# Estimation of National Road Crash Injuries Using Data from Multiple Sources

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| | |
|---|---|
| UN | United Nation |
| WB | World Bank |
| TRL | Total Road length |
| PRL | Paved Road Length |
| RCI | Road Crash Injuries |
| RTC | Road Traffic Crashes |
| RCF | Road Crash Fatalities |
| OLS | Ordinary Least Squares |
| GDP | Gross Domestic Product |
| GOP | Government of Pakistan |
| VRUs | Vulnerable Road Users |
| ADB | Asian Development Bank |
| SIP | Social Indicator of Pakistan |
| GBD | Global Burden of Disease |
| NDC | National Data Coordinator |
| WHO | World Health Organization |
| ESP | Economic Survey of Pakistan |
| MOC | Ministry of Communication |
| PTPS | Pakistan Transport Plan Study |
| SAARC | South Asian Association for Regional Cooperation |
| LIMDEP | Limited Dependent Models |
| MAPE | Mean Absolute Percentage Error |

| | |
|---|---|
| GNI | Gross National Income |
| JICA | Japan International Cooperation Agency |
| OECD | Organization Economic Cooperation and Development |
| GB&AJK | Gilgit-Baltistan and Azad Jammu Kashmir |
| IPHTP | Injuries per Hundred Thousand Population |
| IPTRV | Injuries per Thousand Registered Vehicles |
| IPMVKMT | Injuries per Million Vehicle Kilometer Travelled |
| FPRB | Federal Police Research Bureau |

ABSTRACT

Every year, approximately 1.24 million fatalities and 20 to 50 million non-fatal injuries occur worldwide due to road traffic collisions. These pose a serious social and economic challenge to all countries around the world. . Effective road safety measures can only be introduced if the extent of the problem and its underlying factors are thoroughly explored. Unfortunately, reliable estimates of annual road crash injuries are not available for most countries. Pakistan faces a similar problem and in spite of a rapidly growing population and sharp increase in vehicle fleet size, no real efforts have been made to obtain estimates of the number of injuries resulting from road traffic crashes every year. This study presents an attempt at estimating annual road crash injuries for Pakistan using data provided by the World Health Organization (WHO) and International Road Federation (IRF). To estimate and explore the different factors responsible for road crash injuries in Pakistan, econometric models have been estimated using two different response variables: (1) injuries per hundred thousand population and (2) injuries per a thousand registered vehicles. Total number of registered vehicles, maximum speed on rural roads, enforcement levels of seatbelt law, income levels and safety audit of new roads were found as significant explanatory variables. Modelling results revealed that models estimated using international data were unsuitable and a poor fit \ for predicting annual road crash injuries for Pakistan. However, the developed models helped explore different factors responsible for road crash injuries. Annual road crash injuries for Pakistan were estimated using annual crash injuries data from seventy-four countries having vital registration systems. Based on the injuries per hundred thousand population, a total of 637,283 annual crash injuries have been estimated for Pakistan for the year 2014. This study also carried out a detailed comparison of road crash injury rates of Pakistan with other regional countries as well as countries with different income levels. These road crash injury estimates can be used by the National Highway Authority and Ministry of Communication as input for formulation of multipronged road safety improvement policies for Pakistan.

# CHAPTER 1. INTRODUCTION

## 1.1 Background

Recently, Road Traffic Crashes (RTC) have increased substantially, thus posing a great global challenge. The World Health Organization (WHO), in its report "Global Status Report on Road Safety – 2013", revealed that approximately 1.24 million people die yearly on roads and 20 to 50 million suffer non-fatal injuries as a result of RTC [WHO, 2013]. These consequences of RTC have proven to be an enormous public health challenge, besides leading to social disintegration of the concerned society by injury or death of its members. These impacts tend to be more intangible in countries that are less familiar with modern traffic management and safety strategies. Road Crash Fatalities (RCF) and Road Crash Injuries (RCI) are estimated to witness an increase of upto 65% in the coming 20 years. Therefore, the necessity to implement creative initiatives for the improvement of road safety around the globe, with special focus in poor countries is extremely important. Hospitals in many low and middle-income countries report that traffic-related injuries constitute about 30% to 86% of all trauma admissions. Moreover, the economic cost of RCI is roughly estimated to be around 1- 2% of gross national product (GNP) depending upon the level of development of a country [WHO, 2004]. It is predicted that if the present situation is not addressed and appropriate measures are immediately implemented, particularly in low and middle-income countries, RCI are likely to become the fifth-leading cause of death by the year 2030 [WHO, 2009].

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

A country's population needs an effective, safe and well maintained transportation infrastructure in order for the country's economy to flourish. The benefits are not limited to the country's economic or fiscal matters; they can also extend to the society and its individuals in general. Despite a slow economic growth in Pakistan in recent years, roads did not suffer much. In fact, a reasonably upward growth was observed in the length of roads. The increase is approximately from 148,000 kilometers (KM) in 2002 to 180,000 in 2012 [ESP, 2012]. Generally, the annual growth in road infrastructure in the last 10 years is approximated to be 0.38%.

Nevertheless, population, economy and road infrastructure was not kept in check and vehicle population grew at a high rate. Motorized vehicle population was observed to increase from 5.3 million in 2002 to 11 million in 2012, inclusive of all vehicle types [ESP, 2012]. The contribution of different vehicle groups is as follows: motorcycles (53%), motorcars (33%), tractors (9.3%), buses (1.2%), trucks (2.12%) and rickshaws (0.86%). [NTRC, 2011].

This rapid motorization resulted in higher RTC. RCI and RCF incur a significant economic burden on the country as approximately Rs. 100 billion is spent annually to counteract the negative effects of RCI and RCF [Baguley and Jacobs, 2000; Ahmed, A., 2007]. Estimates with regard to RCI have not been consistent. Deviations in previous studies are generally wide. NTRC, in 1999 estimated that roughly 1.4 million RTC took place in Pakistan [NTRC, 1999]. Studies conducted by Ghaffar et al., [2004] and Fatmi et al.,[2007] established that approximately 1,500 individuals per 100,000 population experience injuries caused by RTC in Pakistan annually. It is estimated that two million crashes took place in Pakistan in 2006 and 0.418 million were of the severe nature [Ahmed, A., 2007]. The number of RCI, according to the WHO report "Global Status Report on Road Safety-2009", are 12,990 for the year 2007; a clear indication of serious under-reporting. Therefore, there exists a need to make an effort at the national level to get reliable estimate of RCI.

None of the researches in past studies considered all the possible contributing factors to RCI. A plausible solution is to develop a model to pinpoint the factors contributing to RCI, with reasonable accuracy based on important variables. The result of this model can be used

for adopting appropriate policy measures to control increasing numbers of RCI and to estimate the annual average RCI in Pakistan.

## 1.2 Problem Statement

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

- Police and hospital data: National Highway and Motorway Police (NH&MP) is responsible for the gathering of data through their police thanas, for road traffic crashes. The data acquired from police may be useful but may not be consistent and is sometimes completely unreliable [NRSP, 2007]. Similarly data obtained from hospital records may have recording issues.
- International organizations: Many international organizations such as World Bank, WHO and Asian Development Bank publish data that can be valuable and helpful with regards to road crash injuries studies.

In Pakistan, there is no systematic procedure for road crash data recording, reporting and storing. Useful RCI data that is both accurate and regularly published or renewed is not yet available. For reliable estimates of RCI, there is a need of appropriate data that contains the required parameters such as population, gross national income, road infrastructure, registered vehicles and traffic laws and their enforcement. This study uses such data provided by international organizations to estimate annual road crash injuries in Pakistan.

## 1.3 Research Objectives

To overcome road safety problems in Pakistan, there is a need to play our role at the national level in inhibiting and reversing the current trends of RCI. Reliable estimation of annual RCI is an important step towards achieving a clear understanding of the nature of the

problem. The problem demands to explore factors affecting RCI. In order to address key aspects of the identified problem, the objectives set forth for this research are:

- To compare the RCI of Pakistan with regional/neighboring countries and with overall global trends to highlight the existence of data under-reporting issues, if they exist
- To develop a model that explores the factors responsible for RCI using aggregate country level data (data from countries that have vital registration system).
- To estimate the annual RCI for Pakistan.

## 1.4 Overview of Study Approach

A brief overview of study approach (Figure 1.1) is as follows:

- A literature review of previous findings of factors contributing to RCI will be conducted, encompassing both international and national efforts.
- RCI data will be collected and collated for Pakistan and other countries from established WHO, IRF and World Bank data sources.
- RCI rate of Pakistan will be compared with rates of other countries from South East Asia and Asia, and with low income countries from around the world.
- Statistical models will be estimated and factors responsible for RCI will be explored.
- RCI rate for Pakistan will be estimated.

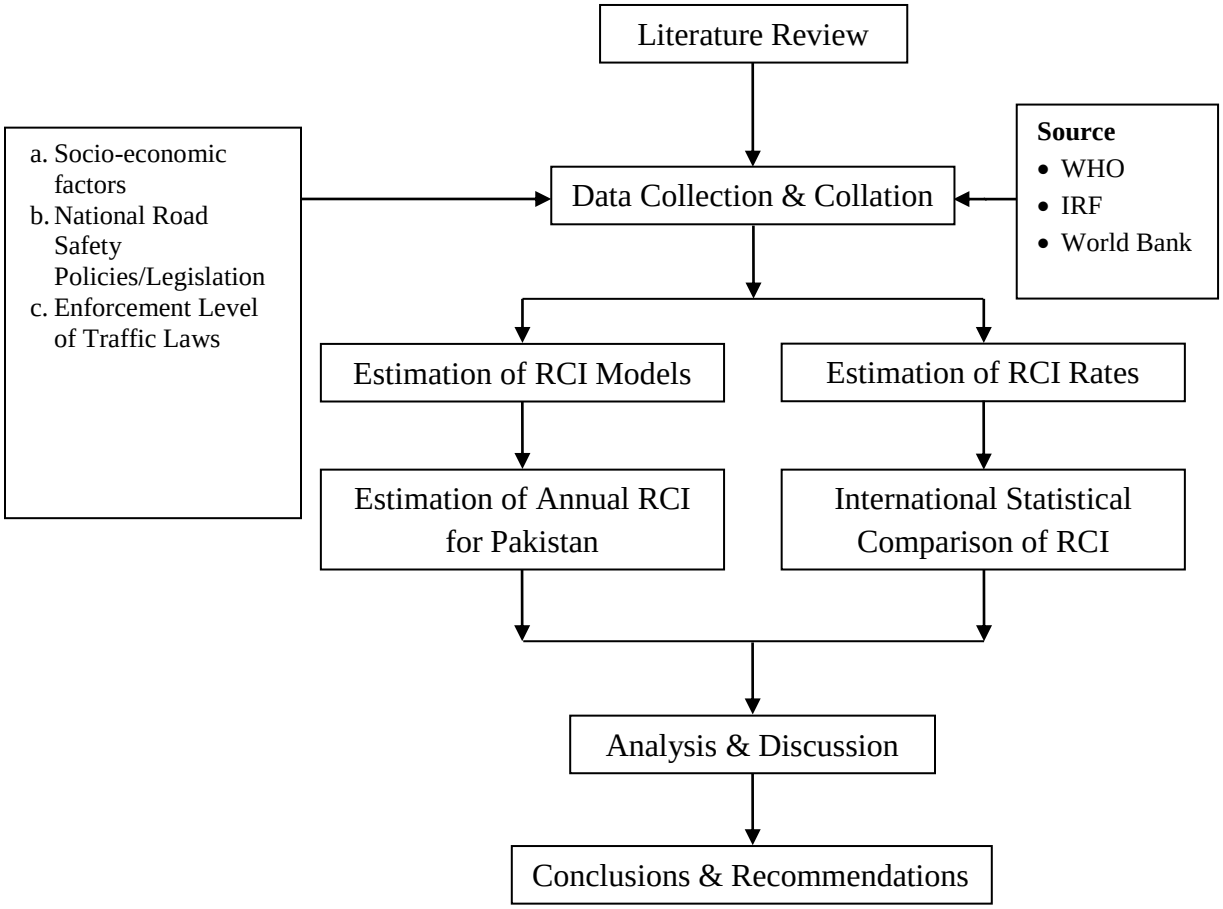


Figure 1.1 Overview of Study Approach

## 1.5 Thesis Organization

This research study comprises of five chapters. Chapter 1 discusses the necessity of reliable RCI estimation data, research objectives and study approach. Chapter 2 talks about what has already been developed and applied for RCI estimation through a comprehensive literature review., Chapter 3 presents a comparison between the RCI rate of Pakistan with South East Asian and Asian countries as well as with low-income countries from around the world.. Chapter 4 focuses on the factors associated with RCI and estimation of RCI. Finally, Chapter 5 presents the research summary, conclusions and recommendations.

# CHAPTER 2. LITERATURE REVIEW

## 2.1 General

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

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

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

## 2.2 Road Crashes Injuries - A Review of Past International Research

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

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

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

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

Another research highlighted the severity of motorcyclist crash injuries in Indiana State. The authors used probabilistic models to determine severity of crash injuries. Injury severity probabilities were influenced by various estimated factors determined using nested

logit and standard multinomial logit model. The authors concluded that the severity of injuries was related to age of the motorcyclist and various other factors like collision type, level of alcohol consumption, roadway characteristics, helmet use and unsafe speeding [Savolainen and Mannering, 2007].

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

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

Anastasopoulos et al. [2009] modeled vehicle crash frequencies using random parameters count models. The study used data from the Anastasopoulos et al. [2008] study. The study concluded that various factors such as pavement condition rating, international roughness index (IR), pavement rutting, pavement friction, length of segment under consideration, type of median, vertical and horizontal curves and shoulder width affect accidents rates. Traffic factors like AADT and percentage of truck in mix traffic streams were found to be significant in explaining the variation in accident rates.

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

Burgut et al. [2010] determined the risk factors involved in road traffic crashes in Qatar. That study utilized cross sectional data collected from health care centers in Qatar. It was found that about 26% of drivers were involved in road traffic crashes, out of which 69%

were males. Furthermore, about 23% of drivers involved in crashes did not use seatbelts while close to 38% of the drivers were either drinking or eating while driving. About 42% of these drivers were using mobile phones while driving.

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

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

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

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

Table 2.1 Summary of Past International Research on RCI

| Study | Data/Time of study | Modeling/ Analysis Technique | Factors related to RCI |
|---|---|---|---|
| Afukaar et al. (2003) | Ghana (1994-1998) | Standard surveillance method | Road type, vehicle type, crash location, age, gender, vehicle speed |
| Zargar et al. (2003) | Tehran (1999- 2000) | Linear regression | Pedestrians, age group, gender, safety devices (helmet and seat belt) |
| Hyder et al. (2006) | South Asia | Review of published articles | Age, gender, population, pedestrians, vehicle occupants, injury location |
| Caliendo et al. (2007) | Italy (1999-2003) | Poisson, negative binomial and negative multinomial | AADT, road length, road geometry and characteristics |
| Savolainen and Mannering (2007) | Indiana state (2003- 2005) | Nested and standard multinomial logit model | Roadway characteristics, helmet use, vehicle speed, motorcyclist age and alcohol consumption |
| Anastasopoulos et al. (2008) | Indiana state (1995-1999) | Tobit regression | Pavement conditions, traffic characteristics and roadway geometry |
| Rasouli et al. (2008) | Iran (1997-2006) | Retrospective analysis | Population and registered vehicles |
| Anastasopoulos et al. (2009) | Indiana state (1995-1999) | Negative binomial regression | AADT, pavement conditions, roadway geometry and traffic characteristics |
| El-Basyouny and Sayed (2009) | Vancouver, British Columbia (1994-1996) | Poisson-lognormal model (PLN) | Road geometrics, traffic characteristics, driver behavior and environmental factors |
| Burgut et al. (2010) | Qatar (2009) | Cross-sectional study | Excessive speed, traffic violation, driver behavior, age, gender and environmental factors |
| Moore et al. (2011) | Ohio state (2002-2008) | Multinomial and mixed logit model | Driver, vehicle, road geometry and environment |
| Chen and Chen (2011) | Illinois (1991-2000) | Mixed logit model (MXL) | Snow road surface, light traffic indicators, driver characteristics, vehicle characteristics and environmental characteristics |
| Schmucker et al. (2011) | India (2005-2006) | Bivariat analysis | Pedestrians, vehicle type, vehicle occupants, type of collision |
| Abay (2013) | Denmark (1998-2009) | Alternative disaggregate models | Pedestrians, motor vehicle, driver's crime history and marital status and driving license |

## 2.3 Road Crashes Injuries- A Review of Past National Research

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

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

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

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

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

Ghaffar et al. [2004] studied factors affecting road traffic injuries in Pakistan using household interview surveys. The study concluded that males, vendors, children under age of 5 years, the urban population and vehicle occupants were major victims of road traffic

injuries. The study had two major limitations: (1) inaccurate information (2) underreporting of accidents.

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

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

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

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

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

Mirza et al. [2013] studied the demographic distribution of road traffic accident victims in Karachi using one year cross sectional data from various hospitals. The authors carried out detailed analyses of autopsy reports (examination of dead bodies) of victims from police cases still under investigation. The study concluded that out of all autopsies, 27.8% cases were victims of road traffic accidents of which 55.8% were between the ages of 19-40 years. The ratio of males to females was 7:1. Furthermore, majority of RTA victims were pedestrians while the second highest number was of motorcyclists. The authors concluded that males ranging between 0-14 years are more vulnerable to road traffic accidents.

Shah and Khattak [2013] carried out analysis of road traffic accidents on motorways in Pakistan. The leading causes of road crashes identified included: (1) lack of driving education and skills (2) inferior geometrics and signage and poorly designed pedestrian facilities, (3) careless driving, (4) drivers falling asleep at the wheel, (5) burst tyres and (6) brake failures. A summary of past studies on RCI carried out in Pakistan is presented in Table 2.2.

Table 2.2 Summary of Past National Research on RCI

| Study | Data/ Time of study | Modeling/ Analysis Technique | Factors related to RCI |
|---|---|---|---|
| Razzak and Luby (1998) | Karachi city (1994) | Capture and re-capture method | Motor vehicle collision, time and location of crash, pedestrians, motorcyclists, vehicle type |
| Hyder et al. (2000) | Pakistan (1956) | Registry-based data | Increased motor vehicle crashes, commercial vehicles |
| Razzak et al. (2004) | Karachi city (1993-1996) | Standard surveillance method | Age, gender and crash type |
| Ghaffar et al. (2004) | Pakistan (1997) | Standard surveillance method | Age, gender, urban population, vehicle occupants |
| Bhatti et al. (2008) | Rawalpindi city (2005) | Cross-sectional survey | Age, gender |
| Razzak et al. (2011) | Karachi city (2007-2008) | Stratified sampling | Road user group, age, gender, household income |
| Farooq et al. (2011) | Rawalpindi city (2007-2008) | Standard surveillance method | Age, gender, site, activity, alcohol use |
| Hussain et al. (2011) | Islamabad (2009-2010) | Standard surveillance method | Road safety awareness, seatbelt/helmet use, under-age driving, vehicle fitness, legislative aspects |
| Shamim et al. (2011) | Karachi city (2006-2009) | Registry-based data | Age, gender, pedestrians, road user group |
| Bhatti et al. (2011) | Karachi (2008) | Comparative analysis of different data reporting system | Age, gender, road user group |
| Khan and Tehreem (2012) | Pakistan | Standard surveillance method | Lack of training, inexperienced drivers, road condition, cell phone usage, intoxicants use, overloading, mismanagement |
| Mirza et al. (2013) | Karachi (2008-2009) | Registry-based data | Age, gender, injury type |
| Shah and Khattak (2013) | Motorway M-2 (2009-2011) | Registry-based data | Lack of driving skill, lack of education, geometric design, careless driving, dozing at wheel, tyre burst, brake failure |

## 2.4 Chapter Summary and Conclusions

RCI are a crucial public health problem around the world. Various studies indicate that millions of people every year are injured while traveling and the figures are expected to keep rising unless innovative and determined efforts are directed to free society from this menace. The situation is improving in the developed world but continues to deteriorate in poor countries.

According to international studies, major contributing factors associated with RCI include road density, number of registered vehicles, population density, level of healthcare services, vehicle kilometers driven, traffic regulations, corruption levels, level of alcohol consumption and employment rates. Research findings show that augmented medical services, good quality of public transport, proper application of road safety regulations, stern enforcement of traffic laws/polices, higher level of road safety awareness, improved road design, strong multi-sectoral involvement in road safety and efficient accident reporting systems contribute towards lower road fatality rates.

No real efforts have has been made at the national level to estimate annual road crash injuries in Pakistan. However, multiple studies have investigated factors linked with RCI and RCF. National studies indicate that factors related to road crash injuries include over speeding, under-age driving, driver fatigue, violation of seatbelt laws, weather conditions, cell phone use while driving and poor road maintenance. National research findings show that better traffic law enforcement, effective road markings, proper seatbelt usage, improved vehicle maintenance standards, enhanced traffic safety education, improved driver licensing systems, modern accidents reporting systems, traffic safety awareness programs and better healthcare systems are likely to result in lower RCI rates.

# CHAPTER 3. INTERNATIONAL COMPARISON OF RCI

## 3.1 Introduction

This chapter compares RCI of Pakistan with South East Asian, Asian, low-income countries in particular and other countries in general from around the world. The data to be used in this study was obtained from WHO "Global Status Report on Road Safety (2009)". RCI rate is evaluated on the basis of "exposure". The normalized measures of relative road safety across the world are injuries per hundred thousand population (IPHTP), injuries per thousand registered vehicles (IPTRV) and injuries per vehicle-miles travelled. These measures have proven to be good surrogates to an individual's potential risk of crash. In this study, IPHTP and IPTRV are comparatively analyzed and illustrated as follows:

$$\text{IPHTP}=\left(\frac{\text{I}}{\text{P}}\right) * 100{,}000 \qquad (3.1)$$

$$\text{IPTRV} =\left(\frac{I}{RV}\right) * 1000 \qquad (3.2)$$

IPHTP is the number of injuries per hundred thousand population; P is the total population of a country; I is total number of injuries in a country; IPTRV is the number of injuries per thousand registered vehicles and RV is the total number of registered vehicles in a country.

## 3.2 Comparison of RCI

This section illustrates comparison of RCI of Pakistan with Asian countries (including South Asian countries), low, middle, and high income countries and in general countries around the world.

## 3.3 Comparison with Low Income Countries

In this group, pedestrians and cyclists form a large proportion of the victims of road crashes. In most of these countries, RCI represents 30% to 86% of all trauma admissions. Current and projected trends forecast a huge climb globally in mortality between the years

2000 and 2020 due to RCI. Without increased and systematic efforts to implement better road safety mechanisms, RCI is are expected to rise in future. Moreover, between the years 2000 to 2020, RCF and RCI are forecasted to increase by 65%, while in low and middle income countries, mortality is expected to rise by 80% [WHO, 2004].

Low levels of traffic law enforcement, especially non emphasis on wearing of helmets and fastening of seat belts, have contributed greatly to road crash injuries in low income countries (WHO, 2009). RCI data that can be useful for understanding the current state of road traffic safety in low-income countries is not available.

To enhance understanding of the current road safety situation in Pakistan, comparative analysis within countries of same or similar levels of income is conducted. Road infrastructure, socio-economic factors and traffic laws and their enforcement levels in such countries tends to be similar to conditions existing in Pakistan. Moreover, other low income countries do not have well established data reporting and recording systems, just like Pakistan, so comparison of road crash injuries with countries with same income levels, highlights the issue of data reporting and recording system in Pakistan. WHO (2009) states that Pakistan is considered a low-income country with an income of 870 US dollar per capita. This low-income category contains forty-one countries whose average IPHTP is 60. Pakistan's IPHTP is 7.93, much below the average. When the classification is limited to IPHTP, three countries have lower IPHTP than Pakistan. Sierra Leone has the lowest, with an IPHTP of 5.08. Pakistan is in fourth place among low-income countries based on IPHTP. Figure 3.1 displays these results.

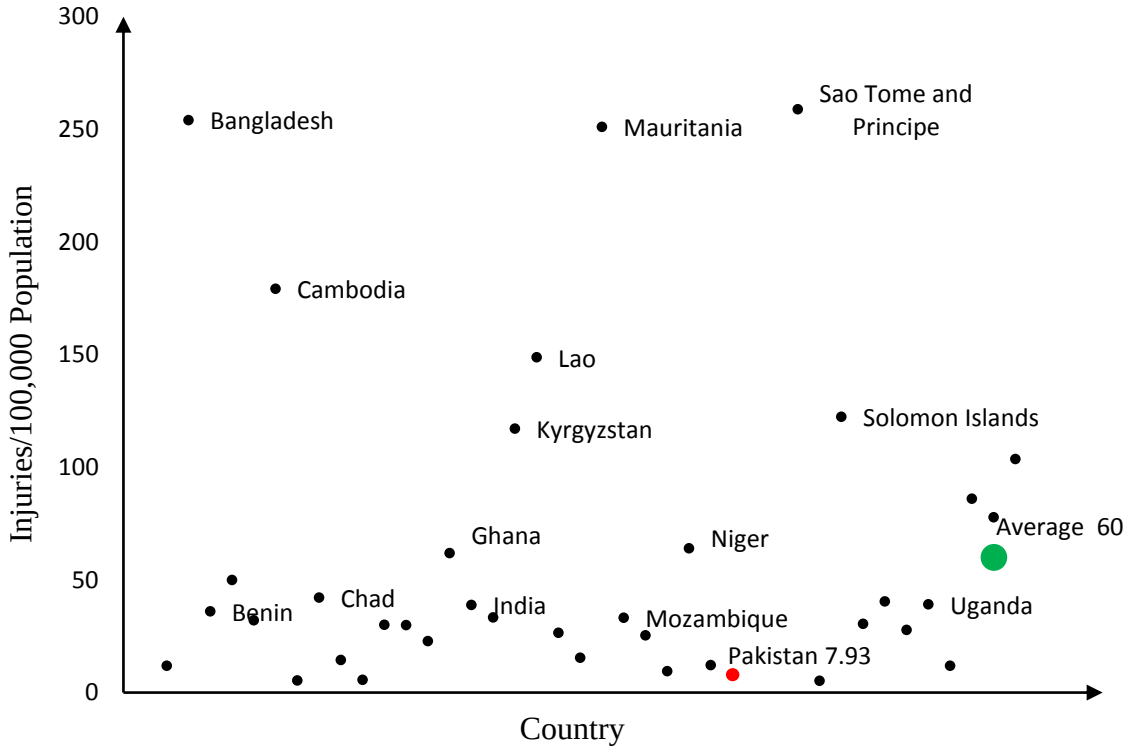


Figure 3.1 Comparison of Low Income Countries Based on IPHTP

The same analysis is carried out for IPTRV. Figure 3.2 highlights the position of Pakistan among other countries. The average value for low-income countries is 45.35. In this parameter, Bangladesh leads the group with an IPTRV of 382.33. Vietnam has the least IPTRV (0.45). The figure shows that two LIC countries have lower RCI rate than Pakistan.

Figure 3.1 and 3.2 indicate that Pakistan's RCI rate is very low. However, when this rate is compared with the country's population road infrastructure, it becomes evident that the data is under-reported. Pakistan's IPHTP and IPTRV are far below the average rate of other low income countries, another fact which supports the theory of under reporting issues.

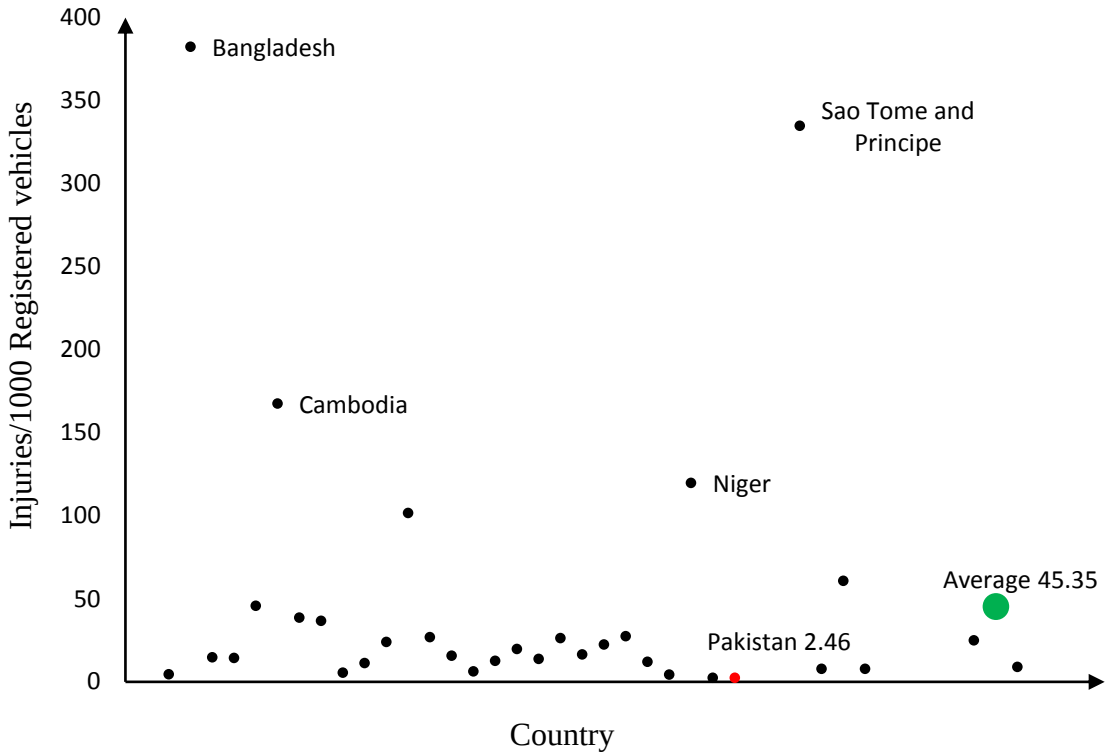


Figure 3.2 Comparison of Low Income Countries Based on IPTRV

## 3.4 Comparison with SAARC Countries

Recent estimates show that 40 people die every hour due to RCI worldwide. More than 903,977 people get injured yearly because of road crashes in SAARC countries. The issue of road safety will continue to adversely affect our society unless swift and adequate counter measures are brought into action.

Pakistan's road safety performance can be reasonably compared to other south East Asian countries, since Pakistan's road geometry, road environment and traffic conditions are somewhat similar to these countries. Figure 3.3 shows the link between IPHTP and six SAARC countries. Amongst these, Pakistan has one of lowest IPHTP. Judging by the results presented in the figure alone, it seems as though Pakistan is doing an excellent job with regard to RCI. However, when this result is compared with the population size of the country and its road infrastructure, it becomes clear that the data being compared is under-reported.

According to the figure, Bangladesh has the maximum RCI rate of 254 amongst SAARC countries.

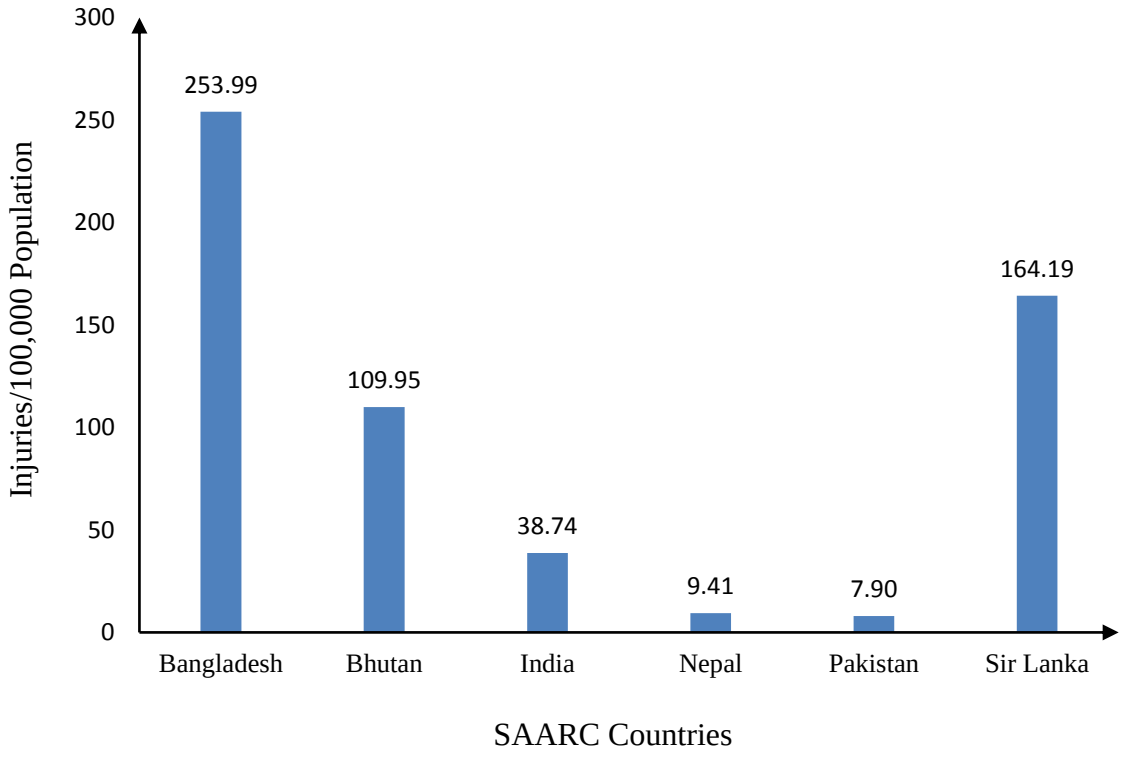


Figure 3.3 RCI in Pakistan Compared to SAARC Countries Based on IPHTP

Besides IPHTP, other facts can be deduced when comparing IPTRV among SAARC countries. When the IPTRV are compared, Pakistan is at bottom with the lowest IPTRV of 2.46. Bangladesh takes the top position with IPTRV of 382.33. This again may be attributed to under-reporting of RCI in Pakistan.

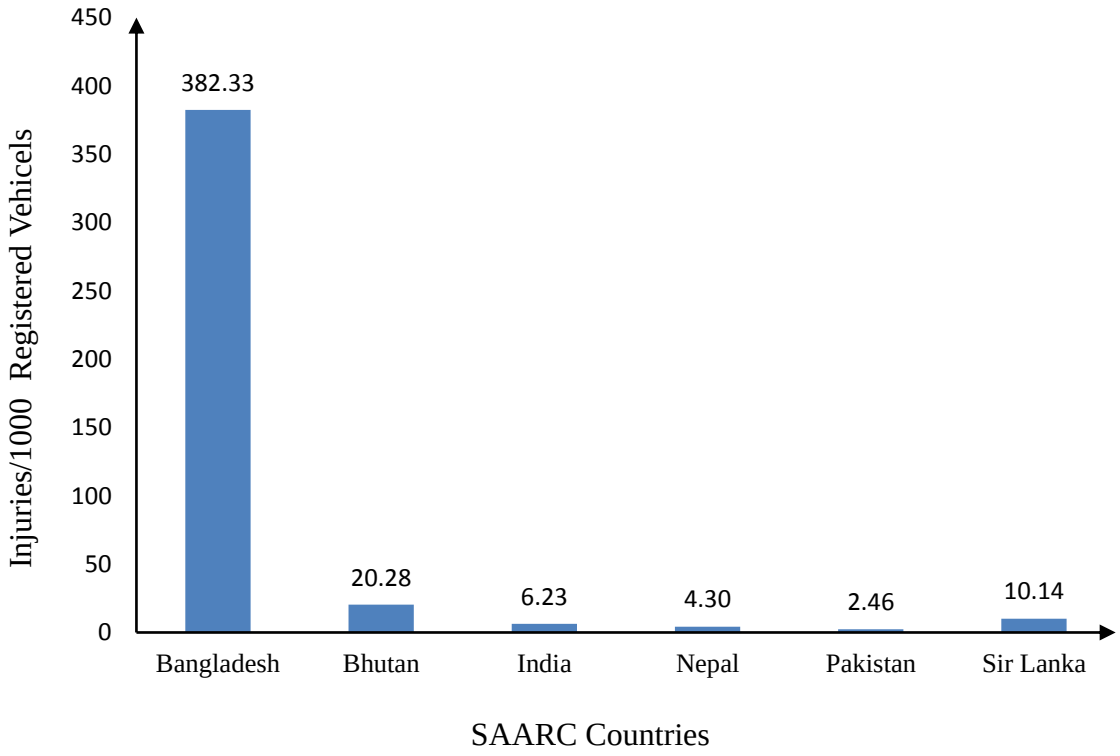


Figure 3.4 RCI in Pakistan Compared to SAARC Countries Based in IPTRV

## 3.5 Comparison with Asian countries

Asia is the largest continent of the world. Road crash injuries are directly related to the number of vehicles. Number of motor vehicles is rapidly increasing in Asian countries, of which motorized two-wheeled vehicles and three-wheelers are more dominant. The large proportion of these vehicles is responsible for a large number of road crash injuries [WHO, 2004]. The IPTRV and IPHTP for thirty-eight Asian countries are illustrated in Table 3.1.

Average IPHTP in Asia are 221.5. Thailand is one of the prominent Asian countries with a high RCI rate of 1523.24, Philippines lies at the bottom with an RCI rate of 1.9. Pakistan has a RCI rate of 7.93 which is astonishingly below the expected average. Countries with high/ better safety standards and strict enforcement of policies have low RCI rates. A large population growth leads to significant increase in travel demand. As a consequence, a definite rise of RCI risk is naturally expected. However, Pakistan's position as second last in the list , does not reflect the expected RCI value and brings into question the reliability of the

data upon which results have been constructed. In other words, the data for this study was supplied by individual countries to WHO and is very likely to be under-reported.

Table 3.1 RCI Rates of Asian Countries - 2007

| Country | IPTRV | IPHTP | Country | IPTRV | IPHTP |
|---|---|---|---|---|---|
| Afghanistan | 4.39 | 11.83 | Morocco | 39.08 | 285.88 |
| Bahrain | 8.92 | 453.73 | Myanmar | 11.82 | 25.32 |
| Bangladesh | 382.33 | 253.99 | Nepal | 4.30 | 9.41 |
| Bhutan | 20.28 | 109.95 | Oman | 13.55 | 328.73 |
| Brunei | 1.83 | 142.54 | **Pakistan** | **2.46** | **7.93** |
| Cambodia | 167.49 | 179.03 | Philippines | 1.06 | 6.67 |
| China | 2.97 | 32.26 | Qatar | 1.74 | 125.26 |
| Egypt | 3.58 | 20.40 | South Korea | 18.44 | 696.56 |
| India | 6.23 | 38.74 | Saudi Arabia | 4.87 | 145.65 |
| Indonesia | 1.04 | 28.51 | Singapore | 12.16 | 233.35 |
| Iran | 40.33 | 962.82 | Sri Lanka | 10.14 | 164.19 |
| Iraq | 3.33 | 25.75 | Sudan | 17.77 | 55.31 |
| Japan | 11.32 | 808.37 | Syria | 11.62 | 81.01 |
| Jordan | 21.34 | 303.31 | Thailand | 37.98 | 1523.24 |
| Kuwait | 6.29 | 301.07 | Timor-Leste | 63.27 | 146.00 |
| Lao | 13.59 | 148.72 | Tunisia | 11.69 | 140.98 |
| Lebanon | 4.48 | 152.86 | UAE | 6.36 | 254.65 |
| Malaysia | 1.27 | 80.40 | Viet Nam | 0.45 | 11.75 |
| Mongolia | 5.75 | 35.45 | Yemen | 24.76 | 85.99 |

(WHO, 2009)

Another criterion on which road safety can be evaluated is IPTRV, which has an average of 26.32 for Asian countries. Considering IPTRV, RCI rate is maximum for Bangladesh (382.33) and minimum for Vietnam (0.45). Pakistan comes in seventh place in ascending order, with an IPTRV of 2.46 in Asian countries, as highlighted in Figure 3.6. Again this low IPTRV rate of Pakistan may be attributed to serious under-reporting of data.

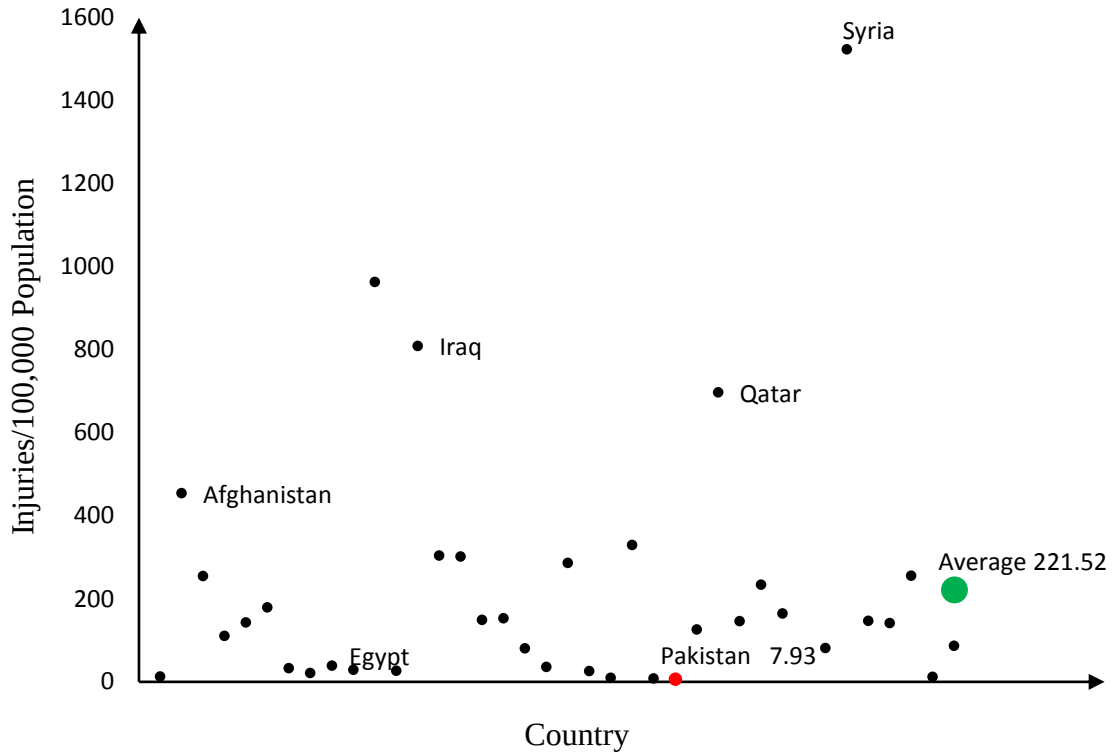


Figure 3.5 RCI in Pakistan Compared to Asian Countries Based on IPHTP

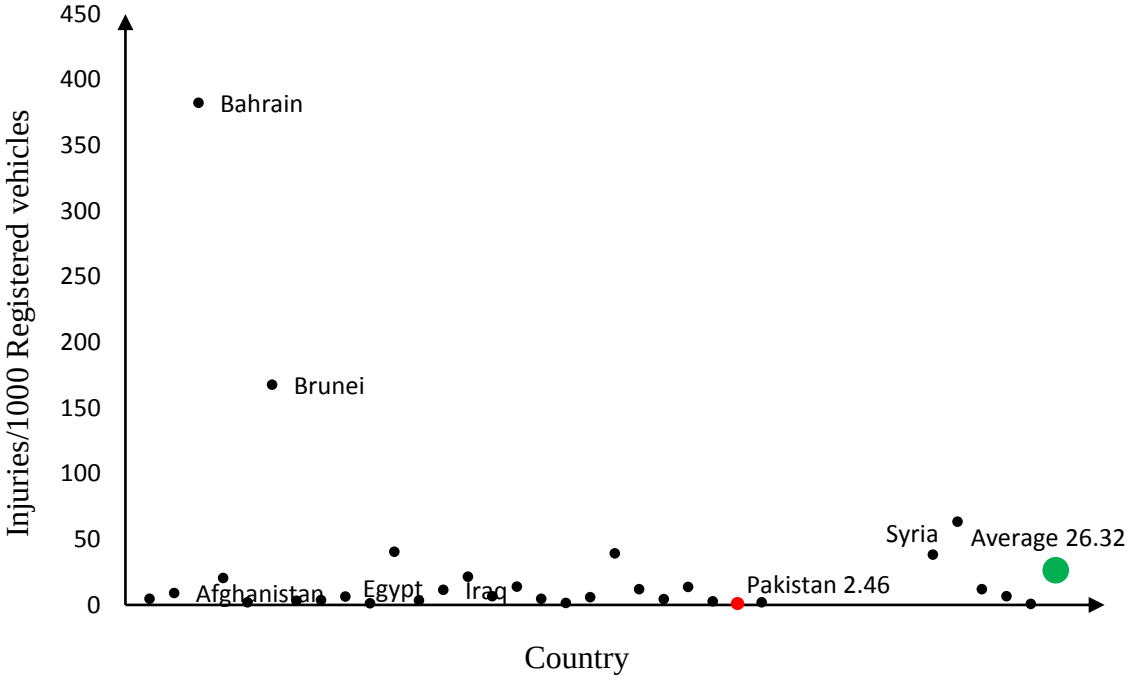


Figure 3.6 RCI in Pakistan Compared to Asian Countries Based on IPTRV

## 3.6 Global Comparison of Road Crash Injury Rates

IPHTP for the whole world is averaged at 245.25. From Figure 3.7, it is apparent that Cook Islands is the leading country with an RCI of 2866.8, while Sierra Leone finds its place at the bottom of the list with an RCI of 5.08. Pakistan lies near the bottom with a rating of RCI as 7.93, which is questionable since the reliability of the data remains undetermined.

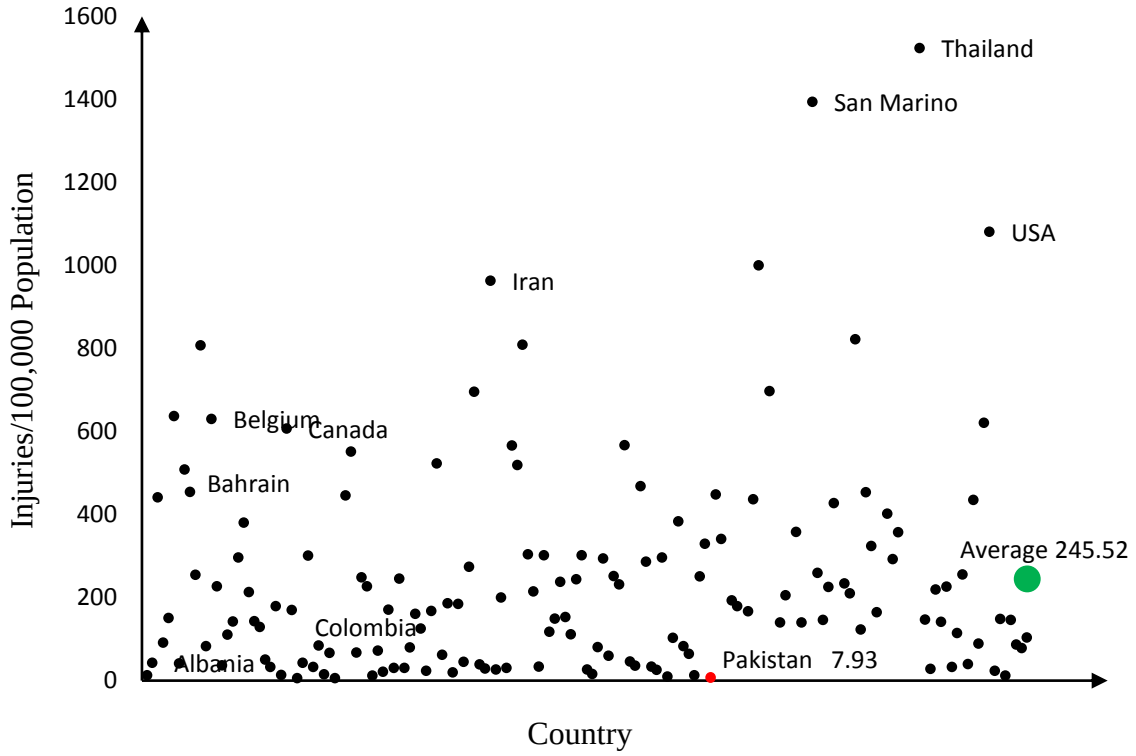


Figure 3.7 Global Comparison of RCI Rate based on IPHTP

Besides IPHTP, a comparison between different countries of the world based on IPTRV was also conducted. In this case, average value of IPTRV is 20.59. Bangladesh has maximum IPTRV (382.33) and Vietnam has the minimum IPTRV (0.45). Fourteen countries are ahead of Pakistan with IPTRV rates lower than Pakistan. This is illustrated in Figure 3.8. Yet again, results appear too good to be true and once again raise questions about the data collection and collation methods adopted in Pakistan.

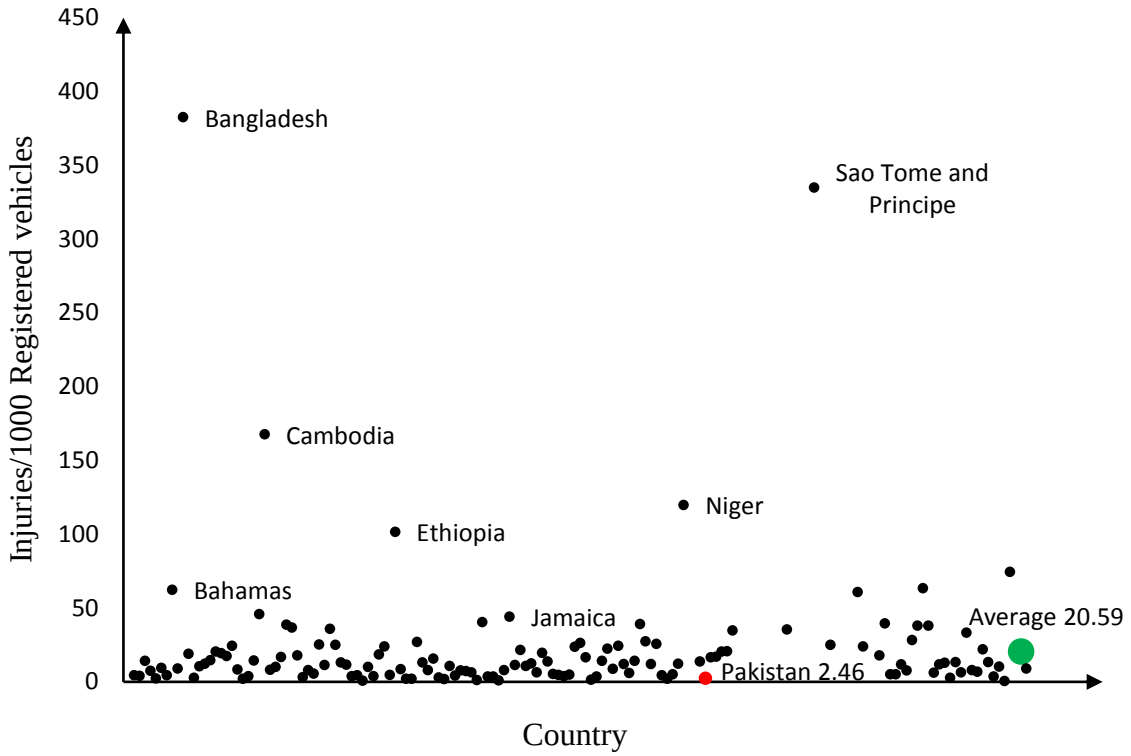


Figure 3.8 Global Comparison of RCI Rate based on IPTRV

## 3.7 Comparison of Global Annual RCI Rate

In this section, a comparison of average annual injuries of the whole world, Asian countries, HIC, MIC, LIC and Pakistan is discussed. As highlighted (Figure 3.9), HIC have higher number of annual road crash injuries. This may be due to better reporting systems present in these countries,otherwise, high-income counties have well established laws and high levels of enforcement, safe road infrastructure, well-established speed limits, good conditions of vehicles and educated drivers and pedestrians. All these factors contribute towards reducing road traffic crashes and improving their outcomes. Pakistan, like other LIC, has a lower annual RCI, indicating poor reporting and recording of RCI. Road infrastructure in Pakistan is not very safe and traffic laws are neither well established nor strictly enforced, especially in comparison to countries with high income levels.

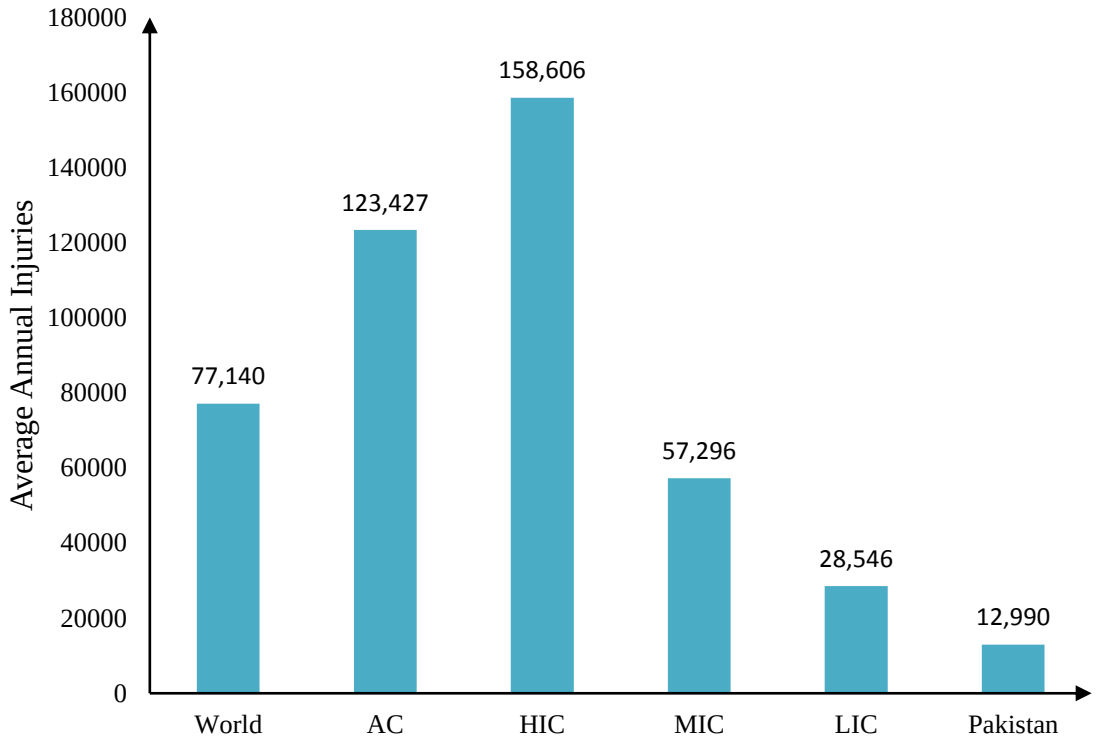


Figure 3.9 Comparison of Global Annual RCI-Reported Data

## 3.8 Chapter Summary and Conclusions

This chapter discussed a statistical comparison of RCI in Pakistan with Asian countries, South East Asian countries, low-income countries and overall with all countries of the world. The objective was to point out issues of RCI data reporting in Pakistan by comparing it with results from other countries. The data for this comparison was obtained from WHO-2009. The RCI are compared based on IPHTP and IPTRV. Different comparisons revealed that Pakistan has lower RCI rate mainly due to poor data reporting and recording. Lastly, a comparison based on average annual RCI of Pakistan with HIC, MIC, LIC, world overall and Asian countries was presented. Lower RCI were noted for low-income, middle-income, Asian countries and Pakistan. This again highlights the issue of data reporting and recording for Pakistan and other countries.

The first step in the right direction should be the improvement of data reporting and recording methods. Once data issues are resolved and the extent of the problem is comprehended, appropriate remedial measures can be adopted to solve the issue of road crash injuries.

# CHAPTER 4. FACTORS AFFECTING ROAD CRASH INJURIES AND ESTIMATION OF ANNUAL ROAD CRASH INJURIES

## 4.1 Introduction

This chapter focuses on factors affecting RCI. Statistical models were developed and their results are discussed here. The models were developed using ordinary least squares (OLS) regression techniques using data from WHO's Global Status Report on Road Safety-2009. Factors affecting RCI were identified from the developed models. RCI for Pakistan for the year 2014 were estimated using the same data set and results have been compared with past national research.

## 4.2 Data Collection from WHO Global Road Safety Report

This study used data from WHO's Global Status Report on Road Safety-2009. This report contains data for many countries but for this study, we only used data of seventy-four (74) countries whose vital registration records exist. The data were grouped into categories such as number of injuries per hundred thousand population (2007), number of injuries per thousand registered vehicles (2007), total number of registered vehicles (2007), maximum speed limit on rural roads in kilometers per hour (2007), enforcement levels of seatbelt laws on a scale of 0-10kilometers of road per kilometer square (IRF, 2007) and many others. Table 4.1 illustrates the descriptive statistics of the data used for model development.

Table 4.1 Summary Statistics of Selected Variables

| Details | Mean | Std Dev. | Max. | Min. |
|---|---|---|---|---|
| RVEH | 12588007 | 32554165 | 251422509 | 24334 |
| GNI | 19939.34 | 18136.23 | 76450.00 | 590.00 |
| RDEN | 1.09 | 1.33 | 7.04 | 0.03 |
| ILVL | 2.49 | 0.53 | 3.00 | 1.00 |
| MAXSR | 78.70 | 15.89 | 110.00 | 40.00 |
| SBLENF | 6.47 | 1.92 | 9.00 | 0.00 |
| SANR | 0.59 | 0.50 | 1.00 | 0.00 |
| POP | 26001283 | 48663573 | 305826246 | 120402 |
| IPHTP | 339.77 | 259.06 | 1523.24 | 30.01 |
| IPTRV | 10.21 | 9.27 | 62.16 | 0.91 |

The WHO gathered data on road safety through a standardized survey conducted in 178 countries across the globe in 2007. The WHO gathered country-level data on road safety for different categories such as (1) road traffic injuries and proportion of injuries by road users, (2) post-crash response, (3) speed laws and enforcement, (4) drunk-driving laws and their enforcement, (5) helmet laws; their enforcement and wearing rates, (6) seatbelt and child restraint laws and enforcement, (7) mobile phone laws, (8) road safety management, strategies, targets and safer mobility. The WHO data were collected through the assistance of a number of different sectors and stakeholders in each country, coordinated by a "National Data Coordinator" at country level.

A numbers of data elements from the WHO report were used in this study for model estimation. These are listed below:

(1) Population

(2) Number of registered vehicles

(3) Road density (km/km2)

(4) Number of hospital beds per thousand population

(5) Continent

(6) Information on vital registration system

(7) National policy for promoting walking and cycling (1-Yes, 0-No)

(8) Effectiveness of overall enforcement level of speed limits (scale 0-10)

(9) Effectiveness of overall enforcement level of drink driving law (scale 0-10)

(10) Effectiveness of overall enforcement level of motorbike helmet law (scale 0-10)

(11) Effectiveness of overall enforcement level of seatbelt law (scale 0-10)

(12) Effectiveness of overall enforcement level of vehicle child restraint law(scale of 0-10)

(13) Public access to pre-hospital care system (1-Yes, 0-No)

(14) Gross national income per capita (US $)

(15) Maximum speed on rural roads (km/hr)

(16) Maximum speed on urban roads (km/hr)

(17) Emergency room based injury surveillance system

(18) Legislation on mobile phone use while driving

(19) Level of investment in public transportation

(20) Audits of existing/new roads

(21) Presence of lead road safety agency or not

(22) National road safety strategy

(23) Level of training in emergency medicine for doctors

(24) Availability of training in emergency medicine for nurses

(25) Speed limits are modifiable/setting at local or national level

(26) National drink driving law

(27) National helmet standards/law

(28) National seatbelt law and application (seat belt law applies to front and rear occupants, mandatory installation of seat belt in newly manufactured vehicles)

(29) Funding of lead road safety agency

(30) National child restraint law.

There are some limitations in the WHO data. For example, the definitions adopted by local agencies vary across the different countries. These definition issues affect data on pre-hospital care-systems, vehicle conditions, road standards and institutional policies because an expert's opinion was sought in collecting this information. Moreover, incomplete vital registration records have been a major problem in gathering data from various developing countries. Similarly, data obtained on total number of registered vehicles, actual number of vehicle miles travelled, miles travelled by different vehicle types, actual seatbelt usage rates and age/gender of drivers also has reporting issues.

## 4.3 Road Crash Injury Models

### 4.3.1 Model Functional Form

The major focus of present research initiative was to estimate models for the identification of factors responsible for road crash injuries in Pakistan. Moreover, an estimate for the RCI of Pakistan for the year 2014 using WHO reported data was desired. Ordinary least square (OLS) regression models were developed using LIMDEP (statistical software package) was used to develop these models. The generic functional form of the estimated model is given in Equation 4.1.

$$y_{(i)} = \beta_0 + \sum_{i=1}^{j}(\beta_i x_i) + \varepsilon_i \qquad (4.1)$$

Where, y (i) = injury rate (IPHTP & IPTRV), β's, $x_i$ and ε's are model coefficients; independent variables and error terms respectively. Road crash injury models can be used as handy tools to study factors affecting RCI and subsequently suggest counter measures its reduction. Furthermore, these models allow us to study the effectiveness of any road safety improvement measures that are implemented. The predictive accuracy of the estimated models was tested by determining the Mean Absolute Percent Error (MAPE).

### 4.3.2 Selection of Explanatory Variables (X)

There are a number of factors that are involved in road crash injuries. The most important and prominent independent variables used for this study are total number of registered vehicles, maximum speed on rural roads in kilometers per hour, enforcement levels of seatbelt laws on a scale of 0-10, population, income levels and safety audit of new roads. These are common variables on which data was gathered by WHO and used in model estimation. The model became functional as variables are truly explanatory of response variable.

### 4.3.3 Selection of Response Variables (Y)

Response variable based on experience such as injuries per hundred thousand population (IPHTP) and injuries per thousand registered vehicles (IPTRV), are preferred for

the use of estimation. Nevertheless, various other response variables, such as the number of injuries per vehicle kilometer travelled, are commonly used by researchers and can be used as surrogates for RCI. This study used injuries per hundred thousand population and injuries per thousand registered vehicles as response variables for model development. Response variable was transformed (natural logarithmic transformation) so that model outputs are always positive. A number of models using different explanatory variables have been estimated and are discussed in the following paragraphs.

### 4.3.4 Model Estimation Results and Discussion

#### 4.3.4.1 Model - 1: Dependent Variable - Log Injuries Per Hundred Thousand Population

Model results indicate that significant variables are total number of registered vehicles, maximum speed on rural roads in kilometers per hour and enforcement level of seatbelt law. The model has reasonable fit for the highly-varied data that were collected from various different countries. This study used data of 74 countries whose vital registration records are available. The $R^2$ value of 0.19 indicates that approximately, 19% variance in data is captured at a 95% level of confidence.

The registered vehicle variable was found to be positively associated with the response variable and findings were intuitive. With increase in the total number of registered vehicles, road crash injuries are expected to rise. The maximum speed is also a significant variable and is directly related to the response variable. If the speed limit is increased on rural roads, chances of injuries would be higher and vice versa. The last significant variable is the seatbelt law which is inversely related to the response variable. If seatbelt awareness is increased, chances of injuries in a road crash are minimized. The model parameter summary is provided in Table 4.2. The estimated model is as follows:

$$LNIPHTP = 5.17 + 0.01E\text{-}06*RVEH + 0.011\ MAXSR - 0.0847\ SBLENF \quad (4.1)$$

Table 4.2 Model Results - Log Injuries Per Hundred Thousand Population as Response Variable

| Variable | Coefficient | t-stat |
|---|---|---|
| Constant | 5.17 | 10.72 |
| RVEH (Registered Vehicles) | +0.01E-06 | 2.59 |
| MAXSR (Maximum Speed on Rural Roads) | +0.011 | 2.08 |
| SBLENF (Enforcement Level of Seatbelt Law) | -0.09 | -1.97 |
| $R^2$ | 0.19 | |
| Adjusted $R^2$ | 0.16 | |
| Number of Observations | 74 | |
| MAPE | 0.093 | |

To check the predictive capability of model, MAPE was estimated as follows.

$$MAPE = \frac{1}{n}\sum_{i=1}^{n} |PE_i| \qquad (4.2)$$

Where PE i = (Ai – Pi) / Ai is the percentage error for observation i of the actual and predicted road crash injuries. The MAPE result for the above estimated (Equation-1) model is 0.09.. MAPE results are illustrated graphically in Figure 4.1.

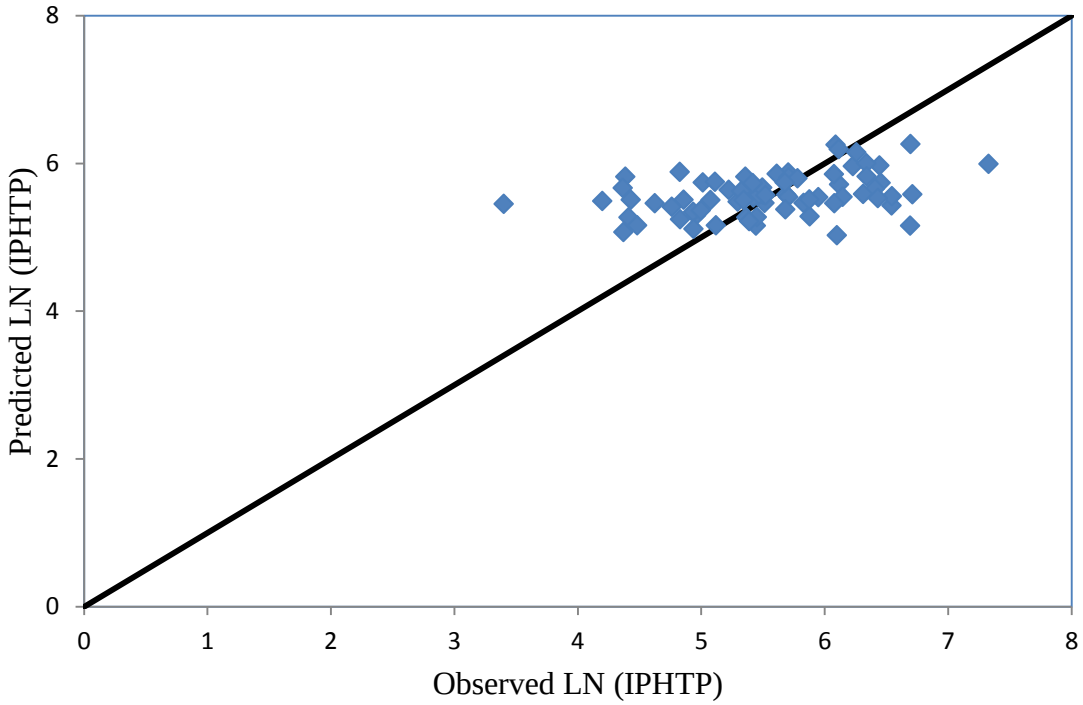


Figure 4.1 Comparison of Actual Vs. Predicted Values (Model-1)

4.3.4.2 Model - 3: Dependent Variable - Log Injuries Per Thousand Registered Vehicles

The detailed model findings are given in Table 4.4. The estimated model is as follows:

LNIPTRVEH = 4.445 - 0.579 ILVL - 0.121 SBLENF - 0.352 SANR (4.3)

Three variables are found to be significant; income level, safety audit of new roads and enforcement level of seatbelt law. The model has an $R^2$ value of 0.29and has a reasonable fit for the highly-varied data. Approximately, 29% variance in the data is explained by the independent variables at a 95% level of confidence. The findings of this model are also intuitive. The income level was found to be inversely related to injury rate and significant at 95% level of confidence. Higher the level of income of a country, lower its RCI rate. Existence of effective road safety policies, good road infrastructure, better vehicle

conditions and educated drivers and pedestrians expectedly result in lower road crash injuries. Seatbelt law enforcement was also found to be negatively associated with the response variable. Seatbelts do not prevent accidents but they do help in lowering injury severity. In addition, the safety audit of new roads was also found to be inversely related with road crash injuries. Figure 4.3 further explains the relationship between actual and predicted road crash injuries, indicating that the model has reasonable prediction capabilities.

Table 4.3 Model Results - Log Injuries Per Thousand Registered Vehicles as Response Variable

| Variable | Coefficient | t-stat |
|---|---|---|
| Constant | 4.45 | 9.38 |
| ILVL (income level) | -0.58 | -3.57 |
| SBLENF (enforcement Level of seatbelt law) | -0.12 | -2.73 |
| SANR (safety audit of new roads) | -0.35 | -2.06 |
| $R^2$ | 0.29 | |
| Adjusted $R^2$ | 0.26 | |
| Number of Observations | 74 | |
| MAPE | 0.23 | |

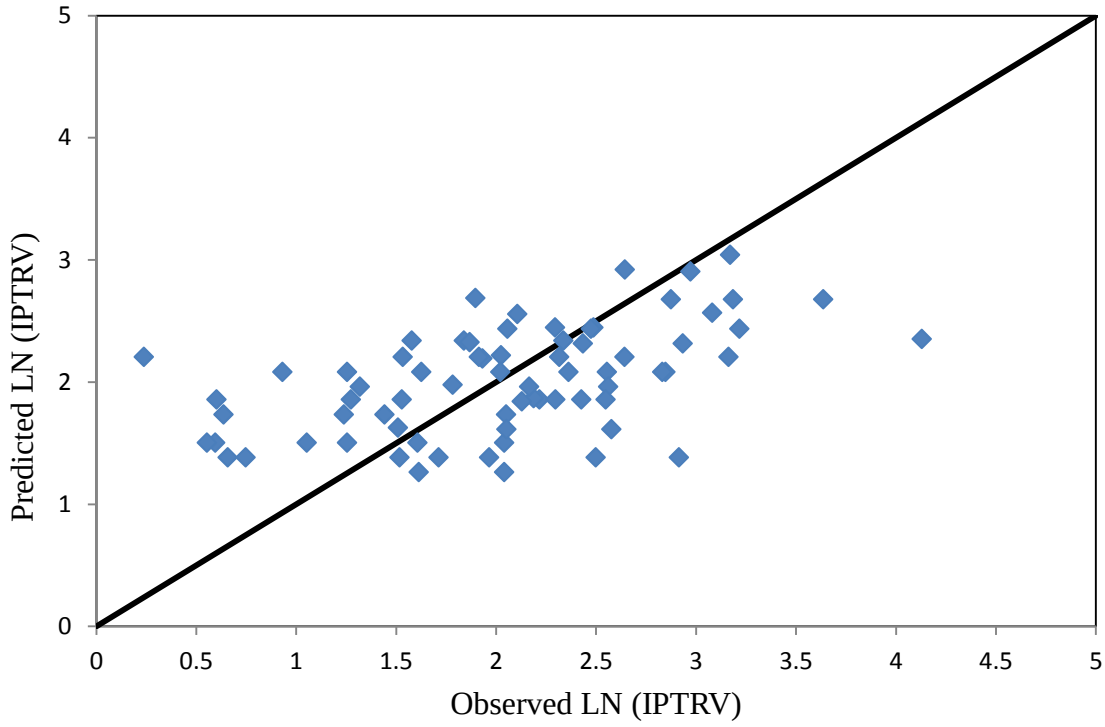


Figure 4.2 Comparison of Actual Vs. Predicted Values (Model-2)

## 4.4 Predicting Annual Road Crash Injuries

It was observed that models developed in this study, (Section 4.3) although having reasonable fit, are not good for predicting RCI rates. The model can be useful for exploring factors responsible for road crash injuries but does not perform well for injuries prediction. The developed model is at best a cause-effect model which helps to explore factors responsible for RCI. An alternate solution to this limitation can be estimation of RCI as the simple average of road crash injuries of the 74 countries having reliable vital registration systems. The average annual road crash injuries of Pakistan are then estimated using population and registered vehicles as response variable in the following manner:

a. Average Injuries based on Population: The average annual injuries of Pakistan based on population, for the year 2014 are as follows:

   Average IPHTP = 339.772 (74 countries with vital registration record)

   Pakistan population in 2014 (World Population Review) = 187,561,850

$$\text{Injuries of Pakistan } (2014) = \frac{339.772}{100{,}000} \times 187{,}561{,}850 \qquad (4.4)$$

Estimated Injuries = 637,282

b. Average Injuries based on Registered Vehicles: The average annual injuries of Pakistan based on registered vehicles for the year 2014 are as follows:

Average IPTRV = 10.21 (74 countries with vital registration records)

Registered vehicles of Pakistan in 2014 (Estimated from NTRC, 2011) = 11,281,890

$$\text{Injuries of Pakistan } (2014) = \frac{10.21}{1000} \times 11{,}281{,}890 \qquad (4.5)$$

Estimated Injuries = 115,188

## 4.5 Comparison of Estimated Injuries with Previous Studies

Table 4.4 shows a comparison of RCI estimated by past studies with this study. Various researchers adopted different approaches to estimate the annual RCI for Pakistan. The number of RCI estimated by past studies have significant discrepancies, which points to the fact that either the data upon which these estimates are based was either insufficient or highly under-reported, or the methods adopted by researchers was flawed.

Hyder et al. [2000] estimated the RCI using 40 years (1956-1996) registry-based data obtained from the Federal Police Research Bureau. The authors calculated 37 RCI per 10,000 registered vehicles that yielded a total of only 41,743 RCI, which seems unrealistic. Ghaffar et al. [2003] estimated 2,813,428 injuries using data from the National Injury Survey of Pakistan (NISP). The NISP collected three months data from household surveys by interviewing residents from all four provinces of Pakistan including both urban and rural areas, except for a few tribal areas. The RCI estimated in that study were 15 RCI per 1000 population. The result of that study also appear unrealistic because the figure seems unusually high. Fatmi et al. [2007] used National Health Survey of Pakistan (NHSP 1990-1994) data in which different households were interviewed. The authors estimated 17 RCI

per 1000 population that yielded a total of 3,188,552 RCI. The estimated RCI was quite high which also seems unrealistic. The present study estimated RCI for Pakistan for the year 2014. RCI calculated in this study are worked out using the average rate method and they are given in terms of population and registered vehicles.

Table 4.4 Comparison with Previous National Studies

| **Study** | **Data Source/Time** | **Data Details** | **Estimated Injuries (2014)** |
|---|---|---|---|
| Hyder et al. (2000) | FPRB 1996 | Police Reported Data Survey clarified on 14.3% crashes recorded by police | 41,743 |
| Ghaffar et al. (2003) | NISP 1997 | Survey Based Data Household Interview Sample of 30,000 Individuals | 28,13,428 |
| Fatmi et al. (2007) | NHSP 1990-1994 | Survey Based Data Household Interview Sample of 18,315 Individuals | 31,88,552 |
| Present study (2014) | WHO 2009 | Aggregate Data of 74 Countries | 6,37,282 |

## 4.6 Chapter Summary and Conclusions

This chapter focused on the estimation of RCI and the factors associated with RCI using cause-effect models. Data WHO "Global Status Report on Road safety-2009" were used to estimate road crash injuries. Ordinary least square regression models were developed using Limdep. Total registered vehicles, maximum speed on rural roads, enforcement level of seatbelt law on a scale of 0-10, income level (Low- $935 or less, Middle- $936 to $11 455 and High- $11 456 or more) and road safety audit for new roads were found to be significant variables. Injuries per hundred thousand population (IPHTP) and injuries per thousand registered vehicles (IPTRV) were used as dependent variables. Annual RCI for Pakistan were estimated using average injury rate obtained for seventy-four countries around world having

vital registration systems. Also, total annual injuries estimated for Pakistan in this study was comparatively analysed with values calculated in past studies.

# CHAPTER 5. CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Synopsis of the Research

This research study, addressed the important issue of road crash injuries estimation in Pakistan. The study is initiated with a general review of literature, both at national and international level. Review of international studies helped to identify major factors pertinent to road crash injuries and the variety of approaches followed in different countries for predicting road crash injuries. Study of causes and consequences of injuries resulting from road traffic crashes enhanced understanding of the severity of the problem at hand. The literature review also helped highlight the gaps in current practice and data availability problems. Similarly, review of past national studies brought attention to issues associated with data reporting and recording systems.

This study also carried out a thorough comparison of road crash injuries of Pakistan individually with Asian countries, SAARC countries, low-income countries and lastly, with all countries around the world. Statistical models were developed to estimate annual road crash injuries for Pakistan and to explore different factors responsible for high traffic crash injury rates using data from the World Health Organization (WHO), International Road Federation (IRF) and the World Bank. Econometric models were estimated using two different response variables; (1) injuries per hundred thousand population and (2) injuries per thousand registered vehicles. It was revealed that models estimated using international data had a low fit and were unsuitable for predicting annual road crash injuries for Pakistan. However, such developed models helped explore the different factors responsible for road crash injuries. Annual road crash injuries for Pakistan were estimated using annual crash injuries of seventy-four countries with vital registration systems. Finally, the study compared road crash injuries estimated for Pakistan with different studies in the past.

## 5.2 Research Findings and Conclusions

The literature review revealed that there is a significant lack of serious research efforts in estimating annual road crash injuries for Pakistan and identifying the major factors

responsible for its high road crash injury rate. Most of the national studies in the past used very limited amount of data for estimating and exploring the factors responsible for road crash injuries. Most studies used descriptive statistics. Past national studies also discussed and revealed under-reporting of road crash injury data by most sources. Review of international road crash injury studies revealed that an extensive effort has been made at the international level to estimate road crash injuries. The major factors associated with road crash injuries are; road density, number of registered vehicles, population density, GDP, level of healthcare services, vehicle kilometers driven, governmental laws and their levels of enforcement. Comparison of road crash injuries of Pakistan with other countries revealed that as per reported data, Pakistan has almost the lowest injury rate, thus indicating serious issues in reporting of injuries. Based on injuries per hundred thousand population, Pakistan has the fourth lowest injury rate among low-income countries, the lowest rate among SAARC countries, second lowest rate among Asian countries and is also in the low bracket overall in the world. This is further proof of serious issues of under-reporting. Similar results were obtained when injuries per thousand registered vehicles were compared between different countries. Total number of registered vehicles, maximum speed limits on rural roads enforcement level of seatbelt law, income level and safety audit of new roads were found as significant factors associated with road crash injuries.

It was observed that the increase in registered vehicles and higher speed limits on rural roads result in higher road crash injuries while higher enforcement level of seatbelt law and safety audit of new roads results in lower number of injuries. Based on the injuries per hundred thousand populations and injuries per thousand registered vehicles, a total of 637,283 and 115,188 annual road crash injuries were estimated for Pakistan for the year 2014.

## 5.3 Recommendations and Direction for Future Research

Road crash fatalities and injuries have emerged as a moral challenge for societies around the world. Reliable information on total traffic injuries and identification of factors responsible for high traffic crash injury rates is therefore an important issue and the first step towards initiating remedial measures. A broad and comprehensive accident data reporting and recording system is recommended for Pakistan. Also, the country needs a dedicated research center where new methods are adopted to conduct road safety research and counter measures are developed that help reduce road crash injuries in the country.

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