predictor variable is significant or not (Collet, 1991). Similarly, the use of t-test isn't apposite in binary logistic regression because the errors in logistic regression aren't normally distributed as they are in t-test that uses Ordinary Least squares (Fey, 2002). On the contrary, binary logistic modeling uses Maximum Likelihood Estimation instead of Ordinary Least Squares to estimate the coefficient of parameters. Similarly the homogeneity of variance doesn't need to be satisfied in binary logistic modeling (Strauss, 1999).

Likelihood ratio test (-2 Log Likelihood) is used to identify the deviance of an estimated binary logistic model. The deviance is the measure of lack of the fit of the model or how much variation is left unexplained by the estimated model. In binary logistic regression, the model fit is compared by comparing the deviance of two models –that is, the null or initial model and the fitted model. The calculated deviance follows a chi-square where number of parameters are accounted as degrees of freedom (Hosmer and Lemeshow, 2000).

$$-2\,Log\,L = \sum_{j}^{n} W_j f_j \log(\pi_j) \qquad (16)$$

Where
$-2\,Log\,L$: Log likelihood criterion (deviance)
W_j = Weight of the jth observation
f_j = frequency of values of the jth observation, and
π_j = estimated probability of the observed response

The odds of a binomial response variable equated by a distinct linear arrangement of independent variables is equal to the exponential function of linearly combined independent variables. The odd ratio helps to indicate how logistic regression performs as a link function linking the likelihood of response variable and the linearly regressed equation (Hosmer & Lemeshow, 2000). Moreover, the odds ratio (OR) is the proportion of two odds- that is, the proportion of the likelihood of occurrence of an event in one group (X) to the likelihood of occurrence of an event in another group (Y). A value of OR=1 corresponds to the same odds of two events. Similarly for OR > 1, the odds of the event (X) are higher than the event (Y) and for OR<1, the odds of event (X) are less than the event (Y) (Harrell, 2001).

$$Odds = e^{\beta 0 + \beta n\, Xn} \tag{17}$$

$$Odds\ Ratio = \frac{Odds\ X}{Odds\ Y} = \frac{\pi}{1-\pi} = e^{\beta n} \tag{18}$$

Where
π = probability of success
1- π = probability of failure

Binary logistic modeling utilizes Wald chi-squared test to determine whether a certain predictor variable is significant or not (Collet, 1991). Similarly, the use of t-test isn't apposite in binary logistic regression because the errors in logistic regression aren't normally distributed as they are in t-test (Fey, 2002). On the contrary, binary logistic modeling uses Maximum Likelihood Estimation (MLE) instead of Ordinary Least Squares (OLS) to estimate the coefficient of parameters. Similarly the homogeneity of variance doesn't need to be satisfied in binary logistic modeling (Strauss, 1999). As show in Table 4.31, a binary logistic model was estimated and all variables significant at the 95 % level of confidence were retained for further analysis. From the model results, eleven variables were observed to exhibit statistical significance with the dependent variable on the basis of Wald test results (Washington, et al., 2003). The detailed mathematical formulation including significant independent variable for the estimated binary logistic framework in Equation 13 can be written as;

$$\begin{aligned}
\ln\left(\frac{\pi}{1-\pi}\right) &= \text{Logit (Pi)} \\
&= \beta_0 + \beta_1 \text{ (Age < 20)} \\
&+\beta_2 \text{ (Drv Experience < 1year)} \\
&+\beta_3 \text{ (Drv Experience 1-5 year)} \\
&+\beta_4 \text{ (Awareness of posted speed limit)} \\
&+\beta_5 \text{ (If helmet saved rider in a crash)} \\
&+\beta_6 \text{ (Rider who think helmet is for safety)} \\
&+\beta_7 \text{ (Rider who wears helmet legislation compliance)} \\
&+\beta_8 \text{ (Rider with helmeted pillion rider)} \\
&+\beta_9 \text{ (Rider reputedly facing visibility issues)} \\
&+\beta_{10} \text{ (Rider with a valid driving license)} \\
&+\beta_{11} \text{ (Rider reportedly facing rearview visibility issues)}
\end{aligned} \tag{19}$$

Table 4.29: Binary Logistic Regression Results of Helmet Use

S No.	Variable	Baseline Category	Coeff	Wald Stat	P Value	Odd Ratio
1	Constant	-	-3.684	10.104	0.002	0.025
2	Age less than 20 years indicator	Age above 50 years indicator	-1.440	4.196	0.018	0.236
3	Driving experience less than 1 year indicator	Driving experience more than 10 years indicator	-0.559	4.587	0.002	0.571
4	Driver experience 1-5 years indicator	Driving experience more than 10 years indicator	-0.919	8.676	0.009	0.398
5	Rider aware of speed limits indicator	Rider not aware of speed limits indicator	0.706	10.986	0.007	2.026
6	Rider saved in past crash by helmet indicator	Rider not saved in past crash by helmet indicator	1.563	12.505	0.000	4.773
7	Rider who think helmet provides safety Indicator	Rider who think helmet can't provide safety	4.860	42.671	0.000	12.92
8	Rider who wear helmet because legislation compliance indicator	Rider not wearing helmet because of legislation compliance indicator	2.630	21.970	0.000	13.87
9	Rider with helmeted pillion rider indicator	Rider with no helmeted pillion rider indicator	1.590	4.642	0.031	4.904
10	Rider reportedly facing visibility issues due to helmet indicator	Rider reportedly facing no visibility issues due to helmet indicator	-0.749	3.651	0.006	0.472
11	Rider with valid license indicator	Rider with no valid license indicator	0.507	7.351	0.024	1.660
12	Rider reportedly facing rearview visibility issues indicator	Rider reportedly facing no rearview visibility issues indicator	-0.524	4.650	0.016	0.592

(Note: Model summary statistics: Number of observations=363; degrees of freedom = 11; log likelihood = -114.0904; restricted log likelihood = -233.078; adjusted McFadden's Pseudo rho-squared (ρ^2) = 0.510. Dependent variable Helmet Use particulars: Rider wearing helmet coded 1, Rider not wearing helmet coded 0.)

For evaluating the impact of different independent variables on helmet use and to check the sensitivity of predictors with respect to the significant independent variables, elasticity of the significant independent variables were computed (Washington, et al., 2003). Elasticity is the percent change in the response variable with respect to incremental change in an independent variable. For continuous variable, elasticity values are used to check for the impact on dependable variable with respect to independent variable whereas, in discrete variables pseudo-elasticity values are used because elasticity cannot be defined in a standard way and elasticities are not valid for those indicator variable that take a value of 0 or 1 (Chang and Mannering, 1999). The pseudo elasticity values of a variables relevant to its category represents the percent change in the probability of response variable when the indicator variable is changed from 0 to 1.

$$E_{x_{ink}}^{P(i)} = e^{\beta_{ink}} \frac{\sum_{i=1}^{n} e^{\beta i' x_n}}{\sum_{i=1}^{n} e^{\Delta(\beta i' x_n)}} - 1 \tag{20}$$

This way, when the discrete variable changes from one value to another value, the variation in choice likelihood of a discrete variable is easily described (Shankar and Mannering, 1996). Equation 20 explains how direct pseudo-elasticity, $E_{x_{ink}}^{P(i)}$, of any dependent variable (k) is obtained from variable x_n (Ulfarsson and Mannering, 2004).

The variables with the lowest pseudo-elasticity values show the lowest impact on the dependent variable; which in this case is seatbelt auto alarm indicator which has the lowest impact on seatbelt use (Table 4.30). In order to check the elasticity of an explanatory variable relevant to independent variable having the lowest elasticity value, the relevant pseudo-elasticity values are computed by taking a ratio of the pseudo-elasticity values of each predictor by the pseudo-elasticity values of that variable which has the least impact on the dependent variable. This procedure helps to classify all independent variables on the basis of their impact on the dependent variable.

Table 4.30: Pseudo-Elasticity (ei) and Relevant Pseudo-Elasticity (ei*)

Variable	**ei**	**ei***
Age less than 20 years indicator	0.107	3.242
Driving experience less than 1 year indicator	0.033	1.000
Driving experience 1-5 years indicator	0.180	5.455
Rider aware of poste speed limits indicator	0.066	2.000
Rider saved in past by helmet in a crash indicator	0.087	2.636
Rider who think helmet provides safety indicator	0.266	8.061
Rider wearing helmet because of legislation compliance indicator	0.223	6.758
Rider with helmeted pillion rider indicator	0.038	1.152
Rider reportedly facing visibility issues due to helmet indicator	0.090	2.727
Rider with valid driving license indicator	0.075	2.273
Rider reportedly facing rearview visibility issues indicator	0.061	1.848
Constant	-	-

The goodness of fit of the model is checked by Likelihood ratio test and McFadden's Pseudo R-squared (R^2) which cautiously indicate that how data set is adequately fitted in a Logit model (Menard, 2002). The R-squared (R^2) equal to 1 represents that the model perfectly fits the dataset however, 0 indicates the absence of any dependence of explanatory variables on response variable (Ayalew & Yamagishi, 2005). For values of Pseudo R-squared (R^2) higher than 0.2, a reasonably better fitted model is presented (Clark and Hosking, 1986). (R^2) value of 0.51 is obtained in this study which is greater than 0.2 and assures adequate model fit. The findings are consistent with the past research that utilized the same criteria to investigate goodness of fit of the model (Yannis et al. 2011; Ozdemir, 2011).

Table 4.31: Determination of Goodness of Fit of the model

Information Statistics For Discrete Choice Model	**Value**
Number of Parameters	12
Log likelihood LL(0) (Restrained Model)	-233.0785
Log likelihood LL(B) (Fitted Model)	-114.0904
McFadden's Pseudo R-squared	0.51051
Likelihood Ratio Test	Restrained against fitted model
LR= -2 [LL(B)-LL(0)]	237.976
Degrees of Freedom	11
Critical X^2 at 95 % level of confidence	19.68
Number of Observations	363

Likelihood Ratio Test (LLT) is the measure of deviance which shows the lack of fitness of the model. Lower values of deviance means higher model fit (Hosmer and Lemeshow, 2000). The test compares the log likelihood of restrained model with the log likelihood of the model at convergence. A lower value of log likelihood of fitted model in comparison to the null model meets the criteria (Cohen, et al., 2002). The deviance of model at convergence is subtracted from deviance of restrained model in order to evaluate the contribution of explanatory variables in the model. The difference in deviance is later assessed on a chi-square distribution where the number of parameters estimated account for the degrees of freedom In this study the criteria is met since, LR= -2 [LL (B)-LL (0)] = -2 [(-233.07)-(-114.094)] = 237.976 > 19.68 = x2 for 11 *df* and for 95 % level of confidence. The test represents that the computed model is statistically preferred as compared to the one with no predictors, and the predictors included are considered statistically significant. The results are consistent with past studies performed by Yannis et al. (2011) and Gourieroux et al., (1982).

The sign of the coefficient of each explanatory variable in the model highlights the impact that the corresponding variable has on the explanatory variable (Yannis, et al., 2011). The negative sign of age indicator suggests that there is a low likelihood of helmet use for riders less than 20 years as compared to the riders aged above 50 (baseline category). The odds ratio highlights that the odds of using helmet among riders with age less than 20 years are 0.236 times the odds of those riders that have age above 50 years. The finding is intuitive and consistent with the past research that highlighted that young and novice drivers are more prone to helmet defiance as compared to mature and adult riders (Skalkidou et al., 1999; Bianco et al., 2005; Young 1980; Oginni et al., 2007; Yagil 1998; Harré et al., 1996; Jonah and Brian, 1990; Simon et al., 1996).

The negative sign of driving experience < 1 year indicator suggests that the probability of wearing helmet in riders with driving experience less than 1 year is less than those riders whose driving experience is more than 10 years (baseline category). The odds ratio suggests that the odds of using helmet among riders with driving experience less than 1 year are 0.236 times the odds of helmet use among riders with driving experience more than 10 years. Similarly, for riders with driving experience between 1-5 years, the probability of wearing helmet is 0.571 times the probability of those riders who have driving experience of more than 10 years.

The positive sign of posted speed limit awareness indicator suggests that the likelihood of wearing helmet among drivers that are aware of posted speed limits is higher than those drivers that aren't aware of the posted speed limits on the roads that they are travelling on. Similarly, the odds ratio shows that the probability of wearing helmet in riders aware of speed limit is 2.02 times more than that of those drivers that aren't aware of speed limit. This finding is perceptive and logically consistent with past research because careful drivers will ensure safe driving through compliance of speed limits and agreement on helmet use (Kraus et al., 1995; Van et al., 1998; Chesham et al., 1993).

Riders that were reportedly saved by helmet in their past crash histories contribute positively to the probability of wearing helmet. This finding is intuitive because for those riders that were saved due to helmet, there is an increased level of confidence on effectiveness of helmets to prevent injuries. Similarly, riders will be more protective and cautious. For that reason, the likelihood of wearing a helmet in those riders who met a crash where helmet saved them are 4.77 times higher than those drivers that didn't encounter a crash where helmet was a life savior. The relationship is consistent to past research (Keng 2005; Bachani et al. 2017; Haqverdi et al. 2015). Similarly, findings suggest that the probability of wearing helmets among riders who wear helmets because of legislation compliance is 13.87 times more than those riders who avoid helmet use because of disregard to laws on helmet use.

A few cases were observed where passenger accompanied by riders were using helmets. The study indicates that for those cases where an accompanying passenger on a pillion seat is wearing a helmet, the chances of the rider wearing a helmet are very high. This is precisely obvious because drivers that convince their bike share users to use helmet will surely comply with helmet use. The model estimates a positive coefficient it this regard that shows an increased probability of wearing helmet in those drivers that have their passengers with helmet on. The odds (likelihood) of wearing helmet are 4.9 times higher than the odds of those riders who have bike share users with no helmet on. The finding is intuitive and similar to the past research that manifests the same results (Burnham, 2012).

The model highlighted that the probability of helmet use is decreased in those drivers who encounter issues in visibility as compared to those drivers that didn't report any visibility issues. The model estimates negative coefficient to this parameter that shows that effect in visibility will cause the rider to defy the use of helmet. Similarly, the likelihood of helmet use in those riders that face visibility issues is 0.47 times as compared to those drivers who didn't face any visibility issues. This finding is intuitive and consistent to the past research (Victoria et al. 2017; Lai and Haung 2008; Norvell et al. 2002).

The model predicts that those riders that own valid driving license contribute positively to the use of helmet as compare to those riders that don’t own valid driving license. Similarly the odds ratio highlights that the probability of wearing helmet for rider having valid license is 1.66 times more than those riders that didn’t own valid driving license. The finding is plausible and consistent to the past research (Papadakaki et al. 2013; Xuequn et al. 2011; Alavijeh et al. 2011).

Drivers who self reportedly admitted to ignore helmet use indicated that helmet cause a decrease in rear-view vision. The model predicts that rear-view vision issues contribute to decrease the probability of wearing helmets by an odds of 0.592- that is, the probability of wearing helmet in riders that face rear-view observation issues is 0.592 times the probability of using helmet among those riders that do no face rear-view vision issues. This finding is intuitive because several riders don’t use helmet because they encounter issues to observe rear-view and in their perspective it can be more hazardous to wear helmet than not to. This finding is intuitive and well consistent with the past research (Orsi et al. 2012).

The impact of each independent variable on helmet use is also explored by calculating the pseudo-elasticity values. As shown in Table 4.31, the pseudo-elasticity of helmet use is greatest for “rider who think helmet is for safety indicator”, which means that the impact on helmet use is highest for the case when the rider acknowledges that helmet is for his own safety and he will always use one. Similarly, the pseudo-elasticity values for helmet use is the lowest for “driving experience < 1year indicator”, which means that the impact on helmet use is the highest for the case when the rider has driving experience less than one year. The relevant pseudo-elasticity values help to classify the impact of all independent variables, which in this case shows that “helmet is for safety indicator” has 8.06 times more impact than “driving experience < 1 year indicator”. Furthermore, the impact of “license indicator” is 2.27 times more than “driving experience < 1 year indicator”. As far as physical discomposure and visibility issues due to helmet are concerned, it was found that riders being faced by visibility and review vision issues have 2.72 and 1.84 times more impact on helmet use as compared to the riders who have driving experience less than 1 year.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Synopsis of the Research

In the present study an analysis of legislation and level of compliance of key crash risk factors (speeding, drink driving, seatbelt, helmet and child restraint) for Islamabad city has been carried out. The data on legislation of key crash risk factors and penalties related to different offenses were obtained from Islamabad Traffic Police (ITP) and National Highway and Motorway Police (NHMP). The data on legislation revealed that both enforcing agencies follow Motor Vehicle Ordinance of 1965 with few recent amendments. It was found that there is no legislation on child restraint in Pakistan. However, for seatbelt and helmet use there are well defined laws but the penalties in cases of seatbelt or helmet law violation are substantially low. Similarly, the legislation on seatbelt doesn't obligate manufacturers to necessarily install seatbelt in all vehicular classes. Moreover, there is no legislation to standardize the quality of crash helmets according to "UN Regulation No. 22" which ensures that helmets available in the markets are strong enough to avoid head injuries in cases of crash involvement.

Furthermore, the study revealed that comprehensive legislation exists on speeding but practically there is no/very low speed enforcement. Also, the as per current legislation there is no penalty or disqualification system for speed violators. In addition, the legislation doesn't differentiate between a high speed offence and a low speed offense and imposes the same penalty for both offences. Moreover, appropriate legislation exists for driving under influence with heavy fines and imprisonment up to 6 months but there exists no legislation to implement drug evaluation and classification program in Pakistan for evaluating the cases of impaired driving. Similarly, the legislation doesn't require the violators to undergo an educational course/ community service or rehabilitation program as practiced worldwide.

Thenceforth, the level of compliance of key crash risk factors has been carried out by conducting self-reported questionnaire survey, speed monitoring by radar gun and interviews from traffic wardens. The survey revealed 67.44 %, 65.8 % and almost negligible, compliance of seatbelt, helmet and child restraint laws respectively. However, speed monitoring revealed an overall 35.22% speed violation with the highest percentage violation on collector roads. In order to investigate factors affecting the use of seatbelt and helmet, numerous trials in N-Logit were executed to develop two separate binary logistic models. Seatbelt usage data modeled using binary logistic regression revealed a low likelihood of seatbelt usage among (1) male drivers (2) taxi drivers (3) drivers with low level of education (3) drivers without history of past crashes (4) drivers that self-reportedly violate speed limits (5) drivers never penalized on seatbelt violation and (6) drivers with no seatbelt auto alarm installed in their vehicles. Moreover, helmet usage data modeled using binary logistic regression revealed that there is a low likelihood of helmet use in (1) young and novice riders (2) riders without valid driving license (3) riders who reportedly face visibility issues at night due to wearing helmet and (4) riders who reportedly face rearview visibility issues due to helmet use. Furthermore, interviews from traffic wardens revealed that opium, hashish and cannabis are commonly consumed drugs and there are no testing equipment such as alcohol or pot Breathalyzer that could test drug use among drivers. It was also revealed that traffic wardens were not aware of any psychological observational techniques such as “walk and turn test”, “one leg stand test” and “finger to nose test” to evaluate possible cases of DUI.

5.2 Conclusions and Recommendations

It is revealed that the current legislation on key crash risk factors in Pakistan is outdated and existing penalties for various traffic violations of key crash risk factors are substantially low. Currently, there is no legislation on child restraint in the country which is a matter of serious concern and demands immediate attention of policymakers. As there is no penalty or disqualification system for speed violators and low and high speed violation have same fine, it is envisaged that speeding violation shall continue to occur. In the absence of appropriate legislation on helmet standards, even high helmet use compliance may not results in reduce injury severity in case motorcycle crashes. Also, manufacturing of vehicles without seatbelts continue to provide excuse for low compliance and pose safety challenge for road user.

Upon investigating level of compliance of key crash risk factors, it was revealed that seatbelt displayed the maximum level of compliance as compared to other key crash risk factors. As High compliance of seatbelt use may be attributed to its ease of monitoring and higher enforcement as compared to other key crash risk factors. A higher percentage of speed violation on collector roads as compared to major / minor arterials was found in this study. This difference in speed violation may be attributed to unrealistically low posted speed on collector roads that need further investigation. Moreover, interviews from traffic wardens revealed that there is more drug use in commercial drivers as compared to non-commercial drivers. This may be due to some specific behavior by a group of drivers that needs further investigation. Generally educated and old age drivers were found better compiling to seat belt and helmet use laws. This is also intuitive and suggests improved driving behavior with education and experience.

The research findings suggest better legislation on all key crash risk factors specially child restraint law. Also, there is need of improved enforcement and public awareness campaigns to increase overall level of compliance of key crash risk factors. In addition, strict enforcement on speed should be implemented to discourage speed offenses however, in case of speed violation, a higher penalty should be imposed in order to discourage drivers for subsequent violation. At national level there is a need to standardize quality of crash helmets and mandatory installation of seatbelt in all newly manufactured vehicles.

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Appendix A: Sample Interview Conducted from Traffic Wardens on Driving Under Influence of Drugs or Alcohol

1. What type of drugs have you observed so far that are used by drivers while driving?
a. Hashish (Local Name Chars)
b. Opium/ Heroin
c. Alcohol
d. Weed / ICE
e. Other

2. In your opinion what percentage of drivers use drugs while driving …………….?

3. Have you ever caught any driver while under the influence of drugs (DWI/DUI)?
a. Yes
b. No

4. If yes, how frequently do you observe drivers who are under influence of drugs or alcohol?
a. Daily
b. Weekly
c. Monthly
d. Annually
e. Other

5. Are you equipped with any testing mechanism like Alcohol Breathalyzer or Pot Breathalyzer to test the level of intoxication of an influenced driver? Is there any psychological assessment technique to investigate drug impaired drivers such as “walk and turn test”, “one leg stand test” or “finger to nose test” ?
a. Yes
b. No

6. Do you know the penalty for driving under influence? Please elaborate.
a. Yes
b. No
c. Elaboration ……………………………

7. Have you ever registered a case of a drink driver and reported it to the Crime control department of Police?
a. Yes
b. No

8. At what time of the day do you observe drivers to be under the influence of drugs or alcohol?
a. Morning d. Night
b. Afternoon e. Midnight
c. Evening

9. What is the general age of Drivers that you have observed to be under the influence of drugs or alcohol (DUI)?
a. 18-25
b. 25-30
c. 30-40
d. 40-50
e. Any other specific age groups

Appendix A: Sample Interview Conducted from Traffic Wardens on Driving Under Influence of Drugs or Alcohol (Continued)

10. Are there any rehabilitation countermeasures for drivers who are held for drink driving?
a. Yes
b. No

11. In which areas of Islamabad have you or your fellow colleagues have observed most cases of DUI?

12. Have you ever observed Alcohol-impaired driving crashes, If yes, How many till now?
a. Yes
b. No
c. How many …………….?

13. Does ITP suspend driving licenses of those drivers who are caught while driving under influence (DUI)?
a. Yes
b. No

14. What type of vehicles upon your observation have been used by drivers that were either drunk or under influence of drugs?

a. Scooter (Motorcycle)
b. Sedan/ Passenger Car
c. SUV / 4*4 / Prado / Land Cruiser
d. Truck/ Commercial Wagons

15. In your opinion, what measure shall be taken by Islamabad traffic Police (ITP) to minimize the cases of drink driving or driving under the influence of drugs?

Appendix B: Sample Questionnaire Survey on Helmet

1. Gender

- Male
- Female

2. Age

- Less than 20
- 20-30
- 30-40
- 40-50
- Above 50

3. Do you own a valid motorcycle license?

- Yes
- No
- Applied for it

4. For how long have you been driving?

- Less than 1 year
- 1-5 years
- 5-10
- More than 10 years

5. Do you know the speed limit to be followed on this road?

- Yes
- No

6. Why do you follow the speed limits?

- Personal Safety
- To avoid penalty
- No Response
- Other

7. Have you ever been penalized for not wearing helmet?

- Yes
- No

8. Have you ever met an accident where helmet saved you?

- Yes
- No

9. Where do you buy your helmet?

- Local bike shop
- Internet
- Other

Appendix B: Sample Questionnaire Survey on Helmet (Continued)

10. How do you feel about wearing your helmet?

- I have to, it's a law
- It's for safety and I would always wear one
- I don't wear a helmet

11. How much did you spend on your helmet?

- Less than 1000
- 1000-2000
- More than 2000

12. Would you like helmet law in Islamabad to continue?

- Yes
- No

13. If you have a passenger with you, does he use a helmet?

- Yes
- No

14. Where do you prefer wearing helmet?

- Low traffic Area
- High traffic Area
- In every traffic condition

15. Do you face any problem to observe rear view while wearing helmet?

- Yes
- No

16. Does helmet effect your visibility during night or rain?

- Yes
- No

17. Does your helmet limit the ability to hear different sounds while driving?

- Yes
- No

18. Do you feel uncomfortable and heated while wearing helmet?

- Yes
- No

19. Do you use cell phone while driving?

- Yes
- No

Appendix B: Sample Questionnaire Survey on Helmet (Continued)

20. How much do you believe that the Helmet law is effective in Islamabad?

- ✓ Rate from 1-10:

21. How much do you believe that the Motorcycle speed law is effective in Islamabad?

- ✓ Rate from 1-10:

Appendix C: Sample Questionnaire Survey on Seatbelt, Speeding and Child Restraint

1. Type of Vehicle
   - Car
   - SUV
   - Suzuki Van
   - Taxi
   - Truck

2.Gender
   - Male
   - Female

3. Marital Status
   - Single
   - Married

4. Age
   - Under 20
   - 21-30
   - 31-40
   - 41-50
   - 51-60
   - Above 60

5. Highest Qualification
   - Primary / 5th grade
   - Matric / 10th grade
   - Intermediate / 12th grade
   - Graduate
   - No education

6. Do you have a valid driving license?
   - Yes
   - No
   - Learner

7. For how long have you been driving?
   - Less than 1 year
   - 1-5 years
   - 5-10 years
   - More than 10 years

8. Do you know the speed limit to be followed on this road?
   - Yes
   - No

9. Why do you follow the speed limits?
   - Personal Safety
   - To avoid penalty
   - No Response
   - Other

Appendix C: Sample Questionnaire Survey on Seatbelt, Speeding and Child Restraint (Continued)

10. Do you drive as per the speed limits or like to over speed?
    - Drive as per the speed limits specified
    - Like to over speed
    - Other

11. If you like to over speed, how much speed limits do you prefer to follow?
    - 40-60 Km/h
    - 60-80 Km/h
    - 80-100 Km/h
    - 100-120 Km/h
    - Above 120 Km/h
    - Other

12. Have you ever been penalized/fined for over-speeding?
    - Yes
    - No
    - More than once

13. Is there provision of seat belt and child restraint (baby car seat) in your vehicle?
    - Front seat belt only
    - Front and Rear seat belts
    - Front seat belt and Child restraint (Baby car seat)
    - Front & Rear seat belts and Child Restraint (Baby car seat)

14. Condition of the seat belt, if seat belt installed?
    - Seat belt working / functional
    - Seat belt Not functional
    - No Seat belt installed

15. Fastening of seat belt?
    - Only by driver
    - Driver & front seat passenger only
    - Driver & front and rear seat passengers
    - Nobody

16. Why do you wear seat belt? (If fastened)
    - To avoid penalty/fine
    - The seat belt auto alarm/reminder makes an irritating noise until I fasten it
    - Personal safety, as seat belts are lifesaving by lessening the impact of a crash
    - It is a law
    - No response
    - Other:

17. Why do you not wear a seat belt? (If not fastened)
    - Seat belt not fitted / faulty
    - Forgot
    - Illness / discomfort
    - Unaware of the law
    - Lack of enforcement
    - Short drive / low speed
    - Not a habit
    - Other

Appendix C: Sample Questionnaire Survey on Seatbelt, Speeding and Child Restraint (Continued)

18. Have you ever met an accident?
    - No
    - Yes (One time)
    - More than Once

19. Were you wearing seat belt at the time of accident?
    - Yes
    - No
    - Have not met an accident ever

20. Did you get an injury due to any accident? If yes, what was the severity of the injury?
    - Have never met an accident
    - Very Serious Injury
    - Severe Injury
    - Minor Injury
    - No injury

21. Have you ever been penalized / fined for a seat belt violation on this road?
    - No
    - Yes (One time)
    - More than once

22. On what sort of journey, do you wear seat belt?
    - Long distance only
    - Short distance only
    - Both long and short distance
    - When there is chance of police enforcement

23. Do you allow your child / kid to sit on front passenger seat of your vehicle?
    - Yes
    - No

24. Any child / kid sitting on front passenger seat during interview survey?
    - Yes
    - No

25. Whether any child / kid sitting in baby car seat (properly secured) or not?
    - Yes properly secured
    - No

26. In your opinion, how much is the safety risk while driving without wearing seat belts and child restraint?
    - Very High Safety Risk
    - High Safety Risk
    - Moderate Safety Risk
    - Low Safety Risk
    - No Risk

Appendix C: Sample Questionnaire Survey on Seatbelt, Speeding and Child Restraint (Continued)

27. Do you have Air bags installed in your car?
- Yes
- No
- Don't know exactly

28. Do you have provision of auto alarm/reminder for seat belts in your car?
- Yes
- No

30. Average Monthly Income?
- Under Rs.10,000
- Rs.10,000 to Rs.20,000
- Rs.20,000 to Rs.40,000
- Rs.40,000 to Rs.60,000
- Rs.60,000 to Rs.80,000
- Rs.80,000 to Rs.1,00,000
- Rs.1,00,000 to Rs.2,00,000
- More than Rs.2,00,000
- No Response

31. In your opinion, how much effective is the Speed Enforcement law in Islamabad (please rate enforcement on a scale of 0 to 10)?

✓ Rate from 1-10:

32. In your opinion, how much effective is the Seat belt law in Islamabad (please rate enforcement on a scale of 0 to 10)?

✓ Rate from 1-10:

33. In your opinion, how much effective is the Child Restraint law in Islamabad (please rate enforcement on a scale of 0 to 10)?

✓ Rate from 1-10: