Epidemiology of Road Traffic Accidents in India: a Review of Literature

2011

Sir Ratan Tata Trust

Road Traffic Accidents (RTAs) are an important public health problem requiring urgent attention in the context of developing countries such as India, which has the highest proportion of deaths due to RTAs in South East Asia. Statistics indicate that the incidence of accidental deaths in India has increased by 32.5% in the last 10 years (1998 - 2008).

This report has been prepared as part of an initiative by Sir Ratan Tata Trust to identify areas of research and design intervention strategies to reduce deaths and disabilities due to RTAs.

The report presents a comprehensive review of information available in India on incidence, distribution and patterns of RTAs; interventions - nationally and internationally - to address the increasing incidence and to identify gaps in research and information on RTAs.

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Title:
Epidemiology of Road Traffic Accidents in India: a Review of Literature

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Road Traffic Accidents in India: a Review

Epidemiology of Road Traffic Accidents in India:
a Review of Literature

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Preface

Recent years have been witnessing an increasing amount of traffic on the roads, leading to increased risks for road traffic accidents to occur. Evidence from developed and especially developing countries indicates that road traffic accidents are on the rise and are the fifth important cause of deaths globally, leading to a significant proportion of injuries, deaths and disabilities in the population. Road traffic accidents have been identified as an important public health problem requiring urgent attention in the context of developing countries such as India, which has the highest proportion of deaths due to road traffic accidents in South East Asia. Recent statistics indicates that the incidence of accidental deaths has increased by 32.5% in the last ten years i.e. from 1998 to 2008, in India. The following report presents a comprehensive review of the information available in India on the incidence, distribution and patterns of Road Traffic Accidents, the interventional attempts made nationally and internationally to cope with this increasing incidence of RTAs and attempts to identify the gaps in research and information on RTAs. The purpose of this report is to explore the areas where attempts can be made to design research as well as intervention strategies that can help to significantly reduce the deaths and disabilities due to RTAs.

The report begins by providing a brief introduction followed by a section on the methodology used to conduct the review and then goes on to present the findings of the review in the results section. The first part of the results section sheds light on the burden of RTAs in India. The second part looks at the distribution and patterns of RTAs in the Indian context, while the third part describes the range of interventions tried in the context of developed as well as developing countries to deal with the problem of RTAs. The report concludes by a brief discussion on the findings of the review and by suggesting the way forward.

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Abbreviations used in the report

RTAs	Road Traffic accidents
RTIs	Road traffic incidents
GOI	Government of India
MORTH	Ministry of Road Transport and Highways
NCRB	National Crime Records Bureau
LMICs	Low and Middle Income Countries
ALS	Advanced Life Support
IRTE	Institute of Road Traffic Education
SIAM	Society of Indian Automobile Manufacturers
ICAP	International Centre for Alcohol Policy
SASPI	Society for Alcohol Related Social Policy Initiative
WHO	World Health Organisation
NIMHANS	National Institute of Mental Health and Neurosciences
GRSP	Global Road Safety Partnership
BATF	Bangalore Agenda Task Force
SUV	Sports utility vehicles
TST	Three wheeled scooter taxis
PHC	Primary Health Centre
CHC	Community Health Centre
RCTs	Randomised Controlled Trials
ITS	Interrupted Time Series
MTVs	Motorised two wheeler vehicles
BAC	Blood and Alcohol Concentration

Abstract

Recent years have been witnessing an increasing amount of traffic on the roads leading to increased risks for road traffic accidents (RTAs) to occur. Evidence from developed and especially developing countries indicates that road traffic accidents (RTAs) are on the rise and are found to be the fifth important cause of deaths globally leading to a significant proportion of injuries, deaths and disabilities in the population. Road traffic accidents (RTAs) have been identified as an important public health problem requiring urgent attention in the context of developing countries such as India, which has the highest proportion of deaths due to road traffic accidents in South East Asia. The situation is even more problematic in the context of India because of lack of proper infrastructural facilities, poor road designs, poor implementation of traffic rules and regulations and a high load of a range of vehicles on the roads. Studies indicate that young adults in their early thirties continue to be the victims of RTAs. Fatalities and morbidities from RTAs mostly affect the economically productive age group. Studies show that pedestrians, users of non-motorised vehicles and users of motorised two wheeled vehicles, who are often from poor or lower middle class households are the victims of fatal RTAs.

Inspite of the high burden of RTAs in the country, there is a lack of systematic information on the true extent of the problem and the multiple dimensions of the problem as the existing studies are isolated, sporadic efforts that vary in study designs and thus cannot be generalisable at the broader level. This lack of adequate and appropriate information on the patterns, distribution, and outcomes of RTAs across the country because of lack of systematic data generation mechanisms at the national and state levels through various sources such as hospitals, traffic police registration systems etc, leads to limitations in designing appropriate intervention strategies to deal with the problem in the country. In addition to this, lack of research efforts to understand the multiple dimensions of the problem in terms of social and economic consequences of deaths, injuries and long term disabilities and their implications for the different sections of the population, the economic burden experienced by the poor have led to inadequate information on the consequences of the problem faced by the most vulnerable members of the population, in India.

The review reveals that the way forward can include efforts that have a multipronged approach and include systematic data generation to understand the true extent of the problem along with awareness and educational programmes directed at both the vehicle users as well as road users. These can be coupled with strict law enforcement mechanisms to control and regulate traffic on the road, improvement in trauma management systems to reduce the intensity of injuries suffered by the victims, encouraging use of safety aids such as helmets among the public and improving infrastructure to make roads safer. Other efforts can also include encouraging more research on improvement in the existing technologies such as helmets by adapting them to local circumstances to encourage their use among people and to promote better vehicular designs that are more stable and crash resistant. Efforts can also include attempts at creation of a common platform at the national level that can include research inputs from different specialities that can lead to a better understanding of the problem and can encourage attention to this problem at the policy level.

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1. Introduction

Roads provide very important means of transport and communication throughout the world and have a great role to play in the development of nations and people through improving access to information and resources, leading to better health outcomes among populations. However, recent years have witnessed an increasing burden of traffic on the roads. The increasing number of vehicles has consequently led to increased opportunities for road traffic accidents to occur, thus placing a considerable health burden on populations because of the associated injuries, deaths and disabilities, world-wide (World Health Organisation, 2009).

Estimates by the World Health Organisation have indicated that globally, road traffic accidents have led to as high as 1.27 million deaths in 2004, which have been found to be equivalent to all the deaths caused by communicable diseases. The most affected are the young population and it has been found that road accidents are one of the top three reasons for deaths among the population from the age group of 5 to 44 years, globally. The World Health Organisation (2009) estimates that road traffic accidents will be the fifth leading cause of deaths worldwide by 2030, leading to an estimated 2.4 million fatalities per year, if proper steps are not taken to prevent deaths and injuries on the road. Low income and middle income countries have higher road traffic fatality rates[1] (21.5 and 19.5 per 100, 000 population, respectively) than high-income countries (10.3 per 100, 000 population). Over 90% of the world's fatalities on the roads occur in low-income and middle-income countries, which have 48% of the world's registered vehicles (World Health Organisation, 2009).

Nearly two-thirds (62%) of the traffic accidents worldwide have been found to be taking place in 10 countries, which form slightly more than half (56%) of the world's population, with the maximum being in India followed by China, United States, The Russian Federation, Brazil, Iran, Mexico, Indonesia, South Africa and Egypt (World Health Organisation, 2009)

Evidence indicates that although India has one percent of the world's vehicles, it accounts for as high as six percent of world's RTAs (Fitzgerald et al, 2006). Seventy three percent of deaths due to RTAs from the South-East Asia Region are in India ((WHO, 2009). RTAs account for 16.8 deaths per 100,000 population (WHO, 2009: p 253) and around 2 million people in India are disabled due to RTAs (WHO, 2009). The RTA rate of 35 per 1000 vehicles in India is one of the highest in the world and so is the associated RTA fatality rate of 25.3 per 10,000 vehicles (Fitzgerald et al, 2006). Estimated cost of RTAs in India is three percent of the GDP, which is much higher than that in high-income countries (Sundar Committee Report, date Unspecified).

> India accounts for as high as 6% of the world's RTAs, although it has 1% of world's vehicles. The RTA rate[2] of 35 per 1000 vehicles in India is one of the highest in the world and so is the RTA fatality rate[3] of 25.3 per 10,000 vehicles

[1]The current recommended definition by the World Health Organisation (2009) of a road traffic fatality for harmonization of surveillance purposes is "any person killed immediately or dying within 30 days as a result of a road traffic injury accident". This data shows the rate per 100, 000 population.

[2]Number of accidents per 1000 vehicles

[3]Fatality rates are calculated as road accident deaths per 10,000 vehicles licensed

In India, roads are an important means of transport. The Indian road network is one of the largest in the world. India has 3.34 million km of road network consisting of national highways, state highways, major and district roads and village roads. National highways account for 2% of the road network, but carry 40% of road traffic. Since 2001, the number of vehicles has been increasing at the rate of 10% per annum (GOI, MORTH, 2008-09) and almost three-fourth of the registered vehicles in India are motorised two wheeler vehicles (MTVs) (WHO, Global Road Safety Report, 2009).

The expansion of the road network in the country has led to an increase in the number of vehicles and in number of accidents with higher number of fatalities (Draft National Road Safety Policy, date unspecified). Inspite of such a high burden of road traffic accidents in the country, India lacks a comprehensive national level database on RTAs, which is acknowledged to be a weakness in addressing policies for prevention of deaths and injuries related to RTA in the country (Draft National Road Safety Policy, date unspecified). Some of the national level data on Road traffic accidents can be accessed from the NCRB reports widely available on the internet. However, this database in itself is inadequate to address the varied dimensions of the road traffic accident problem. In absence of such a comprehensive national level database on epidemiology of RTAs, information can be accessed from a number of small research studies conducted by various research organisations and individual scholars across India.

This report attempts to present a comprehensive review of the available information/ literature/ studies in India on the incidence, distribution, and patterns of road traffic accidents. The review also aims at exploring the intervention efforts made in India to control/prevent traffic accidents as well as those from high income countries. The report aims at identifying the gaps in research and information on RTAs in India and explores the areas where attempts can be made to design research as well as intervention strategies that can help to significantly reduce the deaths and injuries due to RTAs.

2. Methods

Relevant studies were/information was identified through a systematic search of published and unpublished literature on road traffic accidents, injuries and prevention from different sources and triangulation of the search results. This included searching:

- Pubmed databases: The articles were searched by using key words such as 'road traffic accidents', 'Road traffic injuries', 'traffic and trauma', 'road traffic prevention strategies', 'road traffic accident prevention interventions', 'road traffic injury prevention'. In case full text articles were available, they were downloaded. In case the full text articles were not available, abstracts of these papers were accessed.
- Search using google and google scholar: Research articles/academic papers, doctoral and post-doctoral dissertations by scholars (individuals or groups working independently or through an institution) and relevant reports of national and international agencies pertaining to RTA in India were identified through an internet search using google scholar and google. Articles with key words such as 'road traffic accidents', 'road traffic injuries', 'traffic and trauma', were retrieved. Cross references were checked in Pubmed and other journals.
- Snowballing' search: this was done by first downloading some of the available free text journal papers from the earlier searches and then searching and locating the relevant references cited in these papers and some of the reports by again referring back to google searches or pubmed searches.

2.1 Available evidence from India

The literature search found that data on Indian situation regarding RTA and RTI are limited (in scope) and scattered. Most articles discuss the pattern of injury resulting from RTA, and socio-demographic profile of the RTA victims. Types of vehicles involved in the accident and seasonality of the accidents have also been presented by some researchers. There are few papers that describe the details of the impact and still fewer papers that discuss the factors responsible for the RTA such as human error, fault with vehicle design, and road related factors. A part of information regarding nature and type of injuries comes from a number of publications by specialist researchers studying a specific type of injury such as traumatic brain injury, or certain types of fractures or certain types of vision loss. The vehicle and road related aspects are discussed in the works of biomedical engineers, especially from IIT Delhi. A small body of literature discusses issues related to research on RTA in India, surveillance, data collection and compilation systems for RTA, lacunae in available data, factors responsible for less reliability of available data etc. Other related work includes exploration of awareness regarding road safety and safe practices among road users, and issues related to road transport in general (the man-made environment that aggravates RTA). There are also some literature reviews available on varied topics related to RTAs. There are very limited studies in the literature that highlight successful interventions conducted to prevent road traffic accidents in the Indian context. Most of the evidence on interventions done to prevent road traffic accidents is from high income countries. Box 1 below highlights the topics covered in this review.

Box 1: Available (published) information on RTAs in India – topics covered

- Share of RTA to trauma, accidents and injury
- Nature and pattern of injuries resulting from RTAs
- Socio-demographic distribution of victims of RTAs
- Surveillance and data collection systems related to RTAs
- Research on RTAs or lack of it
- Strategies for prevention of RTAs in India or the lack of them

2.2 Locales – geographical area represented by the studies

The present literature review is based on compilation of findings from research studies carried out across India. Most of these are hospital based, carried out at emergency departments or at the departments of forensic medicine at tertiary hospitals or larger district hospitals. Few are population based studies that have used population surveys to find out the history of RTA and associated injury. However, most describe RTAs in urban India, more specifically in larger cities such as state capitals or large educational centres (Box 2). Though there are references in the global literature to RTA being a greater problem in rural areas of LMICs, very little data is available on RTAs and RTIs in rural India. None of the studies claim to be representative of the picture for the entire country. Most of the studies on prevention of RTAs and the successful strategies implemented to control or prevent RTAs are from the developed countries.

Box 2: Location of research studies included in the review

- Cities with population of 1 million or more at the time of data collection (16)
- State capitals (14)
- Other urban areas (Class I[4] cities =58, Class II[5] city =1)
- Rural areas (3)
- Majority from high income countries and a few from middle or low income countries)

The present review is based on a compilation of 171 studies (50 with focus on RTAs or RTIs, 57 with focus on other aspects related to RTAs studies and 64 studies that highlight successful intervention strategies conducted in developed countries with a few examples available from developing countries and from India).

2.3 Scope of epidemiological studies

A large number of studies that describe pattern of injuries have based their findings on reports of medico-legal autopsies along with reports of police inquests, interviews with police officials, representatives of local road traffic authorities and victims or persons accompanying victims of RTA. These studies present socio-demographic data for victims and vehicles involved in RTAs. Some provide details of mode of impact, mode of transport of victims to hospital, availability of pre-hospital care, delays in reaching hospital, severity of injuries and survival time. Studies by specialists such as maxillofacial surgeons, dentists, neurosurgeons, emergency medicine specialists/ trauma care specialists, ophthalmologists, orthopaedic surgeons and plastic surgeons (Box 3) deal with a specific type of injury and then go on to describe contribution of RTAs to that specific type of injury.

[4] Cities with a population of 100,000 and above
[5] Cities with a population of 50,000 to 99,999

Box 3: Scope of the studies included in the review

Study based on -	Key information obtained -
• Medico-legal autopsy records	• Share of RTAs to unnatural/accident deaths, pattern of injuries, cause of death, sociodemographic distribution of victims
• RTA victims reporting to emergency/ casualty departments of hospitals	• Pattern of injuries, severity of trauma, socio-demographic distribution of victims, survival period, pre-hospital care, high risk behaviour
• Specialty or super-specialty departments at tertiary care hospitals studying specific types of injuries	• Share of RTAs to a specific type of injury, socio-demographic distribution of victims, (Such studies provide a range of injuries suffered by the RTAs victims)
• Population surveys	• High risk behaviour in the context of road safety, awareness regarding road safety, reporting of RTAs to government officials, burden of relatively minor RTIs in the community

There is a wide variation in the sample sizes for the studies included in the review. Data bases reported on typically by student medical professionals probably as a part of their academic requirement have smaller sample sizes. The sample sizes vary between 100 to more than 10,000 in case of studies that use records of medico-legal autopsies for arriving at share of RTAs in unnatural death. Research articles written by super-specialists (neuro / plastic surgeons), or those looking at a specific type of injury (e.g. optic nerve injury) and factors responsible for these; also tend to have smaller sample sizes and generally a limited scope as far as RTAs are concerned. On the other hand, studies like the one described by Fitzharris et al (2009), Dandona et al (2006a), and Fitzgerald et al (2006); and the household survey described by Verma and Tiwari (2004) are based on larger samples and are more comprehensive. These studies have multiple related components that provide a deeper insight into the who-why-how of RTAs and RTIs. Sample size along with variables included for analysis reflect on whether the study findings can be generalised and applied to other locations as well.

Of the 80 papers that described original research studies, RTAs or RTIs was the main focus for 50 papers. In these 50 studies, Fourteen (14/50) have explored / documented the relationship between alcohol consumption and RTAs, Nineteen (19/50) have reported on time of RTAs, while very few (6/50) have commented on the seasonality of RTAs and (3/50) on the frequency of RTAs over days of a week. The time lag between occurrence of RTA and accessing medical care has been discussed by some studies (5/50); whereas a few studies have commented on pre-hospital care, quality of emergency care and survival of the RTA victims (19/50) (Box 4).

Box 4: Various related issues addressed in the published literature on RTA

- Alcohol consumption and RTAs
- Time and seasonal patterns of occurrence of RTAs
- Time lag between RTA and access to medical care
- Access to pre-hospital care
- Quality of pre-hospital / emergency care in India
- Data collection, management and dissemination in the context of RTA

A range of studies/reviews appear that look at or examine the trials conducted to see the effectiveness or feasibility of certain interventions in reducing deaths or injuries caused because of road traffic accidents. Majority (53/64) of these are from high income countries and include a range of strategies that have been tested, implemented and have been found to be successful in these countries. There are almost no systematic intervention studies that have been conducted in India. However, few examples are available of attempts made or studies done by Non Governmental organisations such as Global Road Safety Partnership (GRSP) and a few ongoing efforts by NIMHANS in Bangalore and trials conducted by The Transportation Research and Injury Prevention Programme (TRIPP), IIT Delhi.

The commonly used definitions of Road Traffic Accidents (RTAs) and Road Traffic Injuries (RTIs) in the range of studies included in this report are included in Box 5 below.

Box 5: Definitions of RTAs and RTIs

Road Traffic Accidents (RTAs) can be defined as an occurrence of a sequence of events which result in unintended injury, death or property damage" (Park and Park, 2000: p 301; Singh and Dattarwal, 2004: p 20). Another working definition of accidents that has been used in some of the studies includes "a sequence of events that takes place on the road between two or more objects, in which one is any kind of moving vehicle and the other a human being" (Mishra et al, 2010: p 116). "A collision involving at least one vehicle in motion on a public or private road that results in at least one person being injured or killed" (Patil et al, 2008: p 56-57).

Road Traffic Injuries (RTIs) have been defined as: "The term 'injury' by definition means that there is a body lesion due to an external cause, either intentional or unintentional, resulting from a sudden exposure to energy (mechanical, electrical, thermal, chemical or radiant) generated by agent–host interaction. This leads to tissue damage, when it exceeds the physiological tolerance of the individual. On the contrary, injury can also occur due to the sudden withdrawal of a vital requirement of the body, e.g. withdrawal of air in drowning. Thus, an injury is damage to a body organ which occurs rapidly and is visible, with the causative mechanism being sudden energy transfer. Four factors that differentiate injury from other health conditions are: (i) a definite interaction between agent– host and environment, (ii) acuteness of the event, (iii) varying severity, and (iv) chances of repetitiveness" (Gururaj, G., date unspecified: p 326). Road traffic injuries (RTIs) include "fatal or non-fatal injuries incurred as a result of road traffic crash" (Patil et al, 2008: p 56-57).

3. Results

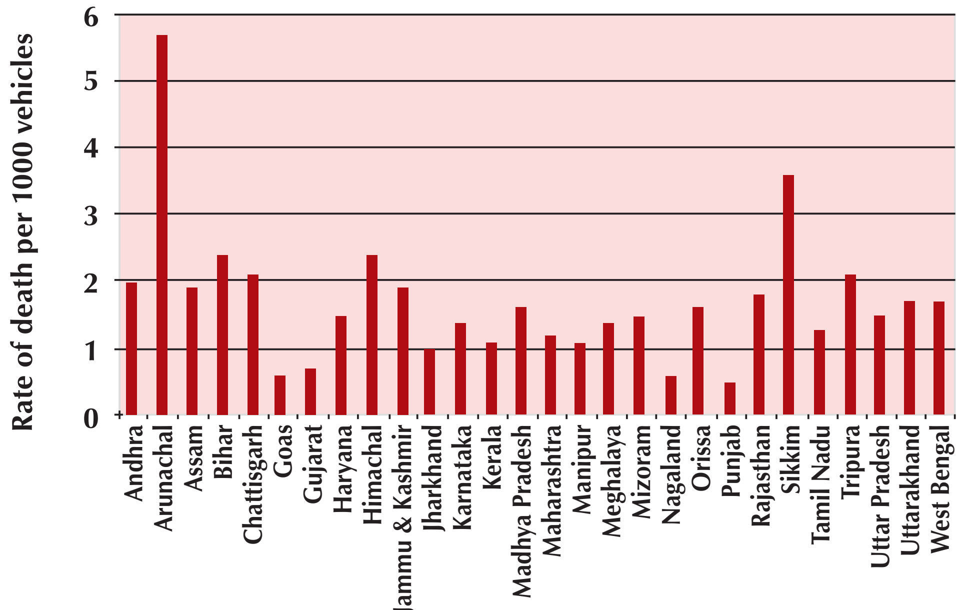
3.1 Burden of RTAs in India

According to official statistics, a total of 4,45,468 'Traffic Accidents' were reported during the year 2008 in India comprising 4,15,855 'Road Accidents', 2,134 'Rail-Road Accidents' and 27,479 'Other Railway Accidents' (NCRB, 2009). A total of 3,42,309 accidental deaths were reported in the country in 2008. It has been observed that 'Road Accidents' in the country have increased by 3.2% during 2008 as compared to 2007. Recent statistics indicates that the incidence of accidental deaths has increased by 32.5% in the last ten years i.e. from 1998 to 2008. The rate of accidental deaths has increased by 11.6% while the population growth has been reported to have increased by 18.8% in the year 2008 as compared to 1998 (NCRB, 2009).

Evidence indicates that there has been corresponding rise in the number of vehicles on the road over the years. For example, data indicates that total motor vehicle population has increased from about 300,000 in 1951 to about 73,000,000 in 2004. Motorcycles are almost five times more than cars and there has been a rise in the number of buses, trucks, and other vehicles, which are equal in number to the number of cars found on the road (Mohan, 2008). Box 6 presents information on the types of roads in India, the proportion of vehicular traffic and the number of deaths due to traffic accidents in the 2008 as compared to the total number of accidental deaths in India.

Evidence shows that Maharashtra and Tamil Nadu have the highest number of registered vehicles in the country. However, the NCRB (2009) data reports that the rate of accidental deaths per thousand vehicles is the highest in Arunachal Pradesh at 5.7 followed by Sikkim 3.6, Bihar and Himachal Pradesh 2.4 each, Chhattisgarh and Tripura 2.1 each and Andhra Pradesh 2.0 as compared to 1.3 at the National level. The rate of deaths per 100 cases of road accidents have been found to be the highest in Nagaland (92.1) followed by Mizoram (89.7) and Punjab (85.8) compared to 28.4 at the National level (Figure 1).

Figure 1: Rate of deaths due to road accidents in 2008



Box 6: India at a glance

- India has a total rural road network of over 3,000,000 Kms and urban road network of more than 250,000 kms with:
- National Highways/Expressways being 70,548 kms
- State highways being 1,28,000 kms
- Major and other district roads 4,70,000 kms
- Village roads 26,50,000 kms
- Data indicates that the total motor vehicle population in India has increased from about 300,000 in 1951 to about 73,000,000 in 2004
- The percentage share of Road Traffic accidental deaths reported during the year 2008 to the total number of reported accidental deaths in India is 34.5% according to a recent NCRB (2009) report.
- 1,00,300 males and 17,939 females totaling 1,18,239 persons were killed during the year 2008, while traveling by various modes of transport on roads

According to the NCRB (2009) data, the rate of accidental deaths per thousand vehicles is the highest in Arunachal Pradesh at 5.7 followed by Sikkim at 3.6 as compared to 1.3 at the national level in India

Coupled with this rise in vehicles, efforts are being made at expanding the road network across the country to meet the needs of the growing demands of the population. India already has a rural road network of over 3,000,000 km, and urban roads total more than 250,000 km. The national highways have a total length of 65,569 km and they serve as the arterial network across the country. Roads carry about 61% of the freight and 85% of the passenger traffic. Highways total about 66,000 km (2% of all roads) and carry 40% of the road traffic (Mohan, 2008).

At the same time, there are ongoing projects such as four-laning of the 5,900-km Golden Quadrilateral connecting Delhi, Mumbai, Chennai, and Kolkata, which is nearing completion. The ongoing four-laning of the 7,300-km North-South East-West corridor was to be completed by December 2009. The National Highway Development Programme, involving a total investment of US$ 55 billion up to 2012, has been proposed for constructing 1,000 km of new expressways, six-laning 6,500 km of the four-lane highways comprising the Golden Quadrilateral and certain other high-density stretches, four-laning the Golden Quadrilateral and NS-EW corridors, four-laning 10,000 km of high-density national highways, and upgrading 20,000 km of smaller rural roads into two-lane highways (Committee on Infrastructure, Department of Road Transport and Highways, 2008).

The increase in population, combined with the increase in the number of vehicles on the road and the ever expanding road structure can lead to disastrous effects if proper steps are not urgently taken to devise systematic ways to deal with the problem of road traffic accidents in India.

3.2 Pattern of RTAs

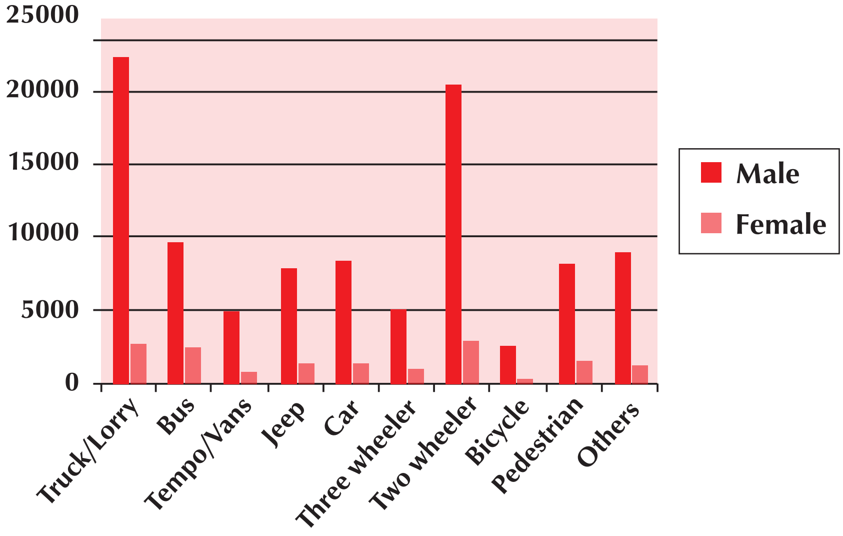
3.2.1 Sex wise and age wise distribution of RTAs in the population

In India, the male to female ratio among RTA fatalities was 6:1 according to a recent NCRB report (NCRB-ADSI, 2009: p 13). This predominance of men among RTA victims is apparent through the studies from all across the country. A review of published work on RTIs shows that males account for more than 80% of RTA victims as compared to women. This has been explained as a result of limited exposure of women to out-door activities and their limited access to vehicles (Dandona et al, 2006a; Jha et al, 2004) and supported by the observed increase in the proportion of women victims over the years as more women leave homes for employment. Relation between men's mobility and RTI is also supported by the finding from a study in Chennai where lower male to female ratio (2.6:1) was observed for elderly patients who presented with maxillofacial trauma (Subhashraj and Ravindran, 2007) as mobility for both men and women tended to be greatly reduced in this age group. Studies from Hyderabad found that more than 80% of riders of motorised two wheeler vehicles were males (Dandona and Mishra, 2004) and men were more likely to suffer road traffic injuries that required longer recovery periods (Dandona et al, 2008a). Majority of the women victims of RTA were observed to be pedestrians (Dandona and Mishra, 2004) or pillion riders (Fitzharris et al, 2009). Fitzharris et al (2009) found that there was a difference in the type of injuries that men and women pillion riders sustained. For example, most women pillion riders rode side-ways, which resulted in fewer fractures of lower extremities and more injuries to the head and torso region including fractures in the head and neck region. Dandona et al (2008a) also found that incidence of non-fatal RTI that required recovery period of 30 days or more was twice among women as compared to men (Box 7 and Figure 2 indicate the gender related differences in Road Traffic Accidents in India).

Box 7: Gender differences in Road Traffic Accidents

- Evidence indicates the predominance of men among RTA victims as compared to women
- Studies indicate that more than 80% of riders of motorised two wheeler vehicles are males and men are more likely to suffer from road traffic injuries that require longer recovery periods
- Majority of the women victims of RTA are observed to be pedestrians or pillion riders
- There is a difference in the type of injuries that men and women pillion riders sustain. For example, evidence indicates that most women pillion riders ride side-ways, which results in fewer fractures of lower extremities and more injuries to the head and torso region including fractures in the head and neck region
- Incidence of non-fatal RTI that require a recovery period of 30 days or more is twice among women as compared to men

Figure 2: Sex wise Road Accident Deaths by Type of Vehicle during 2008 (NCRB, 2009)



Evidence indicates that in 2008, two thirds (66%) of all RTA fatalities in India were in the age group of 15 – 44 years (NCRB-ADSI, 2009: p 30). Studies from different parts of the country have reported similar findings. Additionally, these studies show that the majority of the victims of non-fatal RTAs are also in the same age group (less than 45 years of age). Though various studies have used different age groups, it appears that, on average the RTA victims are in their mid-thirties and one third to three fourth of the RTA victims are in the age group of 21 – 40 years. Segregated data are not available for riders and pillions except for one study from Hyderabad. In this study, riders of motorised two wheeled vehicles were observed to be older (mean age 32.8 ±11.5 years) than the pillions (mean age 28.3 ±12.7 years) (Fitzharris et al, 2009).

The male to female ratio among RTA fatalities was 6:1 according to a recent NCRB report (NCRB-ADSI, 2009: p 13) in India. This predominance of men among RTA victims is apparent through the studies from all across the country.

Traditionally, RTAs are known to be a leading cause of trauma related mortality and morbidity among young adults. However recent studies have found RTAs to be an important cause of traumatic injuries among the elderly as well. Studies from different parts of India show that elderly (more than 60 years of age) account for up to 6% of the RTA victims (Patil et al, 2008; Rai et al, 2007; Pathak et al, 2006; Ganveer and Tiwari, 2005; Jha et al, 2003) and one tenth of the head injury victims because of RTA (Gupta et al, 2007).

Information about children is difficult to compile due to use of inconsistent age groups by authors. However, most studies observe that persons under the age of 20 years account for up to 21% of RTA victims (Table A in the appendix). Kanchan et al (2008) have reported RTAs to be responsible for 38% of deaths in 1 to 19 year old persons. Sharma et al (1993) have observed that 16% of paediatric trauma involving head injury reporting to a tertiary care centre was related to RTAs. Dhal et al (2006) found RTAs to be responsible for half of the (50%, n=50) paediatric spinal cord injuries in Kolkata. In a study from Southern India, 30% of maxillofacial trauma in persons less than 16 years of age was because of RTAs (Kumarswamy et al, 2009).

According to the 2008 figures, 66% of all RTA fatalities in India are in the age group of 15 – 44 years (NCRB-ADSI, 2009: p 30). Most of the RTA victims are found to be in their mid-thirties and one third to three fourth of the RTA victims are in the age group of 21 – 40 years

3.2.2 Geographical distribution of RTAs

The problem of RTAs in rural India has remained largely neglected. Although 80% of India's road length consists of village roads (MORTH, 2009) and RTAs rank fourth among the causes of deaths in 15 -24 year age group accounting for 7% deaths in this age group in rural India (Ministry of Home Affairs, Government of India, 2009), there is little epidemiological data available on RTAs in rural areas. The reference to rural areas in the context of RTAs remains minimal and is restricted to describing share of RTAs to mortalities and morbidities in rural areas. Gururaj (2006) refers to a study conducted in 2004 by Indrayan that found RTIs to be the eighth leading cause of injury related mortality in rural India. Cardona et al (2008) observed that the proportion of RTI was as high as 49% of all injuries in rural Andhra Pradesh. Singh M et al (2009) reported that a majority of spinal cord injuries received at the Government Medical College in Jammu were from rural areas. Based on the findings of a study of medico-legal autopsies of RTA fatalities (n=1872) Singh et al (2005) noted that 43% of fatal RTA took place in urban areas, 40% in semi-urban areas and 17% in rural areas.

In a study of unnatural deaths from Chandigarh, Sharma et al (2004) observed that 78% of RTA took place in rural areas and 22% in urban areas. An observation by Gururaj (2006) in a review of burden and impact of RTIs in India supports the findings from these studies that rural areas bear a high burden of RTAs. Commenting on the increasing share of RTIs to all injuries, Gururaj (2006) notes that the number of RTIs is rapidly increasing in states and places with relatively weaker infrastructure such as B grade metros and towns, peripheral rural areas and highways that are experiencing expansion of road networks and undergoing rapid motorisation.

3.2.3 RTI in certain population groups

In addition to the general /younger population, RTAs account for a significant proportion of trauma for certain population groups. With an increasing geriatric population, geriatric trauma in India and its management is gaining importance. For example, a study by Subhashraj and Ravindran (2007) found that RTAs accounted for 61% of maxillofacial trauma among the elderly. Sinha et al (2008) noted that among geriatric patients with head injury, mortality was the highest (27.5%) for those who sustained injuries in RTA. Patients suffering from epilepsy are at high risk of RTAs as noted by Sapna et al (2008) in a study from South India where 31% epilepsy patients attending an outpatient clinic reported a history of RTA in the year before the interview. According to a study by Gururaj and Benegal (2003), up to 12% of alcohol related injuries were related to RTAs.

3.2.4 RTI in specific population groups

Persons with lower levels of education (less than 10 years of education) were observed to be more among the victims of RTA (Sarangi et al, 2009;Jha et al, 2004; Verma and Tewari, 2004; Gururaj and Benegal, 2003). However none of the studies showed statistically significant association between RTI and level of education.

3.2.5 Income level of RTA victims

Only one study carried out by Dandona et al (2008a) has reported on RTI incidence over per capita income of the victims. The authors found that the incidence of RTI was similar across per capita income (PCI) quartiles of RTI requiring less than 30 days recovery period. In case of RTI requiring 30 or more days recovery period, the incidence was highest in the third quartile(Note: This has not been explained further in the paper.). Occupation of the victims can be considered a proxy indicator for their income levels. In a study from south India, almost a third of the victims (30%, 217.726) were labourers (Jha et al, 2004).

3.2.6 Nature/Patterns of RTA related injuries

Studies indicate that there is variation in the format used by researchers for presenting data on injuries sustained in RTAs. Most have classified the information into (1) whether the injury was fatal or non-fatal; (2) site of injury or body part that sustained the injury; (3) clinical details about the injury. Additionally, some researchers have presented data on severity of injury using standard scales such as the Glasgow Coma Scale (GCS) or Trauma Injury and Severity Score (TRISS) or Abbreviated Injury Score (AIS). Researchers reporting on studies based in emergency departments of large hospitals have commented on use of/correlation between commonly used injury scoring systems and outcome of the injury (Chawdaa et al, 2004; Goel et al, 2004; Murlidhar and Roy, 2004). Severity scores have also been used in some studies that use data from medico-legal autopsies and clinical records of RTA fatalities to analyse correlation between severity of injury and survival period (Sharma, 2005; Verma and Biswas, 2003). Box A in the appendix summarises the formats used by researchers to present and classify the types of injuries among the victims.

Alternately, population based surveys such as those by Dandona et al (2006a) have also used details of health seeking behaviour as proxy indicators for ease of classifying severity of injury for the respondents as well as family members (Box B included in the appendix).

Fatal injuries

Road traffic injuries are one of the most common causes of trauma reporting to the emergency departments of tertiary hospitals that need speciality or super-speciality care. Research from various Indian sites showed that 23 to 40 percent of trauma cases seen at the emergency departments of tertiary hospitals were due to RTAs (Muralidhar and Roy, 2004; Sharma, date not specified; Verma and Tewari, 2004; Goel et al, 2004). Between 14% and 50% of unnatural deaths from unspecified urban areas and 13% of unnatural deaths from rural areas (Cardona et al, 2008) were attributed to RTA. Almost two thirds (61%) of fatal head injuries (Pathak et al, 2008) and half of the fatal chest injuries (50%) (Pathak et al, 2006) were due to of RTA.

Non-fatal injuries

Studies indicate that the share of RTAs in non-fatal injury is even higher. The literature review indicates that injuries range from superficial minor wounds that require treatment in outpatient departments to more severe form of non-fatal injuries that require treatment at super-speciality departments of large hospitals and where even after treatment, victims experience some amount of residual disability. In 2005, India had an estimated 2 million persons disabled due to RTAs (WHO Global Safety Report, 2009). Referring to a number of hospital based research studies, Gururaj (2006) shows that proportion of persons experiencing various health problems and some degree of disability ranged from 43% at four months post RTI to 15% two years after the RTI took place. Research shows that RTAs are responsible for 30% of spinal cord injuries (Singh M et al, 2009) and 21% of paraplegia (Gupta et al, 2008-09). One third of fractures (36%)(Sharma et al, 2007), and more than 60% of maxillofacial trauma among general patient population are a result of RTA (Venugopal et al, 2010; Chandrashekhar and Reddy, 2008; Devadiga and Prasad, 2008; Thapliyal et al, 2008). Forty four to 60% of patients with traumatic brain injury have been observed to be victims of RTA (Kumar et al, 2009; Rajendra et al, 2009; Kumar et al, 2008; Yatoo and Tabish, 2008; Gururaj, 2002; Gururaj and Kollouri, 1999). Almost half (52%) the patients with intra-cranial haemorrhage have been victims of RTAs (Dash and Ray, 2009). Ninety three percent of friction burns have been caused by RTAs (Agarwal et al, 2008). Mahapatra (1999) noted that 61% of bilateral optic nerve injuries accounting for substantial vision loss, were a result of RTAs. Patients with crush injuries, 80% of whom were victims of RTAs, were reported to be at a higher risk of acute renal failure and higher mortality (Paul et al, 2009). A study by Singh et al (2005) found that road traffic accidents were largely responsible for peripheral vascular trauma, which is a less common type of trauma accounting for less than three percent of all trauma cases. However, timely management of peripheral vascular trauma is very important to prevent severe complications that can include amputation of limbs (Singh et al, 2005).

3.2.7 Socio-economic Costs of RTA

Estimating costs of RTA and RTI is a complex process. Scholars have proposed different models for estimating costs of RTA/RTI. Mohan (2002) states that costs of RTA include all costs related to RTI, which can be incidence or prevalence based and quotes Miller (2000) (Details included in Box C in the appendix) who has summarised costs of RTA/RTI into four broad categories – 1. Medical costs, 2. Other resource costs, 3. Work loss costs and 4. Quality of life (Details included in Box C in the appendix). Nationally, cost of RTA and RTI is estimated at INR 55000 crores (WHO, 2009). For the purpose of the present write-up, two broad categories of costs, direct and indirect costs are considered. Direct costs include cost of medical treatment whereas the indirect costs include wages lost, opportunities lost because of resultant disabilities and distress experienced by the victims as well as their families and care givers. Studies indicate that victims in India bear a significant burden of both direct and indirect costs of injuries. For example, a study of impact of RTAs on urban and rural poor households in Bangalore showed that most of the poor households were pushed into poverty as a result of RTA (Aeron Thomas et al, 2004).

Direct costs

Treatment costs including pre-hospital, at hospital treatment as well as rehabilitation expenses incurred as a result of RTI account for the direct medical costs of RTA. A large proportion RTIs need to be treated by specialist and super-specialist medical practitioners such as orthopaedic surgeons, practitioners of emergency medicine, neuro-surgeons, plastic-surgeons etc. Dandona et al (2006a) observed that 76% of RTA victims (995/1306) from Hyderabad required treatment at a health facility and 18% of these (174/995) reported inpatient care. In a retrospective study conducted at AIIMS, Delhi and SGPGIMS, Lucknow, 64% of head injury patients with age less than 20 years of age (n=46; RTA victim =20) had to be treated surgically (Kumar et al, 2009). Babu et al (2005) report on a study on management of extradural hematoma. Of the 300 patients included in the study, 52% had been victims of RTAs. Eighty two percent of these 300 patients needed surgical intervention while the rest were managed conservatively. Nine of the 19 patients who needed surgical intervention at the department of neurosurgery, NIMHANS for post extradural hematoma evacuation infarcts were injured in RTA (Indira Devi et al, 2006).

Research shows that clinical assessment alone is not adequate for assessing the severity/ extent of injury. This is especially true for head injuries including mild traumatic brain injury and spinal cord injuries. In such cases, the use of diagnostic tools such as a CT scan greatly helps in clinical management thus enhancing the outcome. Tirupathy and Muthukumar (2004) report on a study of 381 victims with mild traumatic brain injury; half (52%) of whom were victims of RTAs. They observed that despite a high Glasgow Coma Scale score (13 – 15) indicating relatively mild brain injury, CT scans for 40% of patients showed a lesion. Similar finding was noted by Equabal et al (2005), who concluded that a CT scan for patients with head injuries taken immediately after the injury facilitated 'prompt and accurate action by neurosurgeons'.

However, access to speciality care and affordability of such investigations is an issue especially relevant to a developing country like India. A study of traumatic spinal cord injuries of which a third (35%, n=483) were due to RTAs found that more than three fourth of the patients with spinal cord injury came from poor households with monthly per capita income of less than Rs. 10,000 (Singh R et al, 2003). Only 15% of head injury patients included in a study could afford a CT scan (Prasad et al, Date unspecified).

In case of serious injuries, cost of hospitalisation accounts for a large proportion of medical expenses. In a survey from Delhi, 56% of RTA victims required inpatient care; half of them (50%) approached private sector clinics/hospitals for treatment and 30% sought treatment at public sector facilities (Verma and Tiwari, 2004). Gururaj (2006) refers to a study of 800 households from slums of Chennai by Sathyasekaran (1996), where the incidence rate of RTIs was found to be 1600/100,000 and 3% RTA victims had to be hospitalised and 6.5% and 3.8% were bedridden for less than two weeks and more than two weeks, respectively. A population based survey in Bangalore of 4,822 households revealed that 47% of total injuries were due to RTIs and 15% were hospitalised for more than 24 hours (Gururaj G, 2002). Among 598 patients with mandibular fractures who reported to a tertiary centre in Dharwad, length of hospital stay ranged from 5 – 9 days. Length of hospital stay depended on nature and severity of injuries. Length of hospital stay for patients with spinal cord injuries ranged between 7 – 50 days and was found to be longer for patients with head, spinal cord injury brought in with neurological deficit (Singh M et al, 2009). Gururaj (2006), refers to research on costs of inpatient care that showed that costs of treating brain injury ranged from more than Rs. 1,000 to Rs. 3,000 per day depending on the severity of injury and whether the patient needed ICU care, whereas the estimated average cost of neurosurgical intervention was found be Rs. 11,948.

The treatment costs are not limited to the period immediately following the RTI. Some patients may develop sequel or complications after a long gap that may again require speciality care. About 10 – 80% of all persons with a traumatic brain injury are likely to experience psychiatric sequel necessitating psychiatric care and psychotherapy as well as support for the care givers (Chandra et al, 2004). Datta et al (2009) observed that mean duration of Post Concussion Syndrome (PCS) associated with mild traumatic brain injury was 28 months with a range of 3 – 84 and median of 13.5 months suggesting that 'PCS could manifest early and may persist for a long period' (Datta et al, 2009).

Apart from medical costs, direct costs related to RTAs/ RTIs include damage to property (vehicle), funeral costs etc, data for which are not widely available in the published literature.

Indirect costs

Limited information is available from Indian studies on indirect costs of RTA in terms of loss of employment, disability, and in terms of opportunity costs for the victim and his/her family. In a population survey from Hyderabad, almost half of those who reported a non-fatal RTI (48%, n=1306) had to take leave of absence from work. The average duration of leave (or absence from work) was 16.8 days (range: 1 – 630 days; median: 10 days) (Fitzharris et al, 2009). In a household survey from Delhi, 19% RTA victims reported loss of work for 2 – 4 days, 15% for 5 – 7 days and 13% for 1 – 2 months (Verma and Tiwari, 2005).

A study from Bangalore by Aeron Thomas et al (2004) that assessed the impact of RTA on poor households found that a large proportion of poor households had been non-poor before the RTA. The victims (who had died or had suffered serious injuries) were often the main earners of the households and thus the families suffered a direct loss of income or in food production (rural areas) as a result of a person sustaining RTI. Additionally, many households reported that one or more members had to discontinue study or work after the incident, thus amounting to financial as well as opportunity costs for the family. Most families borrowed money, took up additional employment or sold assets to meet the costs and losses incurred on account of RTA. However this proportion was more among the poor.

The costs as a proportion of total household income were much higher for the poor in cases of fatalities as well as serious injuries. In case of fatalities, as compared to the non-poor, the poor paid 150% more in urban and 72% more in rural areas. In case of serious injuries, the urban poor paid twice as much and the rural poor paid 45% more as compared to the non-poor. The poor had lesser job security and the proportion of poor who could return to their pre-RTA employment was lesser than the non-poor.

> A study from Bangalore by Aeron Thomas et al (2004) that assessed the impact of RTA on poor households found that a large proportion of poor households had been non-poor before the RTA. The victims (who had died or had suffered serious injuries) were often the main earners of the households and thus the families suffered a direct loss of income or in food production (rural areas) as a result of a person sustaining RTI. Also, in case of fatalities, as compared to the non-poor, the poor paid 150% more in urban and 72% more in rural areas

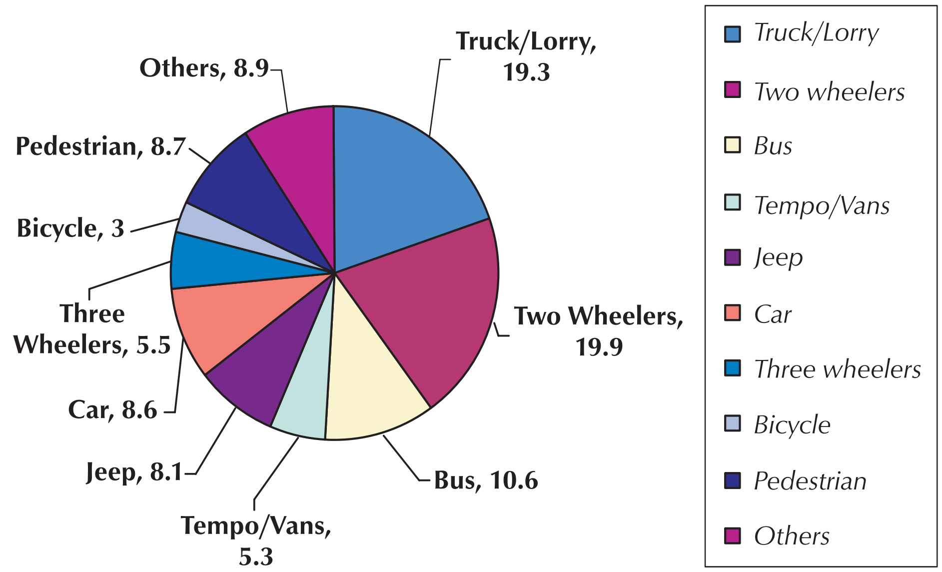
3.2.8 Victims of RTA

All types of road users such as pedestrians, users of non-motorised modes of transport, riders and pillions of motorised two wheeled vehicles, drivers and occupants of four wheeled light vehicles such as cars and jeeps and drivers and occupants of heavy vehicles such as buses, trucks, lorries and tractors are susceptible to RTAs. Figure 3 indicates the road accident deaths by the type of vehicles from different parts of India. In India, as in other developing countries, the vulnerable road users such as the pedestrians, users of non-motorised transport, cyclists and users of two wheeled motorised vehicles account for a large majority of the RTA victims (NCRB, 2009; Mohan, 2002). However, proportion of each group of road-users to the total number of victims of RTAs varies across cities.

Data also indicates that passenger injuries continue to be poorly documented in the context of India and the available studies include data that involves a combination or lumping together of passenger and driver data. The following paragraphs summarise data on types of road users and their share in fatal and non-fatal RTIs as reported by the researchers across various sites in India.

> The vulnerable road users such as the pedestrians, users of non-motorised transport, cyclists and users of two wheeled motorised vehicles account for a large majority of the RTA victims in India (NCRB, 2009; Mohan, 2002)

Figure 3: Road accident deaths by type of vehicles



- **Pedestrians**

In 2008, nationally, pedestrians accounted for 8% of RTA fatalities (NCRB, 2009). There was a difference in proportion across the cities. Twenty nine percent of pedestrian deaths for this period were from Delhi city (NCRB, 2009). The reviewed studies show a wide range in the proportion of pedestrians who are injured in a RTA. In case of RTA fatalities, it ranges from 29% in Rohtak, Haryana (Singh and Dhattarwal, 2004 and Singh H et al, 2009) to 92% in a study from Patna (Singh and Misra, 2001). More than a third (36%, n=61) of the RTA victims from Varanasi who sustained fatal chest injury (Pathak et al, 2006) and almost half (48%, n=100) of those who sustained a fatal head injury as a result of RTA in Manipal (Menon and Nagesh, 2005) were pedestrians.

The proportion of pedestrians among those with non-fatal RTI appears to be relatively smaller. A study of RTA victims presenting to the emergency department of a hospital in Karad, Maharashtra found 13% (n=350) of the injured to be pedestrians (Patil et al, 2008), whereas in a population based study in Hyderabad, Dandona et al (2008a) found that pedestrians accounted for one third (33%, n=1032) of the non-fatal RTI. A study conducted in Bangalore that involved roadside survey of road users (random as well as on suspicion) found that 5% of pedestrians were under the influence of alcohol (Gururaj and Benegal, 2003).

- **Bicyclists and users of other non-motorised vehicles**

In 2008, 3% of RTA fatalities in India were among bicyclists and about 9% among users of other non-motorised vehicles (NCRB, 2009).

Information on proportion of users of non-motorised vehicles including bicycle riders and their passengers; and bullock cart drivers and passengers was available from 14 studies included for the review and showed a wide range. According to these studies, bicyclists and their passengers accounted for 6% to 15% of RTA fatalities (Govekar et al, 2009; Pathak et al, 2008; Gupta et al, 2007; Kochar et al, 2007; Pathak et al, 2006; Singh et al, 2005; Singh and Misra, 2001). Proportion of bicyclists and users of non-motorised vehicles in non-fatal RTI ranged between 4% (Ganveer and Tiwari, 2005) to 39% (Jha et al, 2004).

Data for RTI involving bullock-carts was available from two of these 14 studies. Jha et al (2004) report that 12% (82/726) RTI involved bullock-carts; of these 43 were drivers of bullock carts, 30 were passengers and nine were pedestrians injured in an RTA involving a bullock cart. In the study based on non-fatal RTI reporting to the emergency department of a hospital in Maharashtra, Patil et al (2008) report that 2% percent of the 350 RTI recruited for the study were either drivers or the occupants of bullock carts.

- **Drivers (riders) and occupants (pillions) of motorised two wheeled vehicles**

Riders and pillions of motorised two wheeled vehicles form a large part of the victims of RTA. In 2008, 20% of RTA fatalities in India were among users of motorised two wheeled vehicles (NCRB-ADSI, 2009). Information on proportion of various types of road users among RTA victims was available from 27 papers / abstracts included for the review.

Users of motorised two wheelers accounted for 17 to 42% of RTA fatalities (Govekar et al, 2009; Singh H et al, 2009; Khajuria et al, 2008; Pathak et al, 2008; Gupta et al, 2007; Kochar et al, 2007; Kaul et al, 2005; Singh et al, 2005; Singh D et al, 2003; Sharma et al, 2002; Singh and Misra, 2001). Pathak et al (2006) observed that one fourth (25%, n=61) RTA deaths caused by fatal chest trauma were among users of motorised two wheeled vehicles. A study of fatal head injuries resulting from RTA found that 43% of the victims were users of motorised two wheelers (Menon and Nagesh, 2005).

The proportion of users of motorised two wheeled vehicles was much higher among those with non-fatal RTI. More than half (52%) of those with long bone fractures (Bagaria and Bagaria,2007), 81% of those with maxillofacial injuries (Chandrashekar and Reddy, 2008) and 55% of those admitted to the hospital subsequent to a RTA (Choudhary et al, 2005) were users of motorised two wheeled vehicles. A community survey in Hyderabad among the persons who reported being involved in a RTA in the year before the survey found that 84% of those who reported an RTI were users of motorised two wheeled vehicles (Dandona et al, 2006a). A study on RTA resulting from driving under influence of alcohol found that 79% of the victims were users of motorised two wheeled vehicles (Gururaj and Benegal, 2003).

Distribution of RTA victims over riders and pillions was available from a few papers and varied widely. A study from Hyderabad reported that drivers (riders) and pillions of motorised two wheeled vehicles accounted for 32% and 16% (n=781) of all RTI (Fitzharris et al, 2009). Similar findings were noted in a study from Pondicherry, where 31% (n=254) of all vehicle drivers and 11% of vehicle occupants (n=312) were riders and pillions of motorised two wheeled vehicles respectively (Jha et al, 2004). In another study from Karad, Maharashtra, users of motorised two wheeled vehicles accounted for 61% of drivers (n=119) and 35%

of vehicle occupants (n=172) (Patil et al, 2008). A study from Southern India (Mangalore) observed that among the RTIs involving motorised two wheeled vehicles, 81% of RTI were among the users of geared motorised two wheeler vehicles (Jain et al, 2009).

- **Drivers and occupants of Three Wheeler Scooter Taxis (TSTs)**

Along with two wheelers, rapid growth in three-wheeler vehicles in the Asian countries is considered a risk factor for RTI (WHO, 2009). In the 1990s, TST accounted for between one to ten percent of the vehicular population in some megacities (Mohan et al, 2000). In 2008, 5.5% of RTA fatalities were among the drivers and occupants of three wheeled scooter taxis (NRCB, 2009).

- **Drivers and occupants of four wheelers**

In 2008, 17% of RTA deaths in India were among drivers and occupants of cars and jeeps (NCRB, 2009). Sixteen papers included in the review provided information on the share of four wheeler drivers and occupants in RTIs. Eight of these papers provided information on fatal RTAs and the rest on non-fatal RTIs. The proportion of four wheeler drivers and occupants/passengers among RTA fatalities ranged from (1%, n=108) for a study conducted in Patna (Singh and Misra, 2004) to 26% (Singh H et al, 2009; Singh and Dhattarwal, 2004) in Assam and Haryana. This group accounted for 8% (n=61) of fatal chest injuries (Pathak et al, 2006) and 29% (n=100) of fatal head injuries (Menon and Nagesh, 2005) resulting from RTAs. Four wheeler vehicles were responsible for 36% RTA fatalities over a period of five years between 1999 and 2003 (Singh et al, 2005). Proportion of passengers of four wheelers was relatively low among the fatalities. A study based on autopsies of RTA victims found that 3% of the victims were passengers of cars (Gupta et al, 2007). Proportion of four wheeler drivers and passengers accounted for between 2 and 43% of RTI (Fitzharris et al, 2009; Dandona et al, 2008a; Choudhary et al, 2005; Ganveer and Tiwari, 2005; Jha et al, 2004). Bagaria and Bagaria (2007) noted that 29% of RTI with long bone fractures were drivers and occupants of four wheeler vehicles.

- **Drivers and occupants of heavy vehicles (buses, trucks, tractors etc)**

In 2008, 21.25% of RTA victims were noted to be occupants of heavy vehicles such as trucks and lorries (NRCB, 2009). However, microlevel information on RTI involving drivers and occupants of heavy vehicles was available from ten papers. Heavy vehicles were responsible for 59% (n=950) of RTA fatalities in Allahabad (Kaul et al, 2005) and 33% (n=1872) fatalities from Guwahati (Singh et al, 2005). Menon and Nagesh (2005) noted that 28% (n= 100) of fatal head injuries were occupants of heavy vehicles. Another study reports that 7% (n=100) of RTA fatalities were passengers from trucks and buses (Gupta et al, 2007). The proportion of heavy vehicle occupants to non-fatal RTI varied widely. In a study conducted in Pondicherry, Jha et al (2004) found that bus passengers accounted for 48% of total occupants/passengers who were victims of RTI. Choudhary et al (2005) observed that 23% (n=125) of non-fatal RTI admitted to a hospital in Wardha, Maharashtra were drivers or occupants of heavy vehicles.

3.2.9 When do RTA take place?

Season/Month of the year

According to the NRCB report (2008) at the national level, maximum number of RTAs took place in April (9%) and May (9%) and the least in September (7%). However, there appears to be variation in the seasonality of RTAs across the country. Studies exploring epidemiology of RTAs and RTIs in various cities hint towards link between poor driving conditions (such as visibility resulting from heavy rains or fog or slippery roads in the rainy season) and increased incidence of RTAs. Jha et al (2004) reported that 23% of RTAs in Pondicherry were in rainy season. Forty six percent of RTAs fatalities from Rohtak and 40% from Surat were in winter (Govekar et al, 2009; Singh and Dhattarwal, 2004). Other studies have reported higher proportion of fatal and non-fatal RTA in Delhi during the post-monsoon hot-wet season (Sharma, date unspecified; Verma and Tiwari, 2005).

Day of the week

Data on this is not available at national level. Chandrashekhar and Reddy (2008) found that maximum number of RTA involving alcoholics that resulted in maxillofacial injuries took place on Saturdays. Subhashraj and Ravindran (2007) and Sarangi et al (2009) also found that that 53% of RTA victims (n=80) were injured on Saturdays, whereas Jha et al (2004) observed that 20% of non-fatal RTAs occurred on holidays.

Time of the day

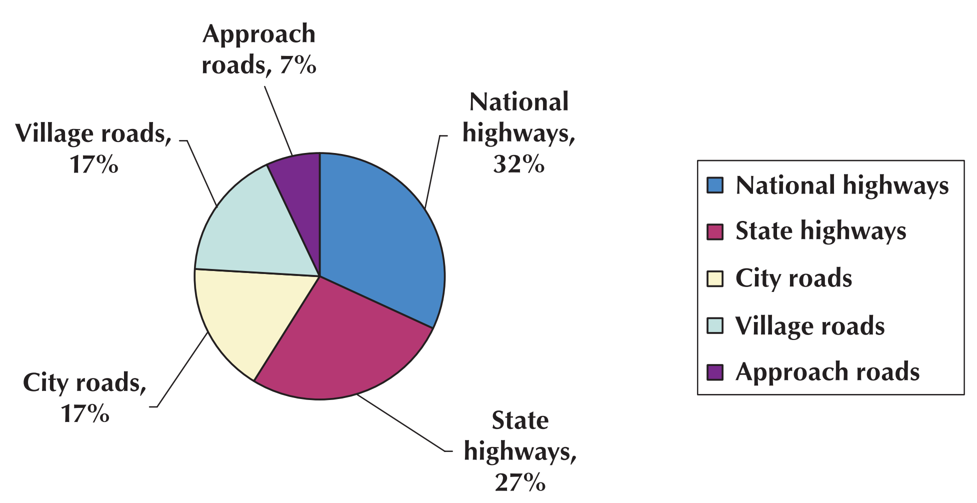
A number of studies have gathered data on peak time for RTAs. The NCRB (2009) report states that most RTAs take place between 3.00 pm and 6.00 pm. However, individual studies do show some variation. A third of fatal RTAs from north-east India (Silliguri and Guwahati) were reported to take place in the morning (6:00 am – 12:00 noon) (Gupta et al, 2007; Singh et al, 2005). Singh and Misra (2001) reported that 70% of fatal RTAs from Patna took place in the daytime.

Chandrashekhar and Reddy (2008) note that almost all (97%) of non-fatal RTA involving driving under influence of alcohol occurred during night, whereas majority (85%) of fatal RTAs involving non-alcoholics took place during the day. Bagaria and Bagaria (2007) found that a cluster of RTAs at a particular place took place in the evening or at night when the visibility was poor and the problem was resolved when the street light at the location was fixed. Proportion of fatalities were higher when the accidents took place at night (Rao et al, 2005). Table B in the appendix summarises the studies on the frequency of occurrence of RTAs throughout the day.

3.2.10 The accident site (where do RTAs take place?)

Road design is an important factor responsible for RTA. However, few epidemiological studies have documented these details. National highways that constitute 2% of Indian

Figure 4: Place of occurrence of RTAs



road network (MORTH, Annual Report 2008-09) and carry 40% of traffic, account for one third of fatal and non-fatal RTIs (Gururaj, date unspecified). Singh and Dhattarwal (2004) in their study found that 32% of RTA took place on national highways, 27% on state highways, 17% on city roads, 17% on village roads and 7% on approach roads (Figure 4 shows the proportion of RTAs on different types of roads). In a study of RTA fatalities in Varanasi, 49% of RTA were found to have occurred on highways and another 43% on city roads (Pathak et al, 2006).

Bagaria and Bagaria (2007) observed that a combination of factors such as the presence of a speed breaker and non-functioning street light led to a cluster of motorcycle accidents. Analysis of RTA fatalities from Patna showed that the majority of RTAs (73%, n=241) took place on straight roads, 1% at T junctions, 10% at Y junctions and 8% each at four-way intersections and traffic roundabouts (Singh and Misra, 2001). A study of 13777 motorised two wheeler accidents from Hyderabad showed that 81% of accidents involving motorised two wheelers were from rural areas and 'major clusters of two wheeler accidents included rural and roadside accidents among males and urban and highway' accidents among females (Umar and Jena, date unspecified). Box D in the appendix summarises the important road related factors contributing to RTAs.

National highways that constitute 2% of Indian road network carry 40% of traffic and account for one third of fatal and non-fatal RTIs. Skidding or overturn is the most common cause in single vehicle RTAs.

3.2.11 Crash characteristics (how do the RTAs occur?)

Crash characteristics such as mode of impact or the conditions facilitating RTA are influenced by a number of human, vehicle, road and environment related factors and in turn influence the nature of injuries that the victims suffer. Skidding or overturn is the most common cause in single vehicle RTAs, the proportion of this to all causes ranged widely across research sites. Gururaj and Benegal (2003) found overturn to be responsible for 28% of RTAs. In a survey from Hyderabad, Dandona et al (2006a) observed that overturn accounted for as many as 31% of RTIs. Another study from Hyderabad by Dandona and Mishra (2004) compared reporting of RTAs by police and newspapers and found that overturn was the cause of 6% of RTAs according to police records. Ten percent of the RTAs that resulted in victims sustaining long bone fractures were overturns (Bagaria and Bagaria, 2007). Jha et al (2004) noted overturn as a cause of RTAs in case of 7% of RTAs fatalities from Rohtak.

When a vehicle hits a pedestrian, the impact determines the type of injuries that the victim sustains. This is the most common type of accident where the victims suffer serious injuries. In a study from Hyderabad, 86% (n=316 crashes) were collisions with vehicles (Dandona and Mishra, 2004). In a study of RTAs involving sport utility vehicles, Kochar et al (2007) noticed that all 150 fatalities of such accidents were hit with such force that the victims were thrown up in the air. Some landing on the roof of the vehicle involved sustained further injuries. Most of these victims were hit from behind (impacted with the front of the vehicle) while crossing the road thus resulting in higher proportion of fatal abdominal injuries.

In case of multi-vehicle crashes, the victim suffers frontal, sideways or rear impact. Sideways impacts at times can also cause vehicles like three wheeled scooter taxis to overturn (Mohan, 2008). Multivehicle crashes accounted for 22% (Ganveer and Tiwari, 2005), 19% in (Jha et al 2004),18% reported by Gururaj and Benegal (2003) to as many as 59% (n=378) of all

RTAs (Fitzharris et al, 2008). Of the 59% multivehicle crashes, 36% were frontal impacts, in 8% cases the victim impacted the rear of the other vehicle, and in 25% cases, the rear end of the victim's' vehicle was hit by another vehicle. Sideways impact accounted for 28% of RTAs (Fitzharris et al, 2008). The proportion of side impact was high in a study by Ganveer and Tiwari (2005) where 64% of multivehicle RTAs reported side impact.

Human error by the driver, passenger or others on the road at the time of RTAs has also been found to be responsible for a high number of accidents. Dandona and Mishra (2004) found that for all RTAs, the cause of accidents was recorded as negligence by driver in the police records. Singh and Dhattarwal (2004) found human error to be responsible for 75% RTA with the driver being at fault in 54% and others on road being at fault in 19% cases from Rohtak. A review of literature by Jagnoor (2006) showed that 84% accidents were because of driver's fault, 6% because of factors such as cattle or fallen trees on the road, 3% because of mechanical defect in vehicles, 2% because of pedestrian fault, 2% because of passenger's fault, 1% because of bad roads and 1% because of bad weather.

3.2.12 Factors responsible for RTA

Risk Behaviour

- **Use of helmet**

Head injury is the most common cause of death in case of RTAs and globally, use of helmets of prescribed standard quality is known to be an effective prevention. Though India has a law mandating use of helmet by both riders and pillions of motorised two wheeled vehicles, the enforcement is poor (WHO, 2009). Studies across the country show that majority of RTA victims had not worn helmets at the time of the accident. A study from Hyderabad (Fitzharris et al, 2009) showed that 80% of RTA victims who were users of motorised two wheeled vehicles (n=378) were not wearing a helmet at the time of crash. More riders (29%, n=252) than the pillions (1%, n=126) were wearing helmets. Only 19% of users (riders and pillions) wore it correctly with closed faced and properly fastened. It was observed that more of helmet non-users (50%, n=252) as compared to helmet users (37%, n=126) suffered loss of consciousness indicating brain trauma. Fitzharris et al (2009) point out that 'risk of moderate to high head injury was five times higher and the risk of open head injury 1.9 times higher when helmet was not worn. Mortality was also higher (but not significantly higher) among those not wearing a helmet at the time of the crash. The findings from this study emphasise the role of helmets in preventing fatality and reducing severity of injury.

Other studies have reported equally high proportion of non-use of helmet. Tiwari and Ganveer (2008) found that 74% of two wheeler drivers did not use helmet at the time of accident. None of the 494 RTA victims with non-fatal RTI from Pondicherry were wearing 'protective gear' at the time of crash (Jha et al, 2004) and 16 of 18 RTA victims who were drivers of motorcycles and had sustained injury in collisions were not wearing helmet at the time of accident (Goel et al, 2004). A study of 450 RTA fatalities from Rohtak found that only one of 104 motorcyclists was wearing helmet at the time of accident (Singh and Dhattarwal, 2004). Proportion of helmet non-use was lower in a study from Bhubaneshwar with only 35% of 80 RTA victims found to be driving without helmets (Sarangi et al, 2009).

A study that explored risk behaviour among 14 to 19 years old school students from Delhi showed that 23% of those who had ever travelled on a motorised two wheeled vehicle never used helmet and 49% only occasionally used helmet (Sharma et al, 2007). In a study among school children from standards 9th to12th in Chandigarh, Swami et al (2006) observed that 62% of 787 school children were aware that non-use of helmet was a risk and 57% had been caught by police for driving without a helmet.

In a survey of users of motorised two wheeled vehicles from Hyderabad (Dandona et al, 2006b), 70% respondents (n=1483) reported no/occasional use of helmet. Researchers observed that ‘driving borrowed motorised two wheeled vehicle, driving moped/ scooterette/scooter as compared to motorcycle, lower education, age more than 45 years and being a male were predictors of no/low use of helmets’. Reasons for non-use included discomfort, not feeling the need for use and inconvenience when not in use. A study on helmet use practices in Kerala by Sreedharan et al (2009) found that women, unmarried persons and those who believed that stricter legislative measures for helmet use were necessary were more likely to use a helmet. Non use of helmets was also associated with indulgence in other high risk behaviours. Those who habitually consumed alcohol, and those who drove under the influence of alcohol were less likely to use a helmet. Seventy eight percent of those who used mobile phone while driving were found to not wear helmet (Sreedharan et al, 2009).

Studies across the country show that majority of RTA victims do not wear helmets at the time of the accident. Though India has a law mandating use of helmets by both riders and pillions of motorised two wheeled vehicles, the enforcement continues to be poor[6]

- **Use of seat belt**

Despite a law mandating use of seat belt for all occupants of four wheelers, there are very few studies correlating this particular high risk behaviour with RTI. In a study based on medico-legal autopsies of 450 RTA victims, four wheeler occupants accounted for 26% of RTA fatalities and none of the car occupants were wearing a seat belt at the time of accident (Singh and Dhattarwal, 2004). Sharma et al (2007) observed that 9% of school students between 14 and 19 years of age never used a seat belt while riding in the front seat of a car; 10% used it only rarely and 52% used it sometimes.

- **Driving under influence of alcohol**

Driving under influence of alcohol is known to be one of the important risk factors for RTAs and serious RTIs. According to the Road Traffic Act (1997), a person is considered to be driving under influence of alcohol when blood alcohol concentration is more than 0.03 g/dl. Benegal et al (date unspecified) found that 75% (118/156) of those with RTI had breath analyser alcohol concentration reading of more than 0.03 or more. In a study from Bangalore, interviews with victims of non-fatal RTIs who reported to emergency departments of selected hospitals showed that nearly 40% of drivers had consumed alcohol one hour before RTAs and 33% had consumed it two hours before the RTAs (Gururaj and Benegal, 2003). In a review of various Indian studies, Gururaj et al (2004) noted that driving under the influence of alcohol was responsible for 15 to 25% of RTIs. Similar findings were reported by Sharma (date unspecified) in a study based in AIIMS, Delhi where driving under influence of alcohol was responsible for 17% of RTIs. Sarangi et al (2009) noted that 15% of RTA victims who reported to the casualty of a private hospital in Bhubaneshwar (n=80) were driving under the influence of alcohol at the time of the accident. Driving under the influence of alcohol accounted for 11% to 60% of RTA fatalities (Khajuria et al, 2008; Singh

[6]National mandatory helmet legislation for motorized two-wheelers (MTWs) is included in the Indian Motor Vehicles Act of 1988. Implementing the law, however, has been left to the states. Many states have yet to implement the legislation (WHO, 2005)

Table 1: Drivers prosecuted by Mumbai Traffic Police for drink-driving on the intervening night of 22nd and 23rd January, 2010

Type of vehicle	Number of drivers prosecuted (%)	
Two wheeler	95	(69%)
Four wheeler	38	(28%)
Three wheeler	1	(1%)
Tempo	0	
Truck	2	(2%)
Bus	0	
Dumper	1	(1%)
Total	137	(100%)

Source: website of Mumbai Traffic Police, http://www.trafficpolicemumbai.org/Pressnote%20on%20Drunken%20Driving.doc. Downloaded on 27th January 2010.

et al, 2005, Pandey et al, date unspecified) and 15% to 87% of non-fatal injuries (Sarangi et al, 2009; Chandrashekar and Reddy, 2008; Patil et al, 2008; Bagaria and Bagaria, 2007; Gururaj and Benegal, 2003).

Singh et al (2005) observed that 31% pedestrians and 7% of bicyclists who died as a result of RTA were under the influence of alcohol. Tiwari and Ganveer (2008) found that 65% of RTA victims with non-fatal injuries 'regularly consumed alcohol'. The impaired judgement resulting from alcohol consumption is apparent from the finding reported by Gururaj and Benegal (2003). In Bangalore, they noted that 36% of victims of RTAs who had consumed alcohol at the time of RTAs were confident that they could drive after drinking. The same study also found out that in case of a night time crash, RTA victims driving under influence of alcohol were less likely to receive first aid (12%) as compared to those who were not driving under the influence of alcohol (21%) (Gururaj and Benegal, 2003). Table 1 shows the type of vehicle drivers prosecuted by the Mumbai police for drink driving.

- **Driving without license**

According to official data, in India, driving license is issued after written, practical and medical tests (WHO, 2009). However, research shows that the general population has a laid-back attitude towards driving licence. A study among school children (standards 9th to12th) from Chandigarh found that 19% of participants rode motorcycles and 2% drove cars and the proportion was higher in private schools as compared to government schools. Majority of these children (70%) had been driving since the age of 12 years and that too without proper licence to drive (Swami et al, 2006).

A survey among drivers of motorised two wheeler vehicles who were more than 16 years of age (legal age for obtaining a license in India) (n=1483) showed that 11% of drivers did not have a license, and 21% had obtained it without completing the mandatory procedures (Dandona et al, 2006b). A study from Karad, Maharashtra (Patil et al, 2008) found that 30% of the non-fatal RTA victims (n=350) did not have a licence. The proportion of those driving without a valid license was 15% in Pondicherry (Jha et al, 2004).

- **Driving with vision / hearing impairment / compromising medical condition**

Though it is an important issue, only one Indian study could be located that commented on drivers' medical fitness and RTA. In a study in Nagpur, Tiwari and Ganveer (2008) observed that a large proportion of drivers who reported to the Medical college Nagpur with non-fatal RTI had visual (44%, n=423) and/or hearing impairment (10%, n=423). An article in India Today quotes a study conducted by AIIMS, Delhi in 2006 that found fatigue and sleep deprivation among professional drivers was responsible for over 60% of RTAs (Srivastav, 2009).

- **Other high risk behaviours/driving practices**

Research across the country on high risk behaviour in the context of RTA largely focuses on driving under the influence of alcohol and non-use of helmets. Non use of seat belts has been mentioned by some. However other factors such as speeding, use of cell phone while driving find only occasional mention in the reports commenting on behaviours contributing to RTA. Gururaj and Kolluri (1999) observed that speeding was responsible for 21%, dangerous driving practices for 10 % to 15% vehicle related problems and for 3% of RTI (n = 1784). In a household survey in Delhi, Verma and Tiwari (2004) observed that 31% of RTA were caused by high speed (n = 680).

- **Pedestrian related**

Pedestrians along with bicyclists and motorcyclists form the vulnerable road users. In addition to high risk behaviour of users of motorised vehicles and road related factors, a number of pedestrian behaviour related factors are responsible for RTIs to pedestrians. In a study from Hyderabad, 53% of 249 pedestrians were found to be injured while crossing the road, 33% while walking on the street, 9% were standing on the road when they were hit by a vehicle, 4% were injured while alighting from or trying to board a bus and 1% were injured while doing other activities (Dandona et al, 2006a). Proportion of pedestrians fatalities as a result of falling off a moving vehicle accounted for 20% of RTA fatalities in Pondicherry and an additional 37% were knocked down by vehicles (Jha et al, 2004). In Bangalore, elderly accounted for 17% of pedestrian fatalities and 10% of non-fatal injuries (NIMHANS-BISP, date unspecified). Dandona et al (2006a) comment that both the pedestrian's disregard for safety practices as well as pedestrian unfriendly road designs are responsible for injuries to this group of road users. Other researchers have also highlighted the increased vulnerability of pedestrians while crossing the road without watching out for the oncoming traffic causing as many as 36% of RTI (Gururaj and Kolluri, 1999). The other factors include road design related factors where pedestrians crossing the road at points where flyovers merge onto the main roads get hit by vehicles speeding down the flyover (Kochar et al 2007).

3.2.13 Road related factors

Street lighting

Only one study was found that commented on relation between poor street lighting and RTA. Using GIS technology, Bagaria and Bagaria (2007) noted that a cluster of motorcycle crashes corresponded with a site with a raised speed breaker and a broken street light. The authors noted that the accidents ceased to take place once the light was replaced.

Road condition (bumps, potholes, objects obstructing road)

Poor road conditions are responsible for between four and ten percent of RTIs (Dandona et al, 2006a). Nearly 5% of non-fatal RTA in Hyderabad were because of a motorised two wheeled vehicle colliding with a non-moving object on the street (such as road divider, stone, speed breaker, tree, wall, foot path etc) or because of the potholes and open manholes on the roads (Dandona et al, 2006a). Collisions with non-moving objects were responsible for 4% (n=316) of RTAs (Dandona and Mishra, 2004) and accounted for 11% (n=494) injuries reported to a casualty department (Jha et al, 2004). Speed breakers without a functioning street light were found to be responsible for a cluster of RTAs in central India (Bagaria and Vagaria, 2007). In a southern Indian city, 25% (n=368) RTAs had taken place when the roads were wet and slippery (Jha et al, 2004). Similar observations were made by Verma and Tiwari (2005) in a study from Delhi where congested and slippery roads were responsible for 20% and 17% RTAs respectively.

Road design

Traffic on Indian roads is heterogeneous and poses specific challenges for road safety. Though pedestrians form a large proportion of fatalities, the needs of pedestrians have not been adequately addressed while designing the roads. Tiwari (2001) refers to a study carried out by IIT (2000) in Delhi that found that 70% pedestrians followed traffic rules while crossing the roads i.e. they crossed the road when the signal was green for pedestrian crossing or for right turning vehicles. Further, the study also noted that at any point number of pedestrians waiting to cross the road at the median of the road was more than those waiting on the sides.

Bicycles are a commonly used mode of transport in rural areas, smaller cities and by majority of the poor in megacities. Bicycle as a mode of transport accounts for between 8% to 18% of road trips across India (Tiwari and Jain, 2008) but have a disproportionately higher share in fatalities (Mohan and Tiwari, 1999). A case study of Delhi showed that fatalities of bicyclists were highest on two or three lane roads during non-peak hours, when the motorised vehicles travelled at higher speeds (Tiwari, 2002). The authors conclude that presence of non-motorised vehicles on the roads slowed down the traffic of the motorised vehicles. Thus, redesigning of roads and intersections could lead to improved efficiency of roads by reduction in delays resulting from traffic moving at sub-optimal speeds, reducing conflicts between pedestrians, bicyclists and motorised vehicles and by cutting down on carbon dioxide emissions (Tiwari, 2001).

A study of a 40 km stretch of National Highway 5 by Rao et al (2005) found that discontinuous service roads and poor design of access roads approaching the highway were largely responsible for RTA in the section of the highway studied. The researchers observed that discontinuous service roads resulted in road user movement in the wrong direction (direction opposite to that of the lane of the highway). Conflicts between 'local traffic' mainly consisting of motorised two wheeled vehicles and 'through traffic' which largely consisted of goods vehicles as a result of poorly designed access roads were another most common reason for RTAs on the highway. Researchers identified and analysed locales that showed clusters of RTAs. This analysis brought forward faulty road designing issues such as an access road that joined the highway at a sharp curve in absence of proper signal to guide the road users; breaks in the median divider that allowed traffic in wrong direction; encroachment at the point where an access road joined the highway, and trees and bushes planted on the median divider that prevented the drivers' from spotting pedestrians crossing the highway that were found to be a responsible for the majority of RTAs.

3.2.14 Vehicle related factors

Overloading /overcrowding

Overcrowding of passenger vehicles such as buses and overloading of goods vehicles is commonly seen to be responsible for RTA resulting in high proportion of fatalities. However, this important issue (despite a cover photograph for the WHO report (2009)- namely the Regional Report on Status of Road Safety: the South-East Asia Region showing seven persons on a motorcycle) does not find any mention in official or research documents. Even after a focused search of published literature only one published study was located that commented on proportion of overcrowded vehicles involved in RTAs. In a study of 350 RTA victims with non-fatal injuries, Patil et al (2008) observed that 75% of four wheelers involved in RTAs were overcrowded. In a study from Pondicherry (Jha et al, 2004), trucks accounted for the highest proportion of vehicles involved in RTAs leading authors to conclude that 'rough driving, over speeding and heavily loaded vehicles offering poor control' could be the possible reasons.

Vehicle design

There is limited information on relation between fatalities, injuries and vehicle design in India. While epidemiologists, forensic medicine practitioners and other members of medical fraternity report on injuries, the vehicle design aspect of injuries has been studied by the researchers from various engineering specialities.

The only epidemiological study that correlated/commented on relation between injuries and vehicular design was from Jaipur by Kochar et al (2005). The researchers studied RTAs involving sports utility vehicles (SUV) where cause of death was head injury or thoraco-abdominal trauma. Eighty percent victims died before reaching the hospital. Fractured pelvis, ribs, vertebrae and injuries to visceral organs were responsible for shorter survival period. Authors note that noticeably absent were the injuries such as fractures of tibia that result from collision with bumper of the offending vehicle. Authors conclude that the aesthetic and aerodynamic design of the SUV included the lack of a bumper or pedestrian guards, which was a feature of the vehicles of yesteryears. These along with the height and contour of the front of the SUV were responsible for more severe injuries in the thoraco-abdominal region resulting in higher fatality and shorter survival time/higher proportion of spot deaths. The authors believe that even with prompt medical care, a large proportion of deaths could have been avoided with modifications in vehicle designs.

Another body of research related to vehicle design and injuries or traffic safety is related to three wheeled scooter taxis (TST) (autorickshaw) that are a common mode of transport in urban India. In the 1990s, TST accounted for between one to ten percent of the vehicular population in some megacities (Mohan et al, 2000). In 2008, 5.5% of RTA fatalities were among the drivers and occupants of three wheeled scooter taxis (NRCB, 2009).

In a study from Hyderabad, Dandona and Mishra (2004) found that according to the police database, 4% of RTA fatalities were drivers and occupants of three wheeled scooter taxis. In 8% of RTA cases, three wheeled scooter taxis were the offending vehicles. Drawing from a number of simulation experiments reported elsewhere, Mohan (2008) reports that three wheeled scooter taxis are safe vehicles for passengers as well as pedestrians as they are not likely to flip over unless hit sideways by another vehicle, and are responsible for less severe injuries because of lighter engines that allow lower travel speed. The structural design of the vehicle also minimises trauma to a pedestrian in case of collision with a three wheeled scooter taxi. Chawla et al (2003) report on simulation studies on crashworthiness of three wheeled scooter taxis and conclude that the severity of injury to driver and passengers of the three wheeled scooter taxi can be reduced by modifications in the design of the vehicle. The researchers suggest that seat belts for both the driver and the passengers, soft padding of surfaces which come in contact with the head of the driver and passenger and rear facing seats can be very useful to eliminate the possibility of the passengers' heads coming in contact with any hard surface on frontal impact (Mukherjee et al, 2007; Chawla et al, 2003). Research by the same group of researchers suggest that the severity of head and knee injury sustained by driver and passenger of TST in case of collision with buses can be reduced by major modifications in the design of TST and bus fronts (Mohan et al, 1997)

In India, overcrowding of passenger vehicles such as buses and overloading of goods vehicles is commonly seen to be responsible for RTA resulting in high proportion of fatalities. However, this important issue does not seem to find any mention in official or research documents. A focused search of published literature finds only one published study that comments on the proportion of overcrowded vehicles involved in RTAs

3.2.15 Socio-economic conditions and susceptibility to RTA

Recent years have brought equity related dimensions of RTAs into focus. For example, evidence indicates that the low and middle income countries bear a disproportionately high burden of RTIs and the poor from all countries are at a higher risk of RTIs (WHO, 2009). A survey of 2100 households from Pune found a higher proportion of unsafe behavioural practices among the poor that made them more prone to injuries including RTIs. The study revealed that the proportion of non-users of helmet because of not having one was higher among the poor; and children from poor households often played on the road for want of suitable places in crowded slum areas, thus exposing them to the risk of RTIs (Mirkazemi and Kar, 2009). Rapidly growing cities have forced the poor to the outskirts of the cities, who tend to stay away from employment centres that are often poorly served by the public transport systems. This leads to more use of two wheelers among the poor as two wheelers tend to be more affordable, reliable and a personalised means of transport (Badami et al, 2004). Long distances from work places, use of two wheeled motorised vehicles and congested roads thus increase the risk of the poor to RTIs. This is also reflected in the epidemiological studies where pedestrians, users of motorised two wheeler vehicles and cyclists account for upto half of the RTA fatalities (Badami et al, 2004).

A study from Bangalore by Aeron Thomas et al (2004) explored the involvement of and the impact of RTAs on the poor. In urban and rural areas, the poor were more likely to be involved in a road crash as pedestrians and the non-poor as motorcyclists. It was observed that in rural areas, the poor were more likely to die of RTIs but no such correlation was seen in urban areas.

3.2.16 Issues related to prehospital care after an RTA has occurred

Preventing mortality and reducing severity of injuries

Pre-hospital care is an important step for preventing mortality and reducing morbidity and disability related to RTAs (WHO, 2005). Inability to carry the injured to the appropriate hospital in time, lack of suitable transport facilities and inappropriate movement of the victim by lay people who lack awareness regarding the risks involved in shifting an injured person can all lead to adverse outcomes in cases such as deaths or disablities in the cases of severe RTI (WHO, 2005). The high proportion of deaths in a short period following

RTAs highlights the need for a strong pre-hospital care system in India (Joshipura et al, 2004). In India, most of the deaths due to RTAs (50% to 90%) take place within 24 hours of the injury and a subset of these victims (3% to 21%) succumb to their injuries before reaching the hospitals. Table C in the appendix provides evidence for this from a number of studies across India. In Bangalore, data collected under the Bengaluru Injury Surveillance Programme (BISP) showed that almost half of the pedestrians involved in RTAs died either on the spot or on the way to a hospital (NIMHANS-BISP, date unspecified). Proportion of those who receive first-aid is negligible. For example, in a study from Kerala, three fourth (76%, n=242) of the RTA victims who reported to a casualty department in Trivandrum had not received timely first aid (Pandey et al, date unspecified). None of the 450 who died of a RTIs in Rohtak (Singh and Dhattarwal, 2004) had received first-aid. Even among those who suffer non-fatal RTIs, very few receive any first aid at the site of RTA. Only five of 35 persons from Guwahati who subsequently lost vision as a result of head trauma had received first aid (Bhattacharjee et al, 2008). Fitzerald et al (2006) quote findings from a prospective study from Mumbai where 82% of trauma victims with severe injuries had not received pre-hospital care before reaching the hospital. A review of existing data by Gururaj, date unspecified) also showed similar findings. Based on their analysis of data from autopsies of 177 RTA victims, Sahdev et al (1994) concluded that 23% of these deaths could definitely and 41% possibly could have been prevented with efficient trauma care.

Transport of the severely injured, especially in cases of head and spinal cord injuries is an important component of pre-hospital care. Evidence indicates that when adequately equipped vehicles and trained personnel are involved in transporting the victim, it can significantly reduce the resultant disability in case of spinal cord injuries. Pre-hospital care with proper spinal stabilisation, prevention of hypotension and oxygen therapy significantly reduces secondary injury to the spinal cord (Upendra et al, 2007). However, in India, a majority of patients with spinal cord injuries are transported by vehicles unsuitable for the purpose. This has been found to increase the risk of secondary spinal cord trauma and neurological deficit. In a study in Rohtak, it was found that, of the 483 patients with spinal cord injuries, only 23% of the 35% patients who suffered from RTI, were transported in an ambulance, and 77% in vehicles unsuitable for transport of spinal cord injuries (Singh R et al, 2003). Similar findings were noted by Singh M et al (2009) in Jammu where 76% patients were transported in vehicles unsuitable for spinal cord injuries without proper immobilisation. 'Injudicious movement of unstable spine leading to worsening compression' is one of the key factors responsible for secondary spinal injury (Upendra et al, 2007: p 293).

The high proportion of deaths in a short period following RTAs highlights the need for a strong pre-hospital care system in India. Most of the deaths due to RTAs take place within 24 hours of the injury and a subset of these victims succumb to their injuries before reaching the hospitals

The importance of proper immobilisation, appropriate pre-hospital care and careful transport of patients with spinal cord injury is highlighted in an epidemiological study of thoraco- lumbar spine trauma carried out at AIIMS, Delhi. Forty eight percent (n=403) of patients with thoraco-lumbar spine trauma were transported to AIIMS in an ambulance. Only 7% patients were transferred directly to the tertiary hospital from the injury site, 73% had been shifted two to four times and 20% between five to seven times to various facilities before reaching the tertiary hospital (Upendra et al, 2007). Similar findings were noted by Pandey et al (2007) among 60 patients admitted to regional tertiary spinal centre at Delhi. Forty three percent of the patients had met with RTIs and had been brought to the centre after being treated at 0 to 6 (mean = 2) health facilities subsequent to the injury. Only 25% of these patients were transported by ambulances. Police patrol vans (12%), cars (47%), autorickshaws (26%), bullock carts (21%) and motorcycles (5%) were the reported modes of transfer to hospitals after the injury. Upendra et al (2007) note that the number of transfers was positively correlated with neurological deficit. The proportion of patients with complete paraplegia significantly increased with increase in number of transfers and all 32 patients with single transfers showed 'independence of mobility' (Upendra et al, 2007: p 292). Another population based survey from Delhi showed that only 5% of the RTA victims were transported by ambulance. Auto-rickshaw or taxis were the most commonly used mode of transport (36%, n=680). A small proportion of persons injured in RTAs used bicycles (10%) and two wheelers (2%) to reach a health facility (Verma and Tiwari, 2005).

Time lag between injury and initiation of treatment is crucial for outcome of the injury as is transfer of victims to appropriate level of health care facility. It is observed that generally the injured are taken to the nearest health facility without considering the ability of the hospital to deal with the trauma (Fitzgerald, 2006). In a study from Andhra Pradhesh on management of peripheral vascular trauma in 662 patients, of the 55% victims of RTA, almost all amputations of lower limbs were among patients who presented to the hospital eight hours or later. Median delay between injury and reaching hospital was observed to be 45 to 60 minutes in a study of RTA fatalities from Rohtak (n=450) (Singh and Dhattarwal, 2004). Only four percent from this series had reached hospital within 15 minutes and another 16% between 15 to 30 minutes of the injury. For a third of the victims, the delay was more than an hour. In a study conducted at AIIMS Delhi, more than half (59%, n=403) patients with thoraco-lumbar spine trauma reached the hospital within 48 hours and these patients showed better neurological recovery compared to those with delayed presentation (Upendra et al, 2007). In another study from Delhi, it was found that most (70%, n=60) of the patients admitted for rehabilitation at the regional spinal centre at Delhi were first treated at local nursing homes, 58% at primary level health centre, 47% at secondary level and only 30% had been treated at tertiary level health facilities (Pandey et al, 2007). The mean delay between injury and accessing the spinal centre was 45 days (range 0 – 188 days). Only 5% patients reached the spinal centre on the day of injury. Lack of awareness about existence of specialised spinal units was reported as the reason for delay by 80% of the patients. Financial constraints and treatment of associated poly trauma were responsible for the delay in case of 10% patients each (Pandey et al, 2007). Data from all the above mentioned hospital based studies shows gross delays in reaching trauma victims to hospitals that often results in unfavourable outcomes. However in a population survey from Delhi, Verma and Tiwari (2004) noted that 70% (n=680) of the RTA victims (severity of injury not specified by researchers) sought treatment within one hour of injury.

Developed countries have reduced mortality and morbidity by strengthening pre-hospital care systems (Dash, 2008). However, India is far from establishing a pre-hospital care system that is of desired quality. The existing pre-hospital care system is rudimentary, inequitable in terms of access, and has limited human and material resources essential for saving lives. The first ever survey of government (tertiary and other), non-government and private hospitals from rural, semi-urban and urban areas conducted by Institute of Traumatology, India in 2002 (Joshipura et al, 2004) found that there were no trauma care systems for rural areas and the ones existing in urban and semi-urban areas were 'elementary in nature'. The research also found that pre-hospital care provided by government/public sector as well as the private sector was available only in urban areas and often overlapped in terms of the geographical areas they covered. Ambulances, which form a crucial part of the pre-hospital care were not available at 12% of the surveyed facilities and air transport (mostly provided by private sector) was accessible for only 4% of facilities. When available, the ambulances were often staffed by untrained personnel, and almost three fourth (72%) had a single staff with the ambulance.

Airway compromise, respiratory failure and uncontrolled haemorrhage, all of which can be treated with 'basic first aid measures', are known to be responsible for most of the deaths in the first hour after the injury (WHO, 2005). A study of causes of RTA related mortality from Varanasi found that 30% of the victims died of hemorrhagic shock and asphyxia and 28% of asphyxia alone (Pathak et al, 2006). Efficient pre-hospital care is known to reduce even delayed complications and disability among trauma victims. Proper immobilisation of fractures, support of oxygenation and maintenance of blood pressure through administration of appropriate intra-venous fluids and drugs in the first few hours after the injury is important for reducing the long term complications and disability among patients (WHO, 2005). The survey in India showed that only 50% of the ambulances had skills and resources for providing airway support and proper immobilisation (splintage), 74% had facilities for administering intra-venous fluids, and 62% for monitoring blood pressure. A third of the ambulances surveyed were used only as transport vehicles and did not have a paramedic on board (Joshipura et al, 2004).

Emergency care for pedestrian victims of RTA – findings from BISP
(copied from the report)

- First aid care was not available for most of the fatally or non-fatally injured pedestrians at crash site.
- 99% of the injured pedestrians were provided first aid by doctors in the nearest hospital.
- Of the injured, 50% were taken to government hospitals and 43% to private hospitals.
- 46% of the injured reached hospitals directly on their own, while 27% and 22% were referred from government and private hospitals, respectively.
- Among the injured, 36% reached the hospital by private vehicles (taxi), 32% by autorickshaw and 22% by ambulance (mainly for inter-hospital referrals).
- Almost all injured pedestrians visited at least 1 hospital before reaching a definite hospital.

(Source: NIMHANS-BISP fact sheet on Pedestrian Safety)

Communication systems are crucial for arranging timely aid for the victim and to make sure that the patient when transported to the hospital is received by clinicians without any delays. Only 4% of the ambulance services surveyed had a comprehensive communication system between the ambulance and the hospital and a third of the services located in urban areas used wireless networks for the purpose (Joshipura et al, 2004).

'...In many countries, few victims receive treatment at the scene and fewer still can hope to be transported to the hospital in an ambulance. Transport, when it is available, is usually provided by relatives, untrained bystanders, taxi drivers or truck drivers, or a police officer. As a result, many victims may needlessly die at the scene or during the first few hours following injury..'. (World Health Organisation, 2005; pp 8)

Trauma care at the emergency departments of most Indian hospitals is far from the ideal. Fitzgerald et al (2006) note that most Indian hospitals do not have trauma teams and do not follow inter-disciplinary approach to trauma care. The survey by Institute of Traumatology, India also found trauma services at the hospital to be deficient with only half the surveyed hospitals having a clear protocol for management of trauma (Joshipura, 2004). The situation was worse at PHC and CHC levels where very few doctors had training and experience in trauma management. In addition to this, health facilities faced shortages of low cost equipment essential for effective trauma care and higher end technology such as CT machines remained unused because of lack of repairs. The most important finding noted by the author was that 'there were wasteful mismatches between availability of equipment and human resources' (Joshipura, 2006: p 931).

Trauma care at the emergency departments of most Indian hospitals is far from the ideal. Most Indian hospitals do not have trauma teams and do not follow inter-disciplinary approach to trauma care

3.3 Road traffic accidents prevention

Evidence indicates that road traffic accidents (RTAs) affect a large proportion of morbidities and mortalities in developed as well as developing countries. However, Road Traffic accidents continued to be ignored as an important public health issue till recently, because accidents and injuries were looked upon as random or chance events that were an unavoidable part of road transport. Recent years have brought about a change in perspective and a new understanding has emerged in terms of looking at road injuries as avoidable events that can be prevented or controlled through intervention (World Health Organisation, 2004).

The systems approach proposed by Haddon has been identified as the best approach to address the problem of road safety and prevention of road traffic accidents. This approach defines road transport as an "ill defined" "man-machine" system that needs systematic interventions and planning (World Health Organisation, 2004: p 12). This approach divides crash events into three phases depending upon the timeline. These include the pre-crash phase, the crash phase and the post crash phase that involve interactions between the epidemiological triad of the human being, machine and the environment.

The Haddon matrix (Table 2) thus highlights the importance of human or behavioural factors such as information, attitudes, enforcement; mechanical factors such as vehicular speed management, equipment design and the broader ones such as road designs and layouts, speed limits, pedestrian facilities in preventing the very occurrence of crashes on the road or what can be called as primary prevention in the first phase. The second phase includes efforts at controlling the intensity or effects of the crashes through efforts at injury prevention by encouraging use of protective devices such as improved, safe and crash protective designs among vehicles as well as on the road. The post crash phase focuses on efforts at fatality prevention and focuses on life sustaining efforts that encourage emergency service access, vehicular designs that minimise risk and fatalities and infrastructural facilities that allow easy access to rescue facilities and prevent congestion of traffic (World Health Organisation, 2004).

Table 2: The Haddon Matrix (Peden et al, 2004 : p 13)

Phase		Factors		
		Human	Vehicles and equipment	Environment
Pre-crash	Crash prevention	Information, Attitude, Impairment, Police enforcement	Roadworthiness Lighting Brakes Speed controlq	Road design and layout Speed limits Pedestrain facilities
Crash	Injury prevention during the crash	Use of restraints Impairment	Occupant restraints roadside objects Safety devices Crash protective design	Crash protective
Post-crash	Life sustaining	First aid, Access to medical facilities	Ease of access Fire risk	Rescue facilities congestion

Inspite of the high degree of motorisation in developed as well as developing countries, many of the efforts at preventing road traffic injuries through systematic interventions come mainly from high income countries. There is very limited or scant evidence of such systematic interventions from low income and middle income countries (Ameratunga et al, 2006). The following section describes the various intervention studies or attempts to shed light on the range of interventions that have been implemented especially in the context of high income countries and wherever available, in the case of middle income and low income countries. The section will then go on to discuss the implications of these interventions in the context of India.

A review of relevant literature indicates that there are a range of interventions that have been attempted to make transport safer by trying to reduce injuries or deaths due to traffic accidents. These include interventions that use legislation to either reduce speeding on the road through restrictions on speed and engine types, or imposing age limits on two wheeler vehicle drivers, traffic law enforcement, introduction of restrictions on licensed drivers etc. The other category of interventions include efforts at making roads safer for driving by speed reduction and control mechanisms. The third set of interventions target changes in vehicular designs to help safer vehicles and driving on the roads. The fourth set of interventions mostly include behavioural interventions that target safe behavioural practices among people and include laws to prevent drink driving among people, educational programmes directed at drivers of vehicles as well as pedestrians to increase their awareness about road safety. Box 8 below provides a summary of these four levels of interventions.

Box 8: Interventions attempted to prevent injuries or deaths due to Road Traffic Accidents

I. Safer Transport

- Restrictions on the speed and engine performance of motorised two wheelers
- Increasing the legal age for use of motorised two wheeler vehicles
- Graduate driver licensing
- Pre license educational interventions
- Post license driver education
- Monitoring driver behaviour
- Changes in the legislation on the use of daytime running lights by motorvehicles
- Deployment of network wide traffic policing programme
- Increase in fines and driver's license withdrawal
- Use of speed reduction or control mechanisms

II. Safer Roads

- Introduction of pavements
- Traffic calming interventions
- Use of safety camera interventions
- Street lighting
- Use of guard rails and crash cushions
- Use of roundabouts as an alternative to signals and stop sign controls

III. Safer vehicles

- Improving visibility
- Seat belt/ Safety belt use
- Booster seat use among four to eight year olds

IV. Safer people

- Helmet use among bicycle and motorcycle driversDrink driving interventions
- Pedestrian education interventions
- Community based injury prevention interventions
- Trauma care interventions

3.3.1 Safer transport

Studies indicate that transport and land use policies that help to curb the traffic on the road and also make safer transport possible on the road have found to bring about a significant reduction in road traffic accidents and the severity of injuries suffered by the victims.

Restrictions on the speed and engine performance of motorised two wheelers:

Many high income countries have imposed restrictions on the speed and engine types to limit the speed of mopeds or motorcycles mostly used by youth, to bring about a reduction in traffic related crashes and injuries. For example, a number of research studies have hinted at the association between the type and the size of engine and possibility of accidents with use of bigger size engines (Yannis et al, 2005; Langley et al, 2000; Damodaran and Elton, 1988). However, there is only one intervention based study that was conducted in the United Kingdom by Broughton (1981), which found that there was a 25% reduction in motorcycle related incidents when restrictions were imposed on the engine size that learner drivers could ride (250 cc to 125 cc) and on maximum power output (Ameratunga et al, 2006).

Increasing the legal age for use of motorised two wheeler vehicles

Another study by Norghani et al (1998) in Malaysia found that increasing the legal age for use of motorised two wheeler vehicles from 16 to 18 years helped in reducing the number of young drivers found on the roads at night (Ameratunga et al, 2006).

Graduate driver licensing

Introduction of Graduate Driver Licensing (GDL) in countries such as USA, Canada, New Zealand and Australia were found to bring about a 28% (4% to 43%) reduction in crash rates according to a review of interventions conducted by Hartling et al (2004). GDL schemes place restrictions on drivers and restrict their exposure to high risk driving conditions for a specified period of time after getting their license. In this review of 12 studies that implemented GDL, effectiveness was assessed against the outcomes of crash accidents, night time crashes, alcohol related crashes and traffic violations. The different types of GDL examined in the review included supervised driving for the first six months after obtaining a license, curfew on driving at night, restrictions on the type of vehicle that can be driven, restrictions on the type of road that can be used and lower blood alcohol concentration limits.

The study found that there was an overall drop in crashes for sixteen year old drivers from 8% to 73%. There was a drop in crashes among teenage drivers in three locations from 7% to 19%. There was a reduction in crash accidents involving sixteen year olds in eight studies by 43%. There was a drop in crashes causing injuries to teenagers in six locations from 11% to 23%.

Pre license educational interventions

A review by Vernick et al (1999) included nine studies that examined educational programmes aimed at young people in the age group of 15-17 years in terms of impact of the training in obtaining licenses and the impact of pre-license training on reduction in traffic rule violations and traffic related crashes. Majority of the studies were done in the United States, while one was done in Australia. There was no information available on the study design of the interventions. The data from the five studies showed that teenagers who had undergone training were more likely to get licenses early, but education did not have any impact on the reduction in traffic related crashes and injuries. Rather, studies found that there was a reduction of 27% in accidents when pre-license related education was removed from some of the schools as those compared to those that had pre- license education in their schools. Another study by Roberts et al (2001) aimed at quantifying the effect of school-based driver education on licensing and road traffic crashes. The study design included randomised controlled trials comparing school-based driver education to no driver education and assessing the effect on licensing and road traffic crash involvement. There were three trials that were conducted between 1982 and 1984 in United States, New Zealand and Australia. It was concluded that driver education led to early licensing among the population. However, there was no evidence to show that driver education led to reduction in traffic injuries. Rather, evidence indicated that it led to a modest increase in road traffic crashes among teenagers.

Post license driver education

A review by Ker et al (2003) aimed at evaluating the effectiveness of post license driver education in reducing road traffic accidents and injuries. Randomised controlled trials comparing post-licence driver education versus no education, or one form of post-licence driver education versus another were conducted. There were 24 trials on driver education, 23 conducted in the USA and one in Sweden. Of these trials, twenty studied remedial driver education. Three were removed from final analysis because of poor methodological quality. Nineteen trials reported traffic offences: pooled relative risk (RR) = 0.96, (95% CI 0.94 to0.98); trial heterogeneity was significant (p=<0.00001). Fifteen trials reported traffic crashes: pooled RR = 0.98 (95% CI 0.96 to 1.01), trial heterogeneity was not significant (p=0.75). Four trials reported injury crashes: pooled RR = 1.12 (95% CI 0.88 to 1.41), trial heterogeneity was significant (p=<0.00001).

It was found that there was no effect of education on traffic accident reduction. The systematic review thus provided no evidence that post-licence driver education was effective in reducing and preventing road traffic injuries or crashes.

Monitoring driver behaviour

Another study by Wouters et al (2000) found that monitoring driver behaviour with the use of car data recorders led to an estimated 20% reduction in accidents. This study was conducted in Netherlands where a field trial of matched experimental/control group design intervention was used. Seven experimental vehicle fleets were used as case and control groups.

Changes in the legislation on the use of daytime running lights by motorvehicles

A study by Hollo et al (1998) in Hungary looked at the changes in legislation on the use of daytime running lights by motor vehicles and their effect on road safety. This analysis looked at 17 studies and the method used to test the hypothesis was comparison group analysis. A 13% reduction was found in the experimental group in the number of frontal and 'crossing' vehicle collisions in daylight, in good visibility conditions, during the after period. The number of frontal and crossing collisions decreased without a simultaneous increase in rear-end collisions.

Deployment of network wide traffic policing programme

A study by Newstead et al (2001) evaluated the outcomes of the Random Road Watch (RRW)[7] policing programme implemented in Australia. The study intended to measure the effect of the RRW programme on crash outcomes in Queensland, Australia. A quasi-experimental study design was used for the evaluation incorporating Poisson regression statistical analysis techniques. The programme was found to be effective in reducing crashes with the largest effects being a significant reduction in fatal crashes by 31%. The program produced a significant 11% reduction in total crashes in areas outside of metropolitan Brisbane.

Increase in fines and driver's license withdrawal

A new Brazilian Traffic Code was introduced in 1998 that included increase in fines and a rigid penalty scoring system that lead to driver license withdrawal. L.Poli de Figueiredo (2001) compared the incidence of injured patients and immediate deaths in road accidents and emergency room admissions to a level I trauma centre in downtown São Paulo between January and December 1998 with corresponding data from between January and December 1997. The results revealed that there was an overall 21.3% reduction in the number of accidents and a 24.7% reduction in immediate deaths, saving 5962 lives on Brazilian highways. Tickets issued fell by 49.5% (601977 during 1997 to 304785 during

[7]This technique involves dividing each police jurisdiction into a number of sectors, and the week into a number of time blocks. The sector to be visited and the time at which it is to be visited are assigned randomly with the whole week being enforced. Enforcement involves conspicuous stationing of a marked police vehicle in the chosen sector for the allocated time block to undertake general road safety enforcement duties.

1998). Motor vehicle accident-related emergency room admissions decreased by 33.2%. The study concluded that costly tickets and threatened driver licences can prove to be very effective in decreasing immediate deaths from trauma. The study recommended further advances in educational programmes associated with road and vehicle safety measures to reduce road traffic mortality in Brazil.

However, studies in countries such as Israel by Beenstock et al (2000) and Norway by Bjornskau et al (1992) have concluded that traffic policing or traffic law enforcements have considerable limitations and lack sustainability when applied alone and have to be supplemented with attempts at behavioural changes among drivers, pedestrians and all stakeholders involved.

Use of speed reduction or control mechanisms

A number of interventions, mostly in high income countries have found that speed reduction or control mechanisms have led to significant reductions in traffic accidents. Studies in the United Kingdom have shown that the chance of a pedestrian being seriously injured or killed if struck by a car is 45% if the car is travelling at 30 mph, but only 5% if a car is travelling at 20 mph. For example, Government research in the United Kingdom showed that 20 mph zones reduced the incidence of traffic accidents by 60% and cut child pedestrian and child cyclist accidents by 67%, while overall vehicle speeds fell by an average 9.3 mph (14.9 kph). Research by local councils such as the Havant Borough Council imposed a 20 mph limit on 20 miles of road and there was a drop in accidents by a significant 40% (Pilkington, 2000).

In another example, attempts were made at speed reduction through the introduction of a new code in the Danish Road Traffic Act in 1977. According to this Act, changes were introduced in the layout and speed limits in a number of residential areas in the cities. Streets were changed to 30 Km/hr and 15Km/hr streets. In addition to speed signs, both types of streets were equipped with speed reducing measures. A few experimental streets were selected for the study, mostly 30 km/h streets. It was found that there was a reduction of 77 accidents and 88 casualties within a period of three years in the 30Km/hr streets. These reductions were because of the implementation of speed signs, speed reducing measures, and a reduction in traffic. The study recorded before and after changes related to traffic accidents in 44 experimental streets. It was found that the reduction in risk of casualties, i.e. the number of casualties per road user km, was 72%, while the risk of accidents seemed to be unchanged. A very high reduction of 78% in the case of serious injuries was found (Engel et al, 1992).

Introduction of speed bumps in countries such as Ghana have shown that a 55% reduction in all deaths and an annual 51% reduction in crashes (Afukaar et al, 2003). The study in Ghana examined the effectiveness of various speed control measures, based on police-reported traffic crashes in Ghana and published works on speed control measures in both industrialised and developing countries. Rumble strips installed on the main highway reduced crashes by about 35% and fatalities by about 55%. However, another intervention study in Italy found that introduction of speed bumps did not lead to changes in road traffic accidents and concluded for the need to use more effective devices such as humps or cushions or integration of speed bumps with traffic calming techniques (Pau et al, 2001).

In a study to evaluate the effectiveness of Speed Enforcement Devices (SEDs) in reducing road traffic accidents (Wilson et al, 2006), the authors examined all studies that compared areas before and after introduction of SEDs and their effect on road traffic crashes and injuries. The review included 26 studies, of which 21 measured the effect on crashes. All these studies found that the areas where SEDs were introduced, there was a reduction in the number of crashes. The reductions ranged from 14% to 72% for all crashes in areas where SEDs were introduced, 8% to 46% for injury crashes, and 40% to 45% for crashes resulting in fatalities or serious injuries. Effects over wider areas showed a crash reduction ranging from 9% to 35%, 7% to 30% for all injury crashes and 13% to 58% for crashes resulting in fatalities or serious injuries. The studies of longer duration showed that these positive trends were either maintained or improved with time.

In another intervention study in Australia by O' Elia et al (2007), new speed enforcement initiatives were introduced and involved covert operations of mobile speed cameras including flashless operations, 50% increase in speed camera operating hours, lowering of camera speed detection threshold and introduction of speed enforcement messages in the mass media. From December 2000 until July 2002 this package of speed-related initiatives were implemented in Victoria, Australia with the aim of evaluating the impact of this package on crash outcomes. Monthly crash counts and injury severity proportions were assessed using Poisson and logistic regression models. The model measured the overall effect of the package after adjusting as far as possible for non-speed road safety initiatives and socio-economic factors. The speed-related package was associated with statistically significant estimated reductions in casualty crashes and suggested reductions in injury severity with trends towards increased reductions over time.

3.3.2 Safer Roads

Introduction of pavements

The introduction of pavements for pedestrians to walk on has been found to have a great potential in reducing pedestrian injuries. Studies in developing countries have shown that lack of pavements can lead to a two fold increase in traffic accidents (Ossenbruggen et al, 2001). Studies in high income countries have shown that construction of bicycle tracks or lanes beside the roads can lead to about 35% reductions in cyclist casualities (Ameratunga et al, 2006). .

Traffic calming interventions

Another review of an intervention on improving safer roads by Bunn et al (2003) found that strategies that aimed at areas wise traffic calming schemes that discouraged traffic through residential areas led to significant reductions in traffic injuries (11%). Randomised controlled trials and controlled before and after trials were selected for the review. 22 controlled before-and-after studies met the inclusion criteria. Seven studies were conducted in Germany, seven in the UK, two in Australia, two in the Netherlands, two in Denmark, one in Japan, and one in Spain. There were no studies in low or middle income countries. Nine trials reported the number of road traffic crashes resulting in deaths; pooled rate ratio 0.79 (95% CI 0.23 to 2.68). Eighteen studies reported the number of road traffic crashes resulting in injuries (fatal and non-fatal); pooled rate ratio 0.85 (95% CI 0.75 to 0.96). Twelve studies reported the total number of road traffic crashes; pooled rate ratio 0.89 (95% CI 0.76 to 1.05). Fourteen trials reported the number of pedestrian-motor vehicle collisions; pooled rate ratio 1.01 (95% CI 0.88 to 1.16). Effectiveness was measured in terms of pedestrian deaths and injuries, pedestrian motor vehicle collisions and all road user deaths, injuries and crashes where road users included pedestrians and cyclists as well as drivers and occupants of road vehicles. These findings have indicated that traffic calming interventions in towns and cities can be an effective intervention to reduce the number of traffic injuries and deaths.

Use of safety camera interventions

A review study by Aeron Thomas et al (2005) evaluated interventions that have used safety cameras that are designed to detect drivers who jump the red light. Outcomes were measured in terms of incidence of road traffic accidents and red light violations at camera sites as well as surrounding areas. The idea behind the interventions was that red light running was a common cause of crashes at signals and that red light cameras could promote compliance with traffic signals. The study design included randomised or quasi-controlled trials and controlled before-after studies of red-light cameras. Before and after periods were monitored each upto one year and for looking at violation of traffic rules, at least one year period after camera installation was monitored for the study. No randomised controlled trials were identified, but 10 controlled before-after studies from Australia, Singapore and the USA met with the inclusion criteria. The review found a reduction of total casualty crashes (RR 0.84), right angle crashes (RR 0.76), rear end casualty crashes (RR 0.87), total crashes (RR 0.85) and red light violations (RR 0.53). The review thus found that red cameras were most effective for total casualty crashes.

A study by Pilkington et al (2005) examined the literature to look at the effect of cameras to detect motorists exceeding the speed limits. This review looked at 14 studies to find out whether speed cameras reduced road traffic collisions and casualties. Six studies looked at the effect of fixed cameras, four looked at mobile cameras while four interventions looked at the impact of combined fixed and mobile cameras. These studies were carried out in the United Kingdom, Canada, Australia, New Zealand and Norway respectively. 13 out of the 14 studies found that safety cameras were effective upto three years after their installation with one study showing effectiveness upto 4.6 years. The use of cameras led to significant reductions in collisions (5% to 69%), 12% to 65% for injuries and 17% to 71% for deaths and were identified as effective in significantly reducing traffic accidents.

Street lighting

Street lighting has been suggested as a low cost intervention with a potential to prevent traffic crashes, especially in the case of low income and middle income countries. A review of studies on street lighting by Bayer et al (2009) found that there were 17 controlled before and after studies that looked at the effect of street lighting on rural roads, trunk roads and motorways (interstate highways) in the USA, the UK, Germany and Australia. The study design included randomised controlled trials, non-randomised controlled trials and controlled before-after studies, comparing new street lighting with unlit roads, or improved street lighting with the pre-existing lighting level.

Of these, twelve studies compared the installation of street lighting with a ''before'' period in which it was absent, four studies investigated the after effect of improvement in the existing street lighting, and one study investigated both of these phenomena in different areas. Ten studies looked at the effect of continuous (midblock) lighting along lengths of road, whereas six studies focused on non-continuous lighting, which occurs exclusively at junctions (intersections) or pedestrian crossings. One study examined both continuous and non continuous lighting. Ten studies collected data at the intervention site while daytime data was used as the control. Seven studies had a different control site from the intervention site. The remaining two studies were treated as daytime controlled studies.

Pooled data from the 15 studies indicated that when considered together, street lighting (new, improved, continuous or non-continuous) had a significant effect on total crashes (pooled rate ratio (RR) 0.45, (95% CI 0.29 to 0.69) for studies with area control data; pooled RR 0.68, (95% CI 0.57 to 0.82) for studies with daytime control data), fatal crashes (pooled

RR 0.34, (95% CI 0.17 to 0.68) for studies with daytime control data; no area-controlled studies were included with this outcome), and all-injury crashes pooled RR 0.78, (95% CI 0.63 to 0.97) for studies with area control data; pooled RR 0.68, (95% CI 0.61 to 0.77) for studies with daytime control data).

The review found that that street lighting can prevent road traffic crashes, injuries and fatalities. This finding might be of particular interest to low and middle-income countries where the policy on street lighting is less developed and the installation of suitable lighting systems is less common than in high-income countries. However, further well designed studies are needed to determine the effectiveness of street lighting in middle and low-income countries.

Use of guard rails and crash cushions

A review of 32 studies that evaluated the effect of median barriers, guardrails along the edge of the road and crash cushions were conducted in Norway. The study found that guard rails and crash cushions were found to reduce both accident rate and accident severity (Elvik et al, 1995). Other similar studies in high income countries such as Sweden have indicated that crash cushions or barriers play an important role in improving safety of vehicle occupants (Ameratunga et al, 2006).

Use of roundabouts as an alternative to signals and stop sign controls

This study by Retting et al (2001) in the United States evaluated the use of roundabouts as an alternative to signal and stop sign controls in reducing road traffic accidents. An empiric Bayes procedure was used to estimate changes in motor vehicle crashes following conversion of 24 intersections from stop sign and traffic signal control to modern roundabouts. It was found that there were significantly higher reductions of 38% for all crash injuries combined and 76% for all injury crashes. Reductions in the numbers of fatal and incapacitating injury crashes were estimated to be as high as 90%. The study concluded that roundabout installation needed to be strongly promoted as an effective safety treatment to reduce road traffic accidents and injuries.

3.3.3 Safer vehicles

Improving visibility

Efforts for safety of vehicles have mostly focused on improving visibility, use of crash protective designs. For example, introduction of laws for automatic daytime headlights in many developing countries has been found to bring about significant reductions in crashes. Studies indicate that this has led to a 15% reduction in pedestrian related accidents such as being hit by cars and a 10% reduction in cyclists related accidents such as being hit by cars on the road (Ameratunga et al, 2006). Measures such as use of highmounted brake lights in cars have also found to bring about a significant reduction in road traffic accidents in high income as well as low income countries. However, there are no studies that have verified these findings with evidence (Ameratunga et al, 2006).

A study by Kwan et al (2008) reviewed the effect of visibility clothing on road safety outcomes. It has been found that pedestrians and cyclists are many a times killed or seriously injured in traffic crashes, especially in developing countries where walking and bicycling are essential modes of transportation. In the UK, data indicates that in every one in three road traffic accident, the victim is a pedestrian or cyclist. It has been realised that these accidents occur because drivers fail to see the pedestrian or cyclist until it is too late. In recent years it has been realised that reflective garments, flashing lights, and other visibility aids can play an important role in preventing crashes on the road.

In this study, the authors reviewed 42 studies from the United Kingdom, which were randomised control trials that compared two similar groups of samples, one using visibility clothing and the other not using visibility clothing and their impact on the road traffic crash outcomes because of better visibility among drivers to detect pedestrians and cyclists. The studies showed that fluorescent materials in yellow, red and orange improved driver detection during the day; while lamps, flashing lights and retroreflective materials in red and yellow, especially those with a 'biomotion' configuration (taking advantage of the motion from a pedestrian's limbs), improved pedestrian recognition at night. It was found that visibility aids significantly helped to improve visibility among drivers to detect pedestrian and cyclists on the road, but the usefulness of the aids for pedestrians and cyclists was not known from the studies.

Use of day time lights have been found to bring about significant reductions in traffic injuries among motorcycle riders. For example, A study by Zador (1985) in the United states analysed the fatal motorcycle crashes from the year 1975 to 1983 from the Fatal Accident Reporting System (FARS). The analysis included comparison of data from places, which had the motorcycle headlight laws to those that did not have laws in place during the time the study was conducted. It was found that in the 14 states that had motorcycle headlight-use laws during the study period, about 600 daytime crashes were prevented by these laws. This use of day time lights led to a 13% reduction in fatal daytime crashes and to an average reduction of about five fatal crashes per year for each of the 14 states. Another study in Singapore (Yuan, 2000) found that motorcycle riders were the most vulnerable drivers on the streets as motorcycles were the most accident prone vehicles on the streets. In November 1995, the Singapore Traffic Police thus made it compulsory for all motorcyclists to switch on their motorcycle headlights during the daytime to increase the conspicuity of the motorcyclists, and reduce the number of motorcycle accidents.

A study was conducted to review the effectiveness of this legislation by looking at the motorcycle accident data reported to the Singapore Traffic Police from the years 1992 to 1996. Odds ratio tests were conducted to assess the effectiveness of this legislation and to investigate if there was a difference in the number of daytime motorcycle accidents by severity before and after the implementation of the legislation. The odds ratio test was used for retrospective case-control studies. The findings indicated that the 'ride bright' legislation was effective in reducing the number of fatal accidents, but there was little change on the number of serious injuries and slight injury accidents.

Another study from Malaysia evaluated the effects of the use of running headlights for frontal conspicuity among motorcycles on reduction in accidents (Umar et al, 1996). Statistical and non-statistical analyses, the odds ratio, the time series analysis models and a simple graphical technique, were employed in this programme. Data were classified according to daytime and night-time accidents involving conspicuity related, single motorcycle accidents and non-conspicuity related accidents, respectively. The analysis indicated that the odds ratio for accidents was much higher ($p<0.6$) before the intervention as compared to that after the intervention. The daytime conspicuity related accidents dropped significantly by about 29% following the intervention while no significant ($p>0.05$) change was noticed for the non-conspicuity related cases. The results confirmed the hypothesis that running headlights intervention was very effective in tackling conspicuity related motorcycle accidents in Malaysia.

Studies from India by Mohan et al (1998) have also found that the use of bright retro reflective material such as colours on motorcycles, bicycles, autorickshaws, helmets and also increasing peripheral lighting on buses and trucks have been effective in reducing accidents on the road (Gururaj, 2006).

Seat belt/ Safety belt use

Installation of safety belts in vehicles has been found to be very important in preventing injury to users with wide range of applications in developed as well as developing countries. For example, studies have shown that seatbelts reduce the risk of serious and fatal injuries by 40% and 65% and by about 8 to 14% when used with airbags (World Health Organisation, 2004). Studies such as those by Rivara et al (1999) aimed at determining the relative efficacy of primary and secondary enforced seat belt laws on outcomes such as crash related mortality and crash related injuries. A review of literature was conducted and 48 such studies were identified. Studies that included a comparison of primary enforcement law to no law, a secondary enforcement of law to no law and an enforcement of primary and secondary both laws to no enforcement were included for the analysis. There were no restrictions on the study design used. Outcome measures included observed restraint use and counts or rates of deaths or serious injuries. It was found that the primary enforcement of laws was associated with a relative risk of death in crashes of 0.54 to 0.97. The reduction in mortality associated with secondary enforcement was found to be modest with relative risk estimates of 0.81 to 1.025. Primary enforcement of laws was associated with the relative risk of serious injuries of 0.20 to 0.89, while in the case of secondary enforcement, it was smaller. The study concluded that primary laws were more effective than secondary laws in influencing better outcomes and reduction of traffic injuries in the United States of America.

Another study by Rivera et al (2000) in the United States aimed at determining the effectiveness of automatic shoulder belt systems in reducing the risk of injury and death among front seat vehicle passengers. This study was a descriptive design and data was collected from 1993 to 1996 National Highway Traffic Safety Administration Crashworthiness Data System on frontseat occupants involved in tow-away crashes of passenger cars, light trucks, vans, and sport utility vehicles. Outcomes were measured by the number of deaths and serious injuries to specific body areas by use of manual lap and shoulder belts, automatic shoulder belts with manual lap belts, or automatic shoulder belts without lap belts, compared with no restraint use. It was found that use of automatic shoulder belts without lap belts was associated with a decrease in the risk of death as compared to no restraint use, but was not statistically significant for all crashes (odds ratio [OR], 0.66; 95% CI, 0.42-1.06) or for frontal crashes (OR, 0.71; 95% CI, 0.38-1.35) after adjustment for occupant age, sex, vehicle, year, airbag deployment, change in vehicle speed during the crash and the direction of force. An 86% lower risk was observed for use of automatic shoulder belts with lap belts (OR, 0.14; 95% CI, 0.07- 0.26 vs no restraint; p value 0.05). Use of automatic shoulder belts without lap belts was associated with an increased risk of serious chest (OR, 2.66; 95% CI, 1.11- 6.35) and abdominal (OR, 2.06; 95% CI, 1.004- 4.22) injuries for all crashes. The study concluded that improperly used automatic restraint systems are less effective than properly used systems and are associated with an increased risk of chest and abdominal injuries.

Another study by Cummings et al (2003) has attempted to evaluate the relative risk of death among belted and unbelted front seat occupants. The study design included matched pair cohort study and data was collected from the Fatality Analysis Reporting System in the United States from 1986 to 1998. The outcome variables included were death within 30 days of crash. The study found that the use of seat belts reduced the relative risk of death by 61% (RR=0.39, 95% CI, 0.37-0.41).

Booster seat use among four to eight year olds

In children aged four to seven years, booster seats are estimated to reduce the odds of sustaining clinically significant injuries during a crash by 59%, when compared to using ordinary vehicle seatbelts. Despite the evidence of effectiveness, many children are not restrained in age-appropriate booster seats. Use of booster seats has been recommended and laws have been implemented to improve safety and prevent accidents and injuries among children in developed countries. The review by Ehiri et al (2006) aimed at evaluating the effectiveness of interventions that promoted the use of booster seats in cars among four to eight year old children in preventing accidental injuries. Randomised and controlled before-and-after trials that investigated the effects of interventions to promote booster seat use were included in the study design.

Five studies involving 3,070 individuals met the inclusion criteria for the study. It was found that all interventions for promoting use of booster seats among 4 to 8 year olds demonstrated a positive effect (relative risk (RR) 1.43; 95% confidence intervals (CI) 1.05 to 1.96). Incentives combined with education demonstrated a beneficial effect (RR 1.32, 95% CI 1.12 to 1.55; n = 1,898). Distribution of free booster seats combined with education also had a beneficial effect (RR 2.34; 95% CI 1.50 to 3.63; n = 380). Education only based interventions also demonstrated a positive impact (RR 1.32; 95% CI 1.16 to 1.49; n = 563). However, interventions that supported enforcement of use of booster seats did not indicate any positive effect in increasing the use of booster seats.

Improved vehicle crash protection, referred to as secondary safety has resulted in significant reduction in deaths, especially for car occupants. Mohan (2004) has observed that this important measure has reduced deaths and injuries among car occupants by more than.30%. The World Health Organisation (2004) has recommended that crash protective vehicular designs with suitable standards should be adopted globally (Gururaj, 2006).

3.3.4 Safer people

Helmet use among bicycle and motorcycle drivers

The use of helmets and its connection with reduction in head and brain injuries has been confirmed by a number of studies and has been found to bring about a significant reduction in injuries from 63% to 88%. For example, a review study by Thompson et al, (1999) attempted to determine the impact of bicycle helmets in reducing head, brain and facial injury among bicyclists for all ages involved in a bicycle crash or fall. No randomised control trials were found, but there were five case control studies that were included in the inclusion criteria. These studies were mainly from the United States, Europe and Australia. The studies found that helmets provided 63 to 88% reduction in the risk of head, brain and severe brain injury for all ages of bicyclists. Another study by Thompson et al (1996) aimed at examining the effectiveness of bicycle helmet use in four age groups. Data was collected from emergency departments of seven Seattle hospitals. Outcomes included head and brain injury. The study design used was prospective case control study. The study found that use of helmets reduced injury by 69% (OR, 0.31; 95% CI 0.26-0.37) and brain injury by 65% (OR 0.35; 95% CI 0.25-0.48).

A study by McPherson et al (2008) looked at studies that assessed the impact of bicycle helmet legislation on the bicycle related injuries and helmet use. Studies that reported changes in either the number of head injuries, helmet use or bicycle use before and after the legislation were included for the review. Studies that included a concurrent control group and which reported on the effect of legislation implemented at either the country, state or province wide level were included. There were five studies from United States that met the inclusion criteria. In all the studies, the target group was children while adults were used as the control group. The review found that bicycle helmet legislation helped in increasing the use of helmets and decreasing the head injuries among populations where it was implemented.

Another study in the United States by Norwell et al (2002) tried to estimate the association between death and helmet use among motorcycle crash victims. Data were collected from 1980-1998 Fatality Analysis Reporting Systems and the study design was a matched pair cohort study. The study population included motorcycle crash driver/passenger pairs. The outcomes were measured in terms of deaths within 30 days of injury. It was found that motorcycle helmets reduced relative risk of deaths by 39%. A study by Rowland et al (1996) in the United States aimed at comparing incidence, type, severity and costs of motorcycle crash related injuries leading to hospitalisation or death among people using helmets and not using helmets. The study design was a retrospective cohort study and data on head injuries motorcycle crash victims was obtained from the Washington State Patrol Records. Data was compared for severity of injury by use and no use of helmets. The study found that riders of motorcycles who did not use helmets were three times likely to be hospitalised with head injury (RR=2.9; 95% CI 2.0-4.4) and four times more likely to have severe head injury than motorcycle riders who used helmets (RR=3.7; 95% CI, 1.9-7.3).

A review study by Liu et al (2004) aimed at evaluating the effectiveness of motor cycle helmet use in reducing mortality and head and neck injury following a motorcycle crash. Studies that investigated motorcycle riders who had crashed and had incorporated helmet use as an intervention and looked at outcomes that included one or more of the following such as death, head, neck or facial injury were included in the review. The study design incorporated studies that compared a control and intervention group and included randomised control trials, non randomised control trials, cohort, cross sectional or case control studies. 53 observational studies were identified. Motorcycle helmets were found to reduce the risk of head injuries and data from 5 well conducted studies revealed that the estimated risk reduction was 72% (OR 0.28; 95% CI 0.23-0.35).

Another review by Royal et al (2005) tried to evaluate the effectiveness of non legislative interventions to encourage helmet wearing among children. Randomised controlled trials, cluster randomised controlled trials and controlled before and after studies were used in the study design. Studies included participants aged 0 to 18 years and described interventions to promote helmet use not requiring enactment of legislation. Studies had to report at least one of the following outcomes: observed helmet wearing; self-reported helmet ownership; self-reported helmet wearing. Twenty-two studies were identified. It was found that the odds of observed helmet wearing were significantly greater amongst those receiving non-legislative interventions (OR 2.30, 95% CI 1.37 to 3.85). The effect was found to be greater for community-based studies (OR 4.30, 95% CI 2.24 to 8.25) and those providing free helmets (OR 4.35, 95% CI 2.13 to 8.89) than for those providing subsidised helmets (OR 2.02, 95% CI 0.98 to 4.17) and for those set in schools (OR 1.82, 95% CI 0.94 to 3.52).

Studies in high income countries have shown that introduction of mandatory laws on helmet wearing can lead to about 25% reduction in head injuries in cyclists and introduction of such laws has led to a 20% to 40% reduction in injury to motorcyclists (Ameratunga et al, 2006). However, studies in developing countries such as Indonesia have shown that inspite of mandatory laws, only 20% of the passengers wore helmets and 55% of the drivers wore helmets correctly. Motorcycle drivers did not wear helmets at night when police were not around. Data from emergency departments found that motorcycles were still involved in 64% of all traffic accident injuries and 33% of trauma patients in emergency departments (Conrad et al, 1996).

It has thus been found that legislation has not been able to help on its own as failure to use helmets, use of nonstandard helmets and use of improperly secured helmets is common in many places, especially in low income countries and calls on efforts to supplement these efforts with complementary prevention and educational strategies (Ameratunga et al, 2006).

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Drink driving interventions

There are three types of interventions that explore the relation between drinking and accidents. One includes the use of mandatory anti drinking laws, others use screening methods for alcohol drinking among drivers and use ignition and interlock devices, use of random breath testing to check for drink driving and implementation of low blood alcohol concentration laws for younger drivers. Implementation of the anti drinking laws were examined by a review by McArthur et al (1999) where the study tried to examine the effectiveness of such laws as compared to other forms of sanctions for reducing drink driving recidivism. Administrative laws can immediately charge penalties for drink driving where the driver's license can get suspended immediately through administrative channels rather than the courts. The effectiveness of this intervention was judged by comparing the performance of drivers who had their licenses suspended through court as against that who had their licenses suspended through administrative mechanisms. The assumption was that administrative procedures are faster and thus more effective. The recidivism and accident rates among drivers from both the groups were examined during the time their licenses were suspended and after they were returned. The target group for the interventions were drivers who were arrested for driving while under the influence of alcohol. The study aimed at comparing the effectiveness of administrative laws on drink driving as against the effectiveness of other forms of sanctions. The outcomes were found to be positive in three states in the United States and negative in two states. It was found that laws against drink driving were positively associated with reduction in driving offenses, drink driving offenses and drink driving related crashes. The results included a combined OR of 0.78 for subsequent drink driving offences, an OR of 0.65 for subsequent traffic crashes and an OR of 0.73 for subsequent alcohol related crashes.

The other review by Willis et al (2004) examined the effectiveness of ignition interlock programmes on recidivism rates of drink drivers by looking at 14 studies from United States, Canada and Sweden. Ignition interlock devices require the driver's breath to be tested for alcohol prior to starting the car. The device does not allow the car to start if the blood alcohol concentration among drivers is high. The effectiveness of this intervention was measured by recidivism rates when the driver was involved in the ignition interlock programme, after the interlock had been removed and then during the entire study period. The study found that the intervention did not reduce but, rather increased recidivism rates among drivers after the interlocks were removed RR=1.33 (95% CI 0.72 to 2.46). There was a reduction only when the interlocks were installed RR=0.36 (95% CI 0.21 to 0.63).

The third review (Zwerling et al, 1999) looked at the effectiveness of imposing low alcohol concentration laws among young drivers and reduction in motor vehicle crashes, injury and fatal crashes. These laws impose lower Blood Alcohol Concentration (BAC) levels on young drivers than the normally acceptable levels so that it would prevent younger drivers from drinking and reduce road accidents, injuries and crashes. Effectiveness of the intervention was measured in terms of all motor vehicle crashes, crashes involving injuries and fatal crashes. The review included six studies from the United States and Australia respectively that aimed at finding out whether lower alcohol blood concentration laws reduced motor vehicle injuries among young drivers. One study found that a 0.02 BAC for first year drivers reduced night time injuries by about 17%. Another study found that a legal limit of 0.02 BAC for drivers under 21 years of age significantly reduced the "had been drinking" crashes as compared to older drivers. A zero BAC level for first year drivers found that there was an 18% reduction in injuries in 17 to 20 year olds and a 4% reduction in fatal or serious injuries. Other studies also found similar reductions in serious or fatal cases.

Another study by Holder et al (2000) evaluated the effect of community based interventions on high risk drinking and alcohol related injuries. A longitudinal multiple time series of 3 matched intervention communities (northern California, southern California, and South Carolina) was conducted from April 1992 to December 1996. Outcomes were assessed by 120 telephonic general population surveys per month of randomly selected individuals in the intervention and comparison sites, traffic data on motor vehicle crashes, and emergency department surveys in 1 intervention-comparison pair and 1 additional intervention site. The intervention included mobilisation of the community, encouraging responsible beverage service; reducing underage drinking by limiting access to alcohol; increasing local enforcement of drinking and driving laws; and limiting access to alcohol by using zoning. The outcome measures included self reported alcohol consumption and driving after drinking; rates of alcohol-related crashes and assault injuries observed in emergency departments and admitted to hospitals. It was found that self-reported alcohol consumption per drinking occasion declined 6% from 1.37 to 1. 29 drinks. Self-reported rate of "having had too much to drink" declined 49% from 0.43 to 0.22 times per 6-month period. Self-reported driving when "over the legal limit" was 51% lower (0. 77 vs 0.38 times) per 6-month period in the intervention communities relative to the comparison communities. Traffic data revealed that, in the intervention vs comparison communities, night time injury crashes declined by 10% and crashes in which the driver had been drinking declined by 6%.

Another review by Peek Asa et al (1999) tried to find the effect of random screening for alcohol on reduction in motor vehicle crash injuries. Two types of random screening programs were used and included Random Breath Testing and Sobriety Checkpoints. Fourteen studies met inclusion criteria that included an evaluation of a random screening program with a control population or baseline comparison. Outcomes included were the proportional decreases in total or alcohol-related fatalities or injuries. All fourteen studies found that random screening was effective in reducing fatalities and injuries. Alcohol-related deaths showed the greatest decreases, ranging from 8% to 71%. Multivariate analyses also showed that random screening significantly reduced crashes and injuries. The study concluded that random screening appears to be effective in a wide range of both United States and Australian populations. However, the study also concluded that there needed to be more studies to determine the long term effects of random alcohol screening and the level of enforcement necessary.

Another study by Goss et al (2008) reviewed the impact of interventions that used police patrolling to reduce drink driving leading to reduction in accidents and crash injuries. The study designs for these reviews included Randomised controlled trials, controlled trials, controlled before and after studies, interrupted time series (ITS) studies, and controlled ITS studies evaluating increased police patrols, either alone or combined with other interventions, targeting alcohol-impaired motor vehicle drivers. Thirty two studies were identified of which one included a randomised control trial, eight were controlled before and after studies, fourteen controlled ITS studies, six ITS studies and three studies included ITS as well as controlled before and after study design.

Two thirds of the studies were removed from analysis as they were found to be inadequate in terms of quality of data. Thirteen of 20 studies showed reductions in total crashes and about two-thirds of these were statistically significant. The review concluded that although beneficial effects of police patrolling were seen, lack of good quality data and methods or designs made it difficult to arrive at conclusive results regarding the association between reduction in drink driving related crashes and injuries due to police patrolling.

Evidence from these interventions reveals that administrative laws can have a good influence on drink driving recidivism. However, results may differ in different contexts because of a number of social and cultural factors. Similarly use of ignition interlock has been found to bring about a significant reduction in drink driving, but only till they are installed. Studies indicate that their removal led to reversal to drink driving among people. Evidence from the above intervention indicates that lowering of BAC levels by imposing laws brings about a significant reduction in drink driving among teenagers and the outcomes are even better with more restrictive laws. These studies reveal that attempts at bringing about behavioural changes through imposing of laws have been considerably successful in bringing about reductions in drink driving and consequently a significant reduction in injuries and fatal accidents in the context of high income countries. However, one needs to be cautious in interpreting these results in the context of middle income or low income countries in different social and cultural contexts and need further investigation.

Another review by Cashman et al (2009) has studied the effects of alcohol and drug use among occupational drivers on traffic injuries. The study design included Randomised controlled trials (RCTs), cluster-randomised trials, controlled clinical trials, controlled before and after studies (more than three time points to be measured before and after the study) and interrupted time-series (ITS) studies that evaluated alcohol or drug screening interventions for occupational drivers (compared to another intervention or no intervention) with an outcome measured as a reduction in injury.

Two time series studies from the United States were found, one included five transportation companies, which evaluated the effect of two interventions on mandatory random drug testing and mandatory random and for-cause alcohol testing programmes. The third study focused only on mandatory random drug testing and was conducted on federal injury data that covered all truck drivers of interstate carriers.

The study found that mandatory random and for-cause alcohol testing was associated with a significant decrease in the level of injuries immediately following the intervention (-1.25 injuries/100 person years, 95% CI -2.29 to -0.21), but did not lead to decrease in level of injuries in the long term or after some time following the intervention (-0.28 injuries/100 person years/year, 95% CI -0.78 to 0.21). Mandatory random drug testing was significantly associated with an immediate change in injury level following the intervention (1.26 injuries/100 person years, 95% CI 0.36 to 2.16) while it did not lead to decrease in injury levels in the long term or after some time following the intervention in two studies (-0.19 injuries/100 person years/year, 95% CI -0.30 to -0.07) and (-0.83 fatal accidents/100 million vehicle miles/year, 95% CI -1.08 to -0.58).

This study also indicated that mandatory testing methods seem to work in the short term, but their effectivity in reducing accident injuries in the long term needs to be further examined through systematic studies.

Pedestrian education interventions

One review by Duperrex et al (2002) has looked at the safety of pedestrians, children in this case by examining the effectiveness of pedestrian safety education programmes in preventing pedestrian motor vehicle crashes. 15 studies were identified for the review. The interventions aimed at changing knowledge and behaviour and looked at the following outcomes, which included children's perceptions about the safest place to cross the road, knowledge of road safety, observed responses and verbal explanations concerning safety behaviour, simple traffic knowledge and simple safety rules and individual knowledge test scores. These were community based interventions targeted at children and in one study included mentally challenged adults. Eight of these interventions involved direct education of children while 7 of then used parents or teachers as educators. Six of the studies were from the UK while the remaining were from the United States, Australia, Canada, Japan and Germany. The interventions were directed at primary schools or Kindergartens and included randomised controlled trials of safety education programmes.

The outcomes were found to be generally positive in term of change in measures of knowledge and behaviour. For example, children from four primary schools chose a higher proportion of routes classified as safe to cross following both training using a table top model and real life situations as compared to control group students. Similar results were observed for children who were trained only using a tabletop model. However, it was found that the effect of these trainings decreased over time. Similarly it was found that other interventions such as training in safety behaviour or caution to be observed vs no caution, introducing the children to the concept of speed, including traffic education in the curriculum, education of parents, education of mentally challenged adults in measured target behaviours such as proper sidewalk behaviour, crossing the street, recognition of intersection, met with positive outcomes. This study provides evidence that good quality road safety training can increase safety knowledge among pedestrians and increase correct behaviour. However, behavioural effects vary widely and could depend on a range of social and cultural contexts where they are applied. Also, the application of the training and the associated behavioural changes and change in knowledge in simulated traffic conditions remains to be tested in actual real life traffic situations.

Community based injury prevention interventions

A review by Klassen et al (2000) has looked at the effect of community based interventions on changing norms concerning acceptable behaviour related to safety to prevent injuries among children. The review includes a wide range of interventions that are targeted at drivers, parents, children, pedestrians and cyclists as well as non road safety interventions. Four studies look at pedestrian behaviour and twelve at cyclists behaviour. Four studies have used interventions to encourage safe crossing behaviour among children one in the age groups of 3 and a half to four year olds, two in the age group of four to six and one in the age group of five. The interventions included and the outcomes measured have been included in Box 9 below.

Box 9: Interventions and outcomes measured

The interventions included:

- One intervention: home based education with parents
- Three school based educational programmes including instruction by a parent or an assistant, education with attitude simulation, behaviour simulation and behaviour and attitude simulation
- Twelve interventions: safe bicycle use by children with outcomes being use of helmets among children
- Four interventions have looked at increasing the use of child restraint or correct seating in cars. The target population was parents with educational material
- Two studies: Teenagers safety knowledge and behaviour regarding safety belt use. This intervention was delivered in the school curriculums in the high schools
- Two studies: Drink driving

The outcomes included:

- Incidence of running ahead
- Improved safety behaviour when crossing on quiet streets with parked cars and junctions
- Actions taken during real life like traffic situations
- Safety behaviour in real life like created traffic situations

Outcomes:

The review found that there was a positive effect on children's crossing behaviour with interventions. Home based education with parent assisted learning led to reduction in running ahead for three to four year olds. School based education for children in the age group of four to six with instructions from a parent or assistant led to improved behaviour in terms of crossing streets at junctions irrespective of who provided the training. However, interventions among five year olds and a school based intervention in the age of four to six did not show positive results, which could be due to poorly designed interventions. In the case of interventions with helmet use, it was found that interventions combining education with legislation showed positive results. Studies that looked at education of parents or public combined with interventions such as financial incentives found positive results.

The review found that the response to child seat belt use was better than safety interventions targeted at teenagers. An educational seat belt use message combined with a physics class was more effective than an emotionally charged seat belt use message directed at high school students. There was very little response for drink driving interventions among teenagers.

Overall it was found that education for four to six year olds has mixed results. Education combined with financial incentives and /or legislation can increase children's bicycle helmet use. High school education does increase young people's attitudes and knowledge regarding seat belts and drinking, but interventions that aim at reducing drink driving among adolescents have been unsuccessful.

A review of studies on seat belt use among children by Turner et al (2005) examined the effect of community based interventions to promote proper use of car restraints for children under the age of sixteen. The studies were conducted in the United States and Sweden and included community based programmes involving legislation, targeted education and mass media. The review found that five out of eight studies had a positive effect on increasing child seat belt use in cars (ages of children were five years, four to to eight years and children under fifteen years). Three studies did not show any positive results.

Another review by Grossman et al (1999) examined the effect of non-legislative community and clinical programmes on the use of child restraints in the population. Eighteen studies were identified of which two included community campaigns, five included day care centre educational programmes while eleven studies looked at the infant car seat loan programme in the peri-partum period. The target group included children under five years of age the outcomes were measured in terms of increased use of seatbelts among children. These studies were implemented in the United States, Canada and New Zealand. The study concluded that intervention programmes did help to increase the use of child car restraints in the short term, but the effectiveness of community based programmes in the long term was found to be doubtful.

Another review by Segui-Gomez et al (1999) examined six studies, four legislative and two educational on the increased use of rear seats for children. The outcome measured thus included increase in the number of children using rear seats and using car restraints. Interventions were targeted at parents and children under the age of fourteen years and were implemented in Denmark, Australia, United States and the United Kingdom. The study found that both legislative and educational interventions directed at children under fourteen years of age and their parents encouraged rear seats usage among children.

Trauma care interventions

Some of the interventions have investigated the effectiveness of measures undertaken to reduce fatality following an accident or injury. For example, in a cochrane review of studies conducted by Bunn et al (2001) it was found that specific interventions like the early fluid resuscitation in bleeding trauma patients, hypertonic vs isotonic saline in fluid resuscitation, spinal immobilisation of patients and advanced vs basic life support training were not found to be effective in reducing trauma among patients and some evidence indicated that they could lead to increase in harm to the victims involved (Gururaj, 2006).

In some instances, models of trauma care initially developed in high income countries are being adopted in low and middle income country (LMIC) settings because of the gradual increase in incidents of accidental injuries in low income countries. In particular, ambulance crews with advanced life support (ALS) training are being promoted in LMICs as a strategy for improving outcomes for victims of trauma. A Cochrane review conducted by Jayaraman et al (2009) aimed at quantifying the impact of ALS trained ambulance crews versus crews without ALS training on reducing mortality and morbidity in trauma patients. The study design included Randomised controlled trials, quasi-randomised controlled trials and non-randomised studies, including before-and-after studies and interrupted time series studies, comparing the impact of ALS trained ambulance crews versus crews without ALS training on the reduction of mortality and morbidity in trauma patients. It was found that three trials met with the inclusion criteria with one controlled before-and-after trial, one uncontrolled before-and-after study, and one randomised controlled trial. It was found that none of the trials demonstrated evidence that ALS training led to reduction in severity of trauma among injured. In a uncontrolled before-and-after study, 'a priori' sub-group analysis showed that there was an increase in mortality among patients who had a Glasgow Coma Scale score of less than nine and received care from ALS trained ambulance crews. Additionally, when the pre-hospital trauma score was taken into account in logistic regression analysis, mortality in the patients receiving care from ALS trained crews increased significantly. The study thus concluded that ALS training did not have any impact on reducing mortality among injury patients.

Studies by Mock et al (1998) have shown that basic first aid training of commercial drivers can help to save lives at the site of injury. It was found that with training in basic aspects of first aid care and availability of basic supplies and equipment, the mortality was reduced from 40% to 9% as demonstrated by the Injury Surveillance System in Cambodia and Iraq (Husum et al, 2003). Interventions that have tried to train police, lay public and drivers have resulted in promising outcomes (Gururaj, 2006). In another study in Africa by Tiska et al (2004) over 300 commercial drivers were trained in a first aid and rescue course designed specifically for roadway trauma and geared to a low education level. The training programme was evaluated at one and two year intervals by interviewing both trained and untrained drivers with regard to their experiences with injured persons. The drivers quickly learned and used control of external haemorrhage. Areas identified needing emphasis in future trainings included consistent use of universal precautions and protection of airways in unconscious persons using the recovery position. The study concluded that training laypersons involved in prehospital transport and care can be very effective in prehospital trauma care for roadway casualties. However, the study also concluded that the training had to be locally devised, evidence based, educationally appropriate, with a focus on practical demonstrations. Interventions on the implementation of prehospital trauma life support in countries such as Mexico found that this resulted in a decline in mortality from 8.2% to 4.7% (Risa et al, 2004).

Another study by Nathen et al (2000) in the United States aimed to find the effect of the implementation of an organised system of trauma care on reduction in mortality due to motor vehicle crashes. Cross-sectional time-series analysis of crash mortality data collected for 1979 through 1995 from the Fatality Analysis Reporting System was conducted from 50 states and the District of Columbia in the United States. The target population included all front-seat passenger vehicle occupants aged 15 to 74 years. It was found that ten years following initial trauma system implementation, mortality due to traffic crashes began to decline; about 15 years following trauma system implementation, mortality was reduced by 8% (95% CI, 3%-12%) after adjusting for secular trends in crash mortality, age, and the introduction of traffic safety laws.

Population based studies indicate that in countries having better organised trauma care systems, there have been 15-20% reductions in trauma based deaths over a period of time. For example, development of regional systems in the United States have led to a decline in trauma related deaths from 34% to 15% (Gururaj, 2006).

3.3.5 The Indian scenario

India lacks a policy on road safety at the national level with specific objectives or goals, resources and indicators, although plans are being made in recent years to draft the National Policy for Road Safety by the Government of India, following the report of the expert committee on road safety (Gururaj, 2008). Efforts have been made by the some of the states such as Kerala, Tamil Nadu and Andhra Pradesh to form independent road safety policies.

However, efforts that lack agency and mechanism at the national level for coordinating, integrating and monitoring road safety have led to very little progress in terms of knowing the true extent of the problem and prevention efforts to tackle the growing problems of road traffic accidents in the country. This is also due to lack of research institutions across the country, lack of skilled manpower to analyse, understand and deal with the problem in a systematic manner, limited participation of the health sector in prevention of road safety and lack of adequate financial resources to address the problem (Gururaj, 2008).

India had a Motor Vehicles Act as early as 1939. Amendments to the Act were made, based on the recommendations of a working group in 1984 and Supreme Court directions in 1988. A review committee was again set up in March 1990, and based on discussions with the National Transport Council, a further set of amendments was brought into effect during 2003. Thus, Motor Vehicles (Amendment) Act of 2003 is currently in place for implementation and has stipulated a number of rules and standards related to road safety. Some of the important areas that will be influenced by the rules and standards include licenses, construction of motor vehicles, equipment of motor vehicles and the maintenance of motor vehicles, safety consideration such as safety belt use, helmet use, laws to prevent drink driving through breath tests, imposing speed limits on vehicles, insurance practices and compensation issues. A number of these interventions for ensuring road safety have already been tried in high income countries and have been highlighted in the earlier part of this report. However, poor implementation laws in India, lack of systematic efforts to assess the effectiveness of these interventions leads to lack of information on the extent of the problem and hinders efforts at prevention of road traffic injuries (Gururaj, 2008; Davies et al,1993).

However, recent years have led to an increasing interest in issues related to road safety as a public health problem needing urgent consideration and there are a few organisations/ institutes/Ngos that have directed attention to this growing menace of road traffic accidents and initiated research and intervention efforts in different parts of India. Some of the research efforts and interventions are ongoing, very few interventions have been evaluated in terms of outcomes and many of the efforts still continue to be sporadic efforts conducted by individual research institutes or by concerned agencies. Presently, most of the commentary and work or interventions on road traffic accidents and their prevention in the literature in India includes law enforcement on drink driving and the use of helmets.

Global Road Safety Partnership (GRSP)

For example, the Global Road Safety Partnership is one such effort that was started in Bangalore in 2000. The GRSP with the Police and the Bangalore Agenda Task Force (BATF) facilitated the development of a partnership road safety programme for Bangalore known as "Suraksha Sanchara" (road safety drive). BATF initiated the process through partnership between the government stakeholders, the private sector and civil society. Their focus was on development of road safety programme through the involvement of citizens or the common people.

The GRSP has been working closely with the City Traffic Police as the lead agency responsible for road safety since 2005. Many local partners have also been involved such as some leading business associations like the Confederation of Indian Industry (CII) and the Society of Indian Automobile Manufacturers (SIAM). International partners have also been included such as Shell, Standard Chartered Bank, the International Centre for Alcohol Policy (ICAP), the World Bank and the World Health Organisation (WHO).

In Bangalore, GRSP and its partners, have tried to raise awareness about road safety and brought all the concerned stakeholders together to create a more united demand for safer roads for the citizens of Bangalore. For example, GRSP along with support from other organisations such as NIMHANS, CIROS , and others have led to the reinstatement of the helmet wearing law in 2006. Following this, data indicates that helmet wearing levels have increased to 80% in the centre of the city where enforcement is high.

The Suraksha Sanchara initiative by GRSP emphasised the need for having safe routes to school among children, traffic calming and safer facilities for pedestrians as a part of the city improvement programme. The programme also focuses on raising awareness, building capacity and delivering and evaluating a few key projects based on good practice. This has led to the establishment of a prioritised traffic and safety plan, B-TRAC that will be implemented from 2010.

GRSP is now expanding its organisation beyond Bangalore and plans to form a national GRSP network. It plans to also collaborate with other states such as Kerala to initiatiate and organise road safety activities focusing on use of helmets, prevention of drinking and driving and development of a hospital injury database.

The interventions undertaken by GRSP include:

- **Workshop for NGOs in road safety**

The GRSP initiated and organised a 2 day workshop in June 2005 for road safety NGOs in India with support from the WHO and the Standard Chartered Bank. (Institute of Road Traffic Education (IRTE), (one of the leading NGOs in Delhi, India) played a pivotal role in guiding discussions and significant contributions were made by the Asia Injury Prevention Foundation from Vietnam and BRAC from Bangladesh. The workshop was the first key step towards sharing knowledge and integrating NGO activities. The workshop recommendations included the creation of an NGO network, interventions focusing on advocacy for improving motorcycle helmet laws and compliance, advocacy for improvement in victim rescue and support systems including changing the law to encourage public participation. The GRSP plans to take forward the plans suggested in the workshop with other organisations working on road traffic accidents in the future.

- **Area improvement schemes**

The GRSP contributed in the preparation of the Urban Safety Guidelines by the Transport Research laboratory, UK and Bangalore University supported by DfID in a workshop led by GRSP, Bangalore Agenda Task Force (BATF) and Bangalore University. A series of area improvement interventions were developed and implemented by the Police and the City Corporation (BMP) with technical support from the GRSP. The interventions aimed at reducing congestion and improving road safety and included systematic collection and analysis of traffic and crash data. The residents and users of the roads in the selected areas were also consulted during the process of the intervention. The outcomes were evaluated in terms of reduction in road traffic injuries and the economic benefits. The study found that there was a 52% drop in seriously injured cases, but there was no change in fatalities. There were 15 fewer deaths on one major arterial road (annual total), there was a drop from 10 to 3 serious injuries at one major intersection; and an estimated annual casualty cost saving of 281,000 USD. (GRSP, 1997).

This demonstration project has also led some important and sustainable changes in the approach to area road safety schemes in Bangalore. For example,

- area schemes are now planned after systematic investigation
- local residents and association are involved in the decision making right from the beginning
- traffic calming techniques are regularly adopted with a focus on pedestrian safety and speed control evaluation and cost benefit techniques are included as a component of all schemes.

Plans have been developed for two new areas, Koramangala and Richards Town and implementation started since 2006 and 2007. The interventions include changes in road hierarchy, one way systems, improved pedestrian facilities and a number of traffic calming measures. GRSP has also initiated the use of raised pedestrian crossings and these have now been installed at over 25 locations.

- **Safe routes to school**

This programme was launched in 2005 by the Police and GRSP and 50 schools from both the government and private sector have joined the scheme. The aim of this project was to examine how children travelled to and from school and the impact of traffic improvements on the safety of the children. The improvements included better public transport facilities to attract children and parents away from private transport, off road parking and drop off/pick up zones, a range of pedestrian crossing facilities protected by traffic wardens at key times and information programmes for children, parents and teachers. The initiative has led to an increase in use of buses among children for travel to and from schools, a drop in student casualties from 41 to 16 in a 6 month period and a reduction in congestion of over 20% in peak hours (GRSP, 1997).

- **Safer Roads Users**

- **Fleet Safety**

60 to 70% of the fatal road crashes in India are reported to involve commercial transportation vehicles, mainly trucks and buses. To help tackle this problem, the GRSP and Shell began the preparation of a fleet safety initiative in 2006 with the aim of improving safety standards of truck operations in India. The emphasis has been on improving the whole management process. Major achievements in the initial pilot phase include the development of a fleet safety audit process, the production, delivery and evaluation of pilot training programmes for owners, managers and drivers involving 6 transporters (operating around 1500 trucks), and the organisation of a stakeholder workshop which developed and agreed a voluntary code of conduct consisting of 20 requirements covering all aspects of safe fleet management. The course evaluation indicated significant driver performance improvements under test conditions and there was strong support from the participating owners who all signed up to the voluntary code.

Following this, Shell India and GRSP organised a workshop on 15-16 May year in Bangalore on managing safety of vehicle fleets, especially road haulers. Over 150 individuals attended the workshop including six companies running approximately 1500 trucks in the South of India. The primary outcome of the workshop was the collaborative development of a code of conduct on fleet safety that will be piloted in Bangalore and Chennai.

- **Drinking and Driving**

A breath analyser survey was conducted to monitor drinking and driving trends after the publicity and enforcement campaign organised by GRSP, BATF, Police and the International

Centre for Alcohol Policy (ICAP) in 2002. Results indicated that there was a significant and a sustainable increase in enforcement levels with a threefold increase in cases booked and a drop in the percentage over the legal limit in the benchmark surveys from 28% to less than 1 %.

NIMHANS Bangalore

A qualitative survey was conducted by NIMHANS on the people's perceptions regarding the legal implications of breath analyser tests for alcohol conducted by the police in the city. The study found that of the 480 road users who were found under the influence of alcohol, 97% were aware that drinking and driving was not permissible under the Indian Motor Vehicles Act; 99% agreed that it was dangerous to drink and drive; but only 3% were aware of the legal consequences (Davies et al, 2003). 50% of the surveyed population revealed that their family members were aware of their drinking and driving habits, but were not aware of their levels of drinking or the dangerous consequences. It was also found that the breathalyser readings were not understood by the public on a large number of occasions. In another study by Gururaj (2003) on the perception of road users on road safety issues it was found that although 94% of respondents agreed that drinking and driving was a major cause of night time accidents in Bangalore, 100% did not know the law, the penalty and legal-health consequences (Davies, 2003).

NIMHANS has also conducted studies on the use of helmets and studies have shown that mortality among unhelmeted riders and pillions was 2.2 times higher compared with helmeted riders. The incidence of skull fractures, contusions and haemorrhages was also found to be more among those without helmets. Concussive head injuries were more among those wearing helmets, thus indicating that in the event of a crash, injuries are of a less severe nature in the presence of helmets (Channabasavanna SM and Gururaj G, 1994; Gururaj G et al, 1993). The studies have shown that

- 60% of total head injuries and deaths were due to road traffic accidents
- 100-120 two wheeler riders on an average suffered from head injuries every month out of which 10-12 succumbed to death.
- Two wheeler riders and pillions constituted 30-40% of total head injuries
- The risk of deaths was two times more among people who did not wear helmets as compared to those who wore helmets
- The severity of head injuries was higher among those without helmets.
- The incidence of skull fracture was 1.2 times more among those riders who wore helmets as compared to those who did not wear helmets.
- The duration of hospitalisation was comparatively more among those who did not wear helmets as compared to those who wore helmets (Gururaj, 2005)

The Government of India

The Government of India also implements public awareness messages such as 'Do not drink and drive', 'Drinking and driving is dangerous', 'One for the road is deadly'. However, these have not found to be very effective on their own as they tend to be isolated efforts. Research indicates that isolated public awareness campaigns are not very successful in altering human behaviour and can be successful only when they are accompanied with other interventions such as legal measures, product modification changes, or those which require public support, which prove to be effective, though only partially (Davies, 1993). None of these campaigns have been evaluated scientifically to know their actual impact on driver behaviour.

Efforts to promote helmet usage have been done through educational or legislative/ enforcement strategies in India. Although a central law exists in India on the use of helmets, the responsibility has been left to individual states to implement the helmet law. States such as Delhi, the union territory of Chandigarh, recently Maharashtra and Gujarat, have put in place a law on helmet use. All other states do not have a notified law. Considerable efforts have been made by government agencies and professionals to inform the society of using helmets in the last few years. In the last several years, information to public has been provided by campaigns, competitions, posters, slogans, road safety awareness programmes and several other strategies. Even the public strongly acknowledge that helmet is a life saving strategy for two wheelers riders and pillions (Gururaj, 2008).

In a study by NIMHANS it was found that 85% of riders acknowledged that helmets are vital, but did not want to use it in the absence of a law (Gururaj, 2005). Experts argue that this exclusive focus on education approach (undertaken sporadically in an untargeted manner) has led to increase in deaths and injuries among motorcyclists in cities such as Karnataka over the past few years. It has now been realised that even in the case of helmet use, educational programmes will only be useful when combined with other approaches that inform and educate public for better acceptance of laws (Gururaj, 2005).

However, a study conducted in Sikkim on the impact of health education intervention by Gupta et al (2007) on road safety and accident prevention among primary school children of Tadong Government School found that health education using validated health education materials and using a systematic study design was effective in improving knowledge and attitudes among the school children. The study design used paired t test that was used to compare pre test and post test results of knowledge, attitudes and practices on road accidents. It was found that education led to significant improvement in knowledge among the children who had been provided education. Thus, there was improvement in terms of the knowledge that road traffic accidents could be prevented by minimal presence on the roads, by avoidance of playing on the road, by respecting traffic signals, waiting for elders to accompany them even if they were late for school. There was also a significant improvement in practice that could be seen from the increase in use of helmets among pillion riders and better adherence to traffic rules while on the road. However, studies in developed countries have found that the sustainability of such educational interventions in the long run remains questionable. Also the results cannot be compared to real life situations and there remain concerns of how much of the knowledge gets translated into practice in real life situations.

Notification of helmet laws followed by enforcement by police agencies has been another population based strategy that has been tried in India to reduce injuries and deaths (Gururaj, 2005). Experience indicates that law enforcement can be very effective as people generally tend to obey and respect the law, people generally dislike paying penalties and prefer to avoid interactions with the police. Enforcements are also cheap and easy to implement (Gururaj, 2005). Studies have indicated that law enforcements can significantly bring down accidents and injuries on the road. For example, studies in the state of Karnataka, indicate that deaths and injuries increase, every time the law is repealed. Studies by NIMHANS indicate that the rate of helmet usage in the absence of legislation is less than 5% while the decision of the government to implement the law has increased the usage rates to 15-20% (as observed during the period 20th April to 1st May, 2005). These studies predict that notification can increase usage rates to 30%, general implementation to about 50% and visible uniform implementation in a strict manner to about 70%. The continuous, sustained and targeted implementation can increase helmet usage rates to about 80% (Gururaj, 2005).

Evidence also indicates that in cities such as Mumbai and Trivandrum, strict implementation of laws on drinking and driving by the state police have brought about a significant reduction in deaths and injuries on the road. For example, the Mumbai police have been commended for making roads safer through strict enforcement drinking and driving laws, discouraging use of mobile phones and adoption of seat belts and helmets (Road Research Newsletter, 2008). Similar studies in the capital of Kerala, Trivandrum have shown that strict enforcement of traffic rules in the capital have brought down the total number of accidents in the state from 2036 in the year 2006 to 1700 in the year 2009. There has been a decline in number of persons killed due to road accidents from 169 to 139 and number of persons injured from 2419 in 2006 to 1795 in 2009 (The Hindu, 2010).

The Transportation Research and Injury Prevention Programme (TRIPP), IIT Delhi

The Transportation Research and Injury Prevention Programme (TRIPP) at the Indian Institute of Technology (Delhi) is an interdisciplinary programme that explores causes and the health effects of road traffic injuries on the population. The department has conducted a number of research and intervention studies on the impact of vehicular designs, road planning, use of safety technologies such as helmets, traffic management practices, land use planning on road traffic injuries. The department also conducts studies on the factors associated with road traffic injuries, injury analysis and pre hospital care.

The areas of expertise of the department include

- Transportation planning and traffic flow analysis for optimising mobility and minimising accidents and pollution.
- Vehicle crash modelling, road safety studies, safer vehicle and helmet design. Studies related to public transport, traffic management, road design and land use planning.
- Epidemiology of factors associated with road traffic injuries, injury analysis and pre hospital care.
- Studies on vehicle technology and engines to minimise fuel consumption and pollution.

The research efforts by TRIPP in Biomechanics and impact modelling include crash simulation exercises with new or old technologies to reduce impact on the victim involved by improvement in older technologies or designing new technologies for safety. These have included studies like improvement in helmets by use of better impact sustaining technologies, making helmets comfortable by improving ventilation, the effectiveness of air bag use among motorcycle drivers, safety analysis of vehicular designs. Studies from the Centre of Biomedical Engineering, IIT, New Delhi have also conducted studies on the usefulness of helmets in preventing injuries. For example, a study conducted by the department found that unhelmeted motocycle riders were found to be at higher risk of sustaining brain injuries as compared to helmeted riders. Unhelmeted riders experienced more injuries (55%) as compared to helmeted riders (24%) (Gururaj, 2005).

The studies in traffic injuries by TRIPPS include a range of epidemiological studies on road traffic accidents in India and their causes with a focus on sustainability and environmental and transport management issues. The department has also conducted research on injury analysis with a focus on the role of technological factors, management factors, quality of resources, issues related to urban infrastructure and transport management on injury management and prehospital care .(The details of all the studies and publications related to these areas can be accessed from their website http://www.iitd.ac.in/tripp/).The recent research projects undertaken by the department include road accident analysis, road safety audits, designing of ambulances for Indian conditions, development of infrastructural standards for roads, ergonomic analysis and designing of safer vehicles such as trucks, rickshaws, tractors, evaluating and understanding road user behaviour.

Institute of Road Traffic Education

The Institute of Road Traffic Education (IRTE), is another non governmental organisation working on road traffic safety in New Delhi. It aims at making roads safer for those who use them. It has been formed by a group of people from interdisciplinary background and includes educationists, doctors, journalists, engineers, ex-servicemen, architects, automobile experts and members of the police.

The activities conducted by the IRTE include working towards a positive road user culture in the country and IRTE is continuing its work in close association with various stakeholders including several corporate citizens, individuals and institutions, national and state governments and undertakes diverse programmes and activities around the year. The activities undertaken by IRTE include:

- Development of innovative traffic enforcement technology
- Introduction of voluntary schemes for public participation in traffic management
- Imparting traffic education through various programmes aimed at different target groups like villagers, school children, pedestrians etc.
- Imparting training to traffic police personnel
- Research & development in the area of collision investigation and analysis
- Undertaking research on various facets of traffic and transportation
- Traffic Engineering and Road Safety Audit
- Conducting workshops, seminars, conferences, debates and discussions on matters concerning road safety management
- Creating standardised driver-training tools & systems as well as conducting driver training and assessment courses.

Further details regarding the organisation can be accessed from their website http://www.irte.com

ArriveSAFE (an NGO working on road traffic safety issues) Chandigarh

The objectives of ArriveSAFE are:

- To reach out to Government, Media, Corporates and Community and make efforts with their support to prevent loss of lives on Indian roads.
- To work as a pressure group to create political will and help improve road safety situation.
- Sensitise masses by raising awareness about road traffic injuries, their grave consequences and thus build community involvement around the issue of Road Safety.
- Develop cost effective road safety programs to increase knowledge, awareness and skills amongst the Indian road users.
- To change the attitudes and behaviours of drivers by creating peoples movement for safe behaviour.

- Promote a positive attitude towards enforcement laws
- Monitoring relevant local and international road statistics and developments in order to affect improvements.

ArriveSAFE is actively working towards its mission through interventions and activities, both individually and with Government/Semi Government support. ArriveSAFE has been developing cost effective dynamic tools to enhance efficiency and deliverability of Road Safety within the existing legal framework. The details regarding the activities conducted by the organisation can be accessed from the following website http://www.arrivesafe.org/activities.php

Other organisations

Society for Alcohol Related Social Policy Initiative (SASPI) is a non-governmental voluntary organisation in India, involved in collaborative programmes to collect data on the effect of alcohol abuse on driving. It encourages people to make informed choices by providing maximum information on the dangers of drinking and driving. SASPI has a few pilot projects involving education and creating awareness of the facts about alcohol. Currently SASPI is one of the partners in the drive against drinking and driving in Bangalore. SASPI's endeavours will cover research, education and advocacy about the responsible use of alcohol.

Other non governmental organisations also include Avahan from Chandigarh that plays an important role in sensitising youth regarding the importance of traffic rules and road safety considerations since the last three years by holding workshops, competitions and staging skits and street plays.

4. Discussion

In the recent years, RTAs have been acknowledged as an emerging epidemic with developing countries bearing a disproportionately higher burden due to associated morbidity, mortality and other losses. In India, the number of RTAs and RTI victims steadily increased over the last decade and now account for almost half of all unnatural deaths. A review of epidemiology of RTAs and RTIs is the first step towards prevention of RTAs and gives an insight into the magnitude of this problem and factors responsible for loss of productive years, life and property damage as a result of RTAs. In India, primarily the young adults in their early thirties continue to be the victims of RTAs. Fatalities and morbidities from RTAs mostly affect the economically productive age group and have serious implications for the economic burden in terms of GDP lost, in addition to being responsible for heavy social costs. Studies show that in India, pedestrians, users of non-motorised vehicles and users of motorised two wheeled vehicles who are often from poor or lower middle class households are the victims of fatal RTAs. Road traffic accidents are known to push victims and their households further down the poverty spiral. Most of the RTA related injuries require expensive speciality care that accounts for a large part of costs due to RTAs. Income lost, either permanently in case of death or disability, or temporarily in case of non-fatal minor RTIs is another component of costs. Road designs that ignore the realities of Indian traffic are to be held responsible for high number of conflict situations that result in vulnerable road users losing lives or suffering serious injuries and disabilities. Absence of laws for controlling high risk road use behaviour, weak law enforcement, and weak trauma care services are responsible for a large number of RTAs and preventable deaths. However, absence of accurate consistent information on magnitude of the problem remains to be the true challenge in dealing with RTAs in the Indian context.

With a high burden of RTA and related injuries and fatalities, India needs reliable data to inform policies and practice for prevention of RTA and preservation of life. However, at present researchers seem to be little interested in research on injuries in general and specifically on RTA. A review of literature on RTI from low and middle income countries showed that though India accounts for 6% of global burden of RTI, India's contribution to scientific literature on RTI was 0.7% only, with a ratio of less than one article per 1000 RTA fatalities (Borse and Hyder, 2008). Mathew et al (2008) draw similar findings. Mathew et al (2008) reviewed scientific literature published from India and included in PubMed. They observed that only 0.8% articles reflected research on injury and only 0.1% on RTA. Based on their findings, Mathew et al (2008) conclude that trauma research output from India is currently insufficient and unfocused and therefore unable to inform the practice of medicine and surgery in India.

The problem lies at multiple levels, the most important being the level of data recording for RTA. In India, the local police are required to maintain records of RTA from sites, complaints lodged by persons or from liaison officers at hospitals. These data are then compiled and presented by the National Crime Records Bureau in the form of an annual report. However, researchers have explored and found that in India there is gross under-reporting of RTA and RTI. The quality of data has also been found to be less than satisfactory (Dandona et al, 2008b, Dandona and Mishra, 2004). In a review of existing data from various Indian studies, Gururaj (2006) observed a large variation in the proportion of deaths and serious injuries attributed to RTA, thus highlighting the need for 'strengthening information systems and research in India'.

Dandona et al (2008b) carried out two research studies, a population based survey and a hospital based study in Hyderabad to assess the magnitude and pattern of the under-reporting of RTA and fatalities to police. The population based study identified 1032 RTI of which only 2% (20/1032) were reported to police. The proportion of reported RTI was higher (25%, n=675) for the hospital study where victims or accompanied persons were interviewed at the emergency department of selected hospitals. It was observed that non-fatal RTI were more likely to be reported when the offending vehicle was a car, jeep or a heavy vehicle; when more than one persons were injured; when the crash took place at night (between 10 pm – 6 am) or when the costs of treatment of RTI were high (more than Rs. 5,000). The study also found that RTIs that reported to public hospitals were twice as likely to be reported to police as compared with those that reported to private hospitals. Compared to the reporting of non-fatal RTI, proportion of reporting of RTA fatalities was higher. Fourteen of 18 fatalities were reported to the police. Fatal RTA were not reported when the family perceived it to be the deceased persons' fault or when it was a hit and run case. The household survey found that a large proportion of RTA victims 'did not find it necessary' to report a non-fatal RTI. The proportion was 77% among those who sought treatment at OPD and 24% among those who were treated as inpatients. People also tended not to report RTA when a settlement was reached between the two parties involved or when the RTA concerned was a single vehicle crash (Dandona et al, 2008b).

Under-reporting to police was also observed in a study carried out in Bangalore where police reported ten injuries for every road traffic death and household survey reported 27 serious injuries (requiring hospitalisation) for every road death among non-poor households and 11 serious injuries for every road death among the poor households (Aeron Thomas et al, 2004). Gururaj (2006) points out that with the national average ratio of RTA death to injuries of 1:4; reporting of reverse ratio (for example 8:1 in Pune) in many B and C grade cities indicates under-reporting of RTI.

> Under reporting to the police has also been found as one of the reasons for lack of adequate data on road traffic related accidents and injuries. For example, in a study carried out in Bangalore, police reported 10 injuries for every road traffic death and household survey reported 27 serious injuries (requiring hospitalisation) for every road death among non-poor households and 11 serious injuries for every road death among the poor households (Aeron Thomas et al, 2004). Gururaj (2006) points out that with the national average ratio of RTA death to injuries of 1:4; reporting of reverse ratio (for example 8:1 in Pune) in many B and C grade cities indicates under-reporting of RTI.

In another study, Dandona and Mishra (2004) compared police records and newspaper reports on fatal RTA. They noted a great disparity between the sources with each emphasising different areas. For the same time period, newspapers reported fewer RTA as compared to police data; the proportion of victims by cause varied greatly – for example, according to police records 26% of pedestrian deaths were due to collision with truck or lorry type heavy vehicles whereas according to news paper data, these heavy vehicles were responsible for 42% of pedestrian deaths. Further, according to the police data all crashes were 'head on collisions' whereas the newspapers gave segregates presentation of causes of RTA. On the other hand none of the newspaper reports commented on behaviour of drivers and according to police negligent behaviour of drivers was responsible for all accidents.

A review of existing literature on socio-demographic, geographical distribution of RTAs; factors responsible for RTAs and the key factors that can play a role in controlling RTAs indicates that the available data continues to be incomplete in terms of representing the realities different parts of the country. For example, the studies have been mainly carried out in larger cities and the information available only includes RTAs that take place on national or state highways and arterial roads from the cities. There is limited data available on the epidemiology of RTAs that might be taking place in rural or semi-urban areas or on smaller roads from the cities. The data thus cannot be generalised at the country level. Besides there is lack of comparability of data because of lack of uniform study designs. This lack of availability of consistent, uniform and representative data from the different parts of the country has been identified as one of the major limitations for understanding the true extent of the problem and devising strategies directed at control or prevention of RTAs (Gururaj, 2006). At the same time, data from other sources such as police records also continues to be inadequate and incomplete. For example, many a times, the victims do not feel the need for reporting a RTA for varied reasons; and the police records reflect skewed data where for all RTAs, the mode of impact is documented as head-on-collision and cause as negligence of the driver (Dandona et al, 2008b). This can have serious implications as policy makers rely on police data for estimates on the extent and nature of the problem that inform the policies for prevention of RTAs and RTIs (Dandona et al, 2008b, Dandona and Mishra, 2004).

The lack of availability of consistent, uniform and representative data from the different parts of the country has been identified as one of the major limitations for understanding the true extent of the problem and devising strategies directed at control or prevention of RTAs (Gururaj, 2006).

The review indicates that RTAs are responsible for up to a third of unnatural deaths and are a leading cause of deaths, hospitalisations and disability in India. As high as two thirds of the victims are in the productive age group of 15-44 years. However, in spite of the high number of deaths and disabilities, the socio-economic burden of RTAs (fatalities and injuries) is not adequately addressed in the Indian literature. Most of the studies focus on fatalities or injuries that require medical care either on outpatient or inpatient basis. There is also very limited data available on RTAs that result in minor injuries that are treated within homes. The issue of affordability of treatment for RTIs continues to be addressed by a very few researchers and appears to have been neglected in the literature. However, the available evidence suggests that medical treatment costs for RTI are unaffordable for many as the management of RTAs often requires expensive investigations such as CT scan injury assessment, surgical interventions and prolonged hospitalisations. For example, a study on spinal cord injuries found that three fourth of patients came from households with per capita monthly income of less than Rs. 10,000 whereas, earlier studies on costs of neuro-surgical care have noted that average per day cost of hospitalisation for head injury patients could easily be more than Rs. 3000 (Gururaj, 2006). Data on hospitalisation also continues to be limited. There is no information on length of hospital stay and resultant costs borne by the accident victims.

Studies also indicate that non-availability of pre-hospital care and unorganised trauma care also contribute to a high proportion of spot deaths and disabilities among victims. Studies show that about two thirds of the disabilities in India are estimated to be a result of RTAs. However, there is no information available on the economic, social burden of these disablities experienced by the victims and their families. There is no information available on the direct expenses related to RTAs namely property damage, costs of pre-hospital care and transport, costs of legal procedures resulting from the RTAs. Some evidence from a study in Bangalore does indicate that RTAs lead to a significant economic and social burden in terms of direct and indirect costs on the victims and their families. The study found that the poor tended to be at a higher risk of RTA fatalities. The study also found that disabilities related to RTAs led to a significant burden on the victims and their families and led to further deterioration of their situation because of lack of resources. However, the proportion of those who received any form of compensation was very less (around 10%). This study indicates the urgent need for more studies on the economic consequences and the burden experienced by RTA victims who suffer from long term injuries.

Studies indicate that a range of factors such as the heterogeneous traffic in India where pedestrians, cyclists and users of other non-motorised vehicles share road space with motorised light and heavy vehicles are responsible for increased risk to the vulnerable road users. Poor street lighting, bad road surface, open manholes and large objects lying around on road are the road related factors noted to be responsible for crashes. However these factors continue to be poorly researched in the literature. The impact of driver behaviour, pedestrian behaviours, their attitudes, perceptions and responses to the enforcement of laws by the government, the impact of these laws on the drivers and pedestrians, the impact of unsafe practices among the road users on road traffic accidents continues to be poorly researched in the Indian context.

Most of the studies have focused on the safety of drivers of vehicles and the factors associated with road traffic injuries among users of vehicles. However, evidence indicates that pedestrians also show unsafe road use practices. Inappropriate crossing of roads is the most common reason for RTI among pedestrians and account for as many as half of the pedestrian injuries. Pedestrians can also sustain a RTI while walking on the road or while boarding or alighting from a moving vehicle. However, very few studies have focused on road use practices of pedestrians.

Other factors that researchers have identified as being responsible for RTAs in Indian circumstances are vegetation on the divider obstructing the drivers' vision of pedestrians crossing the roads, encroachment on the roads especially where approach roads from cities/towns meet the national highway. Such situations are unique to the Indian context. Factors such as overcrowding and over loading of heavy vehicles in the Indian context have been found to be responsible for loss of control over the vehicle and crashes that result in high fatality. Though a common sight and knowledge for people of India, these issues have not been given adequate attention in the scientific literature on RTAs and RTIs.

> A review of efforts made to study effectiveness of a range of interventions that can have an impact on reduction in road traffic accidents indicates that there is a lack of systematic availability of data at the national level to highlight significant factors responsible for road traffic accidents. This has led to the lack of systematic intervention studies in the context of India

A review of efforts made to study effectiveness of a range of interventions that can have an impact on reduction in road traffic accidents indicates that there is a lack of systematic availability of data at the national level to highlight significant factors responsible for road traffic accidents. This has led to the lack of systematic intervention studies in the context of India. There are sporadic studies or interventions that have been conducted in specific areas in the country that have looked at the impact of use of helmets, enforcement of traffic regulations, changing the road infrastructure and the effectiveness of education on the change in traffic behaviour and their impact on road traffic accidents. However, these studies cannot be generalisable and cannot be used to represent the outcomes at the national level as many a times they lack systematic methodologies and their outcomes are difficult to apply in a different context.

The review indicates that there are almost no intervention studies that have been conducted in low income countries, inspite of the high burden of road traffic accidents in low income countries. For example, an examination of all the reviews on road safety interventions produced by the Cochrane Injuries Group (CIG) to determine the proportion of research from LMICs found that of all the 13 systematic reviews that included a total of 236 studies, only six of the studies (2.5%) of the trials were found to be conducted in low income countries. All the six trials were included in the same review, ''Helmets for preventing injury in motorcycle riders''. Three trials were from Taiwan, two in India and one in Indonesia (Perel et al, 2007).

Most of the successful interventions have been conducted in high income countries and include a range of factors influencing safer transport, safe people and safer vehicles. However, many of the researchers have cautioned regarding the appropriateness of using the same intervention in middle income countries as well as low income countries as the results could be different in different countries because of the differing socio-economic and cultural contexts. Also, the same intervention implemented in the context of low income countries such as India might not give the same results. For example, evidence from India indicates that the introduction of law enforcing people to wear helmets did not reduce the road traffic accidents because of reluctance on the part of the people to wear them. In addition to this, use of inferior quality helmets that could be bought at cheaper rates that did not measure upto the safety standards led to no change in the severity of injuries in case of accidents (Gururaj, 2008). There is also a difference in the way in which law is enforced in India. For example, poor level of law enforcement India has been documented in the WHO Global Road Safety report (2009). India does not have a national regulation for speed limits in urban area; it is not mandatory for the car manufacturers to install seat belts, and to adhere to fuel standards; there are no laws about child restraint and there are no formal audits of the existing road infrastructure (WHO, 2009). On the scale of 0 – 10 where zero means not effective and ten – most effective; India has law enforcement efforts for drink-driving law at level 3; and for law mandating use of helmet and for use of seat belt at level 2 (WHO, 2009: p 114).

Though cell phones have been around for over a decade in India, there is not a strict law controlling its use while driving. The website of Mumbai Traffic Police states that over a week between 4th and 10th January 2009, 284 persons were apprehended ('cases were made') for using mobile (cell phone) while driving. Under the present law, drivers are fined a token amount of Rs.200 for using a mobile handset while driving, but use of hands-free devices which can also be equally hazardous is not restricted. Authorities (as quoted in a news article in the Times of India) acknowledge the limitations in law enforcement but also point out that 'better road etiquettes' are equally essential for controlling RTA fatalities (Majumdar, 2002). However, there is evidence to show that stricter enforcement gives favourable results. In Mumbai more stringent enforcement of driving under influence of alcohol in general and special campaigns on December 31st to prevent large number of fatalities saw 720 drivers prosecuted and resulted in RTA free night in 2009 (Mumbai Traffic Police, 2009).

In a survey among school students from Delhi, researchers found that 30% of the 550 14 – 19 year old school students interviewed from the study reported having knowingly disobeyed traffic rules in the month preceding the interview. 20% had travelled with a driver who had consumed alcohol before driving, 37% had been in a vehicle with a driver who did not possess a valid driving license. Males and students with both parents alive were more likely to indulge in risk behaviour (Sharma et al, 2007). A survey of 4183 motorised two wheeler drivers from Hyderabad found that 60% of participant drivers had committed a traffic violation in three months before the interview and only a third of these were caught by the police. Of those who were caught and fined by the police, only half (56%) paid the fine and 26% paid a bribe. The rest 18% (more women than men) did not pay the fine Dandona et al, (2006b) andTabish et al (2006) attribute a large proportion of traumatic brain injuries among children to non-implementation of safety measures and traffic rules.

5. The way forward

A comprehensive review of the literature on road traffic accidents in India indicates that road traffic accidents are one of the important public health problems contributing to a large number of deaths and disabilities in the country. The condition appears to be worsening day by day with an increase in vehicles on the road and lack of systematic mechanisms in place to deal with the problem. Evidence has indicated that scattered, isolated and sporadic efforts can generate very little results in terms of generating information on the true extent and nature of the problem, which can be a hindrance in devising systematic evidence based interventions that can be applicable to local conditions or circumstances in the Indian context. Research in developed countries has indicated that the approach in dealing with road traffic accidents needs to be integrated and multidimensional taking into consideration the multiple factors that lead to road accidents and influence the outcomes of road accidents.

In the context of India, the way forward could include a number of short term and long term steps that can be undertaken to bring about a significant change in the present situation.

5.1 Short term steps/strategies/interventions

Experience in high-income countries indicates that efforts have been made in systematic ways to deal with the problem of road traffic accidents through systematic generation of data to understand the extent, distribution and causational factors for road accidents. The situation in India is very different where there is a lack of policy dealing with road traffic accidents and its prevention at the national level and only a few states have a policy in place to deal with the problem at the local level.

Lack of availability of systematic data at the level of India is because of efforts that have been isolated sporadic and the present data that is available through a number of studies in different parts of India, does not give a complete picture of the situation. The lack of coordinated efforts and the absence of appropriate mechanisms for systematic data generation at the national and state levels through various sources such as hospitals, traffic police registration systems, leads to this lack of availability of complete and authentic data on which interventions can be based.

The way forward could include:-

* **Ensuring generation of comprehensive data bases that can be used for planning effective interventions.**

This could be through:

Encouraging research organisations to undertake systematic country wide research studies to understand the extent of the problem, the geographical patterns of road accidents, the factors affecting road traffic accidents, the local contexts that affect or influence accidents, the impact of local climatic conditions, the social, cultural and economic circumstances influencing the events that lead to accidents, the social and economic burden of road traffic accidents in terms of short term as well as long term injuries and disabilities suffered by the victims and deaths due to road traffic accidents. The research efforts also need to go hand in hand with establishment of data recording systems at the various levels such as traffic police, urban and rural hospitals through

- Sensitisation of traffic police in public health aspects of Road Traffic Accidents
- Improving data recording systems at casualty, emergency departments of hospitals
- Introducing standardised formats for recording RTA related data
- Introducing co-ordinated efforts that can lead to systematic triangulation of data bases
- Encouraging members of the general public to the need for reporting a road traffic accident irrespective of the injuries sustained, damage suffered or perceived fault of the victim. This would be successful only if the procedures for registering a RTA with the police are made people-friendly.

* **Ensuring safe transport through encouraging safe driving practices such as**
  - Introduction and strict enforcement of age limit on licenses
  - Introduction of pre license training and education
  - Implementing laws to reduce the speed of vehicles
  - Implementing laws against drink driving,
  - Implementing laws combined with awareness and education campaigns for making seat belts and helmet use mandatory.
  - Ensuring medical fitness before issuing licenses

  Studies in high income countries as well as a few studies from Bangalore, Kerala and Mumbai in India have indicated that systematic and organised law enforcement strategies in the context of drink driving and helmet use can go a long way in reducing road traffic accidents. Studies have also shown that educational interventions alone that attempt to bring about a change in behaviour do not tend to be sustainable and do not lead to change in behaviour unless backed by laws or enforcement strategies. Studies also indicate that interventions or strategies using multiple methods can be more effective in bringing about positive outcomes. Law enforcement combined with training and educational efforts could be very useful in the context of low income countries such as India to bring about a significant reduction in the road traffic accidents. Efforts also need to be made in the Indian context to adapt and replicate successful intervention models such as those in Bangalore, Mumbai and Kerala to other parts of the country to bring about successful outcomes.

* **Generating awareness among road users**
  - Making drivers of vehicles aware of traffic rules
  - Sensitising pedestrians to traffic rules
  - Creating awareness among drivers regarding medications/morbidities that could hamper driving skills
  - Sensitising drivers and pedestrians to the increased susceptibility to RTAs on alcohol consumption

A number of studies in high income countries have used strategies such as pedestrian education, which can be very relevant in the context of low income countries such as India where pedestrians are the most common victims of road accidents. However, many of the studies that have been conducted to see the effectiveness of education on pedestrians have been conducted among children. Studies on generating awareness among children in high income countries as well as in India have mostly been done under controlled conditions and do not indicate whether these awareness generation programmes would be effective in real life situations. However, studies from India, Bangalore, on perceptions of adults about drinking and driving practices as well as laws have indicated that awareness generation programmes that combine information on safe driving and traffic safety rules, with enforcement of rules have been found to be most effective in reducing road traffic accidents.

* **Improving safety of road users by using aids to improve visibility of cars, bicycles, heavy trucks, motorcycles, autorickshaws, helmets of bicycle users, buses and pedestrians**

A number of interventions in high income countries have demonstrated that use of aids such as visibility clothing that includes use of fluorescent colours among motorcycle users as well as bicycle users can be very useful for driver detection at night or during winter when it gets dark very early. Other visibility aids for ensuring safety have included daytime headlights or high mounted brakelights for visibility of vehicles and drivers on the road. Studies also indicate that use of lamps, flashing lights and retro reflective material in red and yellow can improve pedestrian recognition at night. Studies in India have also indicated that retroreflective material on bicycles, motorcycles, autorickshaws, helmets and increased peripheral lights on buses can be useful in reducing accidents. Law enforcement to include visibility materials among vehicles as well as among pedestrians in India could be very useful to reduce accidents especially at night time on highways or even in winter season in the north of India where visibility is compromised very frequently because of intense fog. The same can be true in case of heavy monsoons on the road when use of headlights or high mounted breaklights can improve visibility on the roads.

* **Improving trauma management systems to prevent mortality among the injured**

Studies in high income countries as well as in low income countries have demonstrated that availability of immediate and appropriate trauma care at place of the accident can bring about significant reductions in mortality and disabilities among the victims. For example, studies in high income countries as well as low income countries such as India and Mexico have shown that training laypersons involved in prehospital transport and care can be very effective in reducing complications, disabilities and deaths among accident victims. However, the studies also indicate that the training has to be locally devised, evidence based, educationally appropriate, with a focus on practical demonstrations. In additon to prehospital care, the need for immediate transport and communication facilities become extremely important in any accident situation and making available well equipped ambulance services is very crucial in a low income country such as India. Some of the significant steps that can be taken to improve trauma care services in India can include

- Ensuring availability of well equipped ambulances. Studies have indicated that availability of simple, cost effective and reliable equipment is very effective in reducing deaths and severity of injuries on the roads.
- Training of laypersons or general public, drivers, policemen and others in prehospital transport and care. Studies in high income countries have indicated that training of lay people in prehospital emergency care can be very effective in reducing injury outcomes.
- Introducing courses on pre-hospital transportation, and life support for paramedics
- Establishing better communication systems between ambulances and hospitals
- Strengthening trauma care at hospitals and ensuring that trauma patients are attended by trauma specialists and a team of experts from various branches of medicine.

- Ensuring regular supply of equipment essential for trauma management at health care facilities
- Sensitising medical professionals at primary and secondary level health care facilities that often are the first ones to attend to trauma patients about the need for tertiary level care

5.2 Long term strategies/steps/interventions

* **Making roads safer**
  - Improved road designs that take into consideration the traffic reality of India (heterogeneous traffic)
  - Ensure spaces for pedestrians and lanes for cyclists and other non-motorised modes of transport. For example, studies in low income countries have found that introduction of pavements on the roads for pedestrians to walk have led to reductions in road traffic accidents. Efforts could be made in the Indian context to make pavements an essential part/mandatory of all road widening schemes that continue to be implemented in different parts of the country with increasing urbanisation.
  - Establish and implement speed limits through a range of speed control measures such as use of speed cameras, red light cameras, use of speed bumps, rumble strips on the road. Interventions such as use of speed bumps and rumble strips have been found to be very useful in the case of low income countries such as Ghana and can be tested in the context of low income countries such as India.

* **Encouraging use and development of safe, effective and low cost technology for Indian conditions** by
  - Ensuring the availability of standardised, low cost, tried and tested helmets in the markets in India. Studies in a number of low income countries have shown that people tend to use poor quality helmets with faulty designs that are locally made as those tended to be cheaper than the standard ones. These helmets are not useful in reducing trauma and severity of injuries among the victims. Thus, high costs of available standardised helmets, lack of availability of appropriate designs suitable to the local conditions can lead to poor use of helmets among the people, besides lack of awareness and general insensitivity to obey the traffic rules. For example, use of helmets can be very uncomfortable in a country such as India because of the hot climate. Heavy and tight fitting helmets are thought to be very uncomfortable and also lead to difficulty in driving scooters, which has led to resistance from the people to obeying the mandatory use of helmets in cities.
  - Encouraging research on developing and testing new technologies such as development of helmet designs that are better ventilated or materials that make it more crash protective and less heavy, vehicular designs that can be crash protective and more stable, use of appropriate technologies to control speed of vehicles on the roads. For example, research organisations such as TRIPP, IIT Delhi, India have been conducting research on finding out better helmet designs that would be safe, convenient, cost effective and suitable for Indian conditions. The organisation also conducts a number of research trials on appropriate and safe vehicular designs that can sustain vehicular crashes on Indian roads.
  - Ensuring that the tried and tested technologies developed in India are taken up by the market and made available to the consumers at low prices.

- Investing in research for modifying vehicle designs to minimise trauma to occupants in case of single vehicle and multi-vehicle crash; and to pedestrians in case of a collision between a vehicle and a pedestrian. Some work in this area has been done by TRIPP on designs of fronts of heavy vehicles and three-wheeled scooter taxis (autorickshaw).

* **Other**
  - Establishing support groups and restorative justice programmes for victims of RTA
  - Encouraging new research on finding new, locally relevant, sustainable ways of reducing road traffic injuries in the context of India
  - Reaching out to people to sensitise them to RTAs as a public health issue and increasing visibility of RTA prevention as a health related agenda at various forums
  - Convincing the politicians about public health implications of RTAs and generating political will to ensure adequate support in terms of grants for research and implementation of strategies for addressing the issues related to RTAs.
  - Creating a forum for sharing of insights generated though research carried out by professionals from varied areas of speciality such as automobile engineering, biomechanics, road design, city planning, law enforcement, trauma care and various medical specialties that deal with RTIs. This group of experts can establish and maintain a dialogue with politicians to influence the policy. Generation of demand by sensitising public is also important and the forum could play a key role in that by carrying out campaigns/ research at grass root level. All this could be done by establishing an apex organisation that will house / facilitate research on all aspects of RTA.

6. Appendix

Table A: Proportion of younger age groups among RTA victims

Author / Study	Age group (years)	Proportion of specified age group to sample	Sample
Patil et al 2008	0 – 14	11%	Non-fatal RTI
Ganveer and Tiwari 2005	<18	8%	Non-fatal RTI
Jha et al 2004	0 – 19	18%	Non-fatal RTI
Jha et al 2003	0 – 19	18%	Non-fatal RTI
Devadiga et al 2008	11 – 20	16%	Maxillofacial injuries in RTA
Rai et al 2007	0 – 20	17%	Fractured mandible in RTA
Choudhary et al 2005	0 – 20	4%	RTI including fatal injuries
Gupta et al 2007	0 – 20	21%	Fatal head injuries in RTA
Pathak et al 2006	0 – 15	2%	Fatal chest injury

Table B: RTA frequency throughout the day

Time of the day	Type of injury	Authors	Details
Morning/after sunrise/day time	Fatal and Non-fatal	Menon and Nagesh, 2005	12:01 pm – 6:00 pm (39%)
	Fatal	Pathak et al, 2008	9:00 am – 6:00 pm (48%)
	Fatal	Gupta et al, 2007	6:00 am – 12:00 noon (30%)
	Fatal	Singh and Misra, 2004	Daytime (70%)
	Fatal	Singh et al, 2005	6:00 am – 12:00 noon (34%)
	Non-fatal	Chandrashekhar and Reddy, 2008	6:00 am – 6:00 pm (85% of RTA involving non-alcoholics)
	Non-fatal	Ganveer and Tiwari, 2005	6:00 am – 6:00 pm (53%)
Late evening/ night after sun-down	Fatal and Non-fatal	Fitzharris et al, 2009	6:00 pm – 12:00 pm (40%)
	Fatal and Non-fatal	Jain et al, 2009	6:00 pm – 10:00 pm (Highest number, % not presented)
	Fatal	Kumar et al, 2008	6:00 pm – 6:00 am (53%
	Fatal	Pathak et al, 2008	6:00 pm – 9:00 pm (25%)
	Fatal	Singh and Dhattarwal, 2004	6:00 pm – 8:00 pm (25%)
	Fatal	Pandey et al, date unspecified	6:00 pm – 8:00 pm (Majority;% not presented)
	Non-fatal	Chandrashekhar and Reddy, 2008	6:00 pm – 12:00 midnight (97% of RTA involving alcoholics)
	Non-fatal	Bagaria and Bagaria, 2007	Evening or night when light was poor (Majority, % not provided)
	Non-fatal	Jha et al, 2004	6:00 pm – 7:00 pm (7%)
	Non-fatal	Gururaj and Benegal, 2003	At night (53%)
Other	Fatal	Menon et al, 2008	2:00 pm – 8:00 pm (Most RTA, % not presented)
	Non-fatal	Verma and Tiwari, 2004	3:00 pm – 6:00 pm (Maximum, % not presented)

Table C: Place of death for RTI victims

Author/s	Place of death of RTA victims				Remarks
	On the spot	**On the way to hospital**	**Before reaching the hospital**	**within 24 hours**	
Fitzharris et al, 2009	6/42	12/42	–	24/42	–
Jain et al, 2009	60%	–	–	–	–
Singh H et al, 2009	–	–	–	77%*	*40% of these within 1 hour
Dandona et al, 2008b	8/18	2/18	–	–	–
Kumar et al, 2008	40%	–	–	12%	–
Pathak et al, 2008	–	–	–	64%	–
Singh et al, 2008	–	–	28%	33%	–
Gupta et al, 2007	22%	3%	–	36%	–
Sharma et al, 2007	–	–	31%	19%	–
Pathak et al, 2006	70%	19%	–	–	–
Kaul et al, 2005	26%	21%	–	–	–
Kochar et al, 2005	69%	11%	–	–	–
Singh et al, 2005	30%	15%	–	–	–
Sharma et al, 2005	–	–	27%	35%	–
Singh and Dhattarwal, 2004	15%	–	–	52%	–
Sharma et al, 2003	–	–	–	72%*	*34% of these within 1 hour
Verma and Biswas, 2003	–	–	44%	–	–
Sharma et al, 2002 (Abstract)	–	–	–	62%	–

Note: % are not cumulative where not indicated
Additional information not included above:
Banerjee et al, 1998: majority died on the spot
Kochar et al, 2005: 51% of those with thoracoabdominal injuries died on the spot and another 47% within 24 hours

Box A: Summary of formats used by researchers to present data on RTIs

- Fatal or non-fatal
- Body region that sustained the injury (Head, neck, face, chest, abdomen, upper limbs, lower limbs or combinations – head and neck region, cranio-facial, thoraco abdominal etc)
- Clinical Details about injury to specific organ / body region:

  * Head injury: fracture of skull, specific bones fractured, type of fracture, intracranial hemorrhage, site of haemorrhage, Glasgow Coma Scale score, type of injury sustained by brain – contusion, laceration, infarcts, herniation etc.
  * Chest injury: organs involved, mode of death such as asphyxia etc; condition of pleural cavity such as pneumothorax, haemothorax, pyothorax; contusion, rupture of lung; contusion, laceration of heart; trauma to pericardium; tamponade; bone involvement; bones involved etc.
  * Spinal cord injury: level of injury, nature of injury, neurological deficit at presentation and after treatment etc
  * Maxillofacial injury: bones involved, type of injury, associated head injury etc
  * Injury to eye: parts involved, vision loss

- Cause of death in case of fatal injury (traumatic brain injury, trauma to heart, lungs, major vessels in thoraco-abdominal region, hemorrhagic shock, spinal cord injury)
- Residual disability (in case of traumatic brain injury, spinal cord injury, vision loss)

Box B: Data on severity of RTI from a population survey (Dandona et al, 2006a)

* **Type of injury**

  (1) None
  (2) Minor bruises
  (3) More than minor bruises
  (4) Death

* **Site of injury**

  (1) Head /Neck
  (2) Face
  (3) Hands/Shoulder/Arms
  (4) Abdomen / Stomach / Chest
  (5) Knee / Leg
  (6) Minor bruises (body part not noted)
  (7) Others

* **Health seeking**

  (1) Treatment sought out of home (Yes / No)
  (2) Treatment as an Outpatient / Inpatient
  (3) Returned to daily routine completely (Yes / No)

Box C: Classification of costs of RTA / RTI – Excerpt from Mohan, 2002 pp 34.

'Miller summarises the burden of injury losses into the following categories:

1. Medical Costs: include emergency transport, medical, hospital, rehabilitation, mental health, pharmaceutical, ancillary, and related treatment costs, as well as funeral/ coroner expenses for fatalities and administrative costs of processing medical payments to providers.
2. Other Resource Costs: include police, fire, legal/court, and victim services (e.g., foster care, child protective services), plus the costs of property damage or loss in injury incidents.
3. Work Loss Costs: value productivity losses. They include victims' lost wages and the replacement cost of lost household work, as well as fringe benefits and the administrative costs of processing compensation for lost earnings through litigation, insurance, or public welfare programs like food stamps and Supplemental Security Income. As well as victim work losses from death or permanent disability and from short-term disability, this category includes work losses by family and friends who care for sick children, travel delay for uninjured travellers that results from transportation crashes and the injuries they cause, and employer productivity losses caused by temporary or permanent worker absence (e.g. the cost of hiring and training replacement workers).
4. Quality of life includes the value of pain, suffering, and quality of life loss to victims and their families.'

Box D: Key road related factors contributing to RTA (Source: Rao et al, 2005)

1. Road Width
2. Width and state of shoulders
3. Width of the median
4. Grades
5. Deficiency in sight distance
6. Radius of the horizontal curve and deficiency in super elevation at curves

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